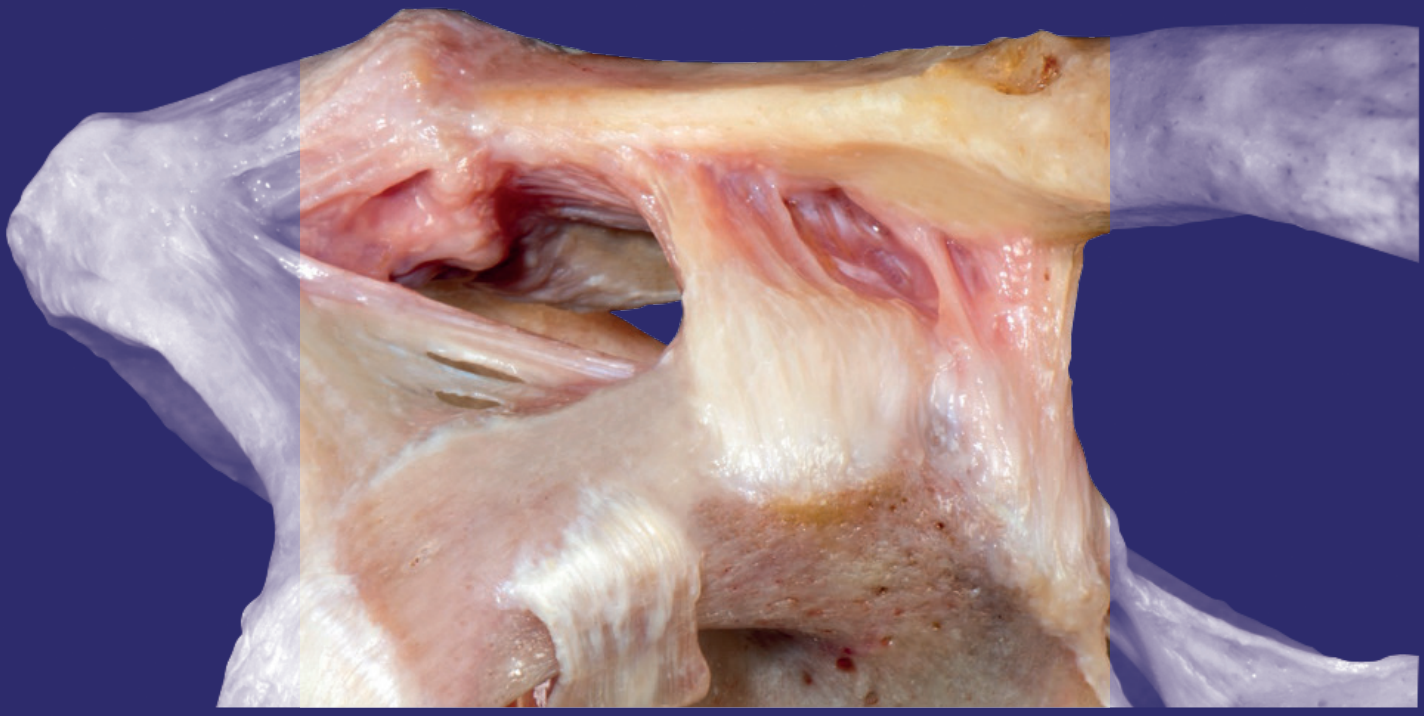
Universitat Autònoma de Barcelona

Rotura de los ligamentos coracoclaviculares: trascendencia clínica y estrategias anatómicas de reconstrucción

LUIS GERARDO NATERA CISNEROS

Rotura de los ligamentos coracoclaviculares:

trascendencia clínica y estrategias anatómicas de reconstrucción



TESIS DOCTORAL

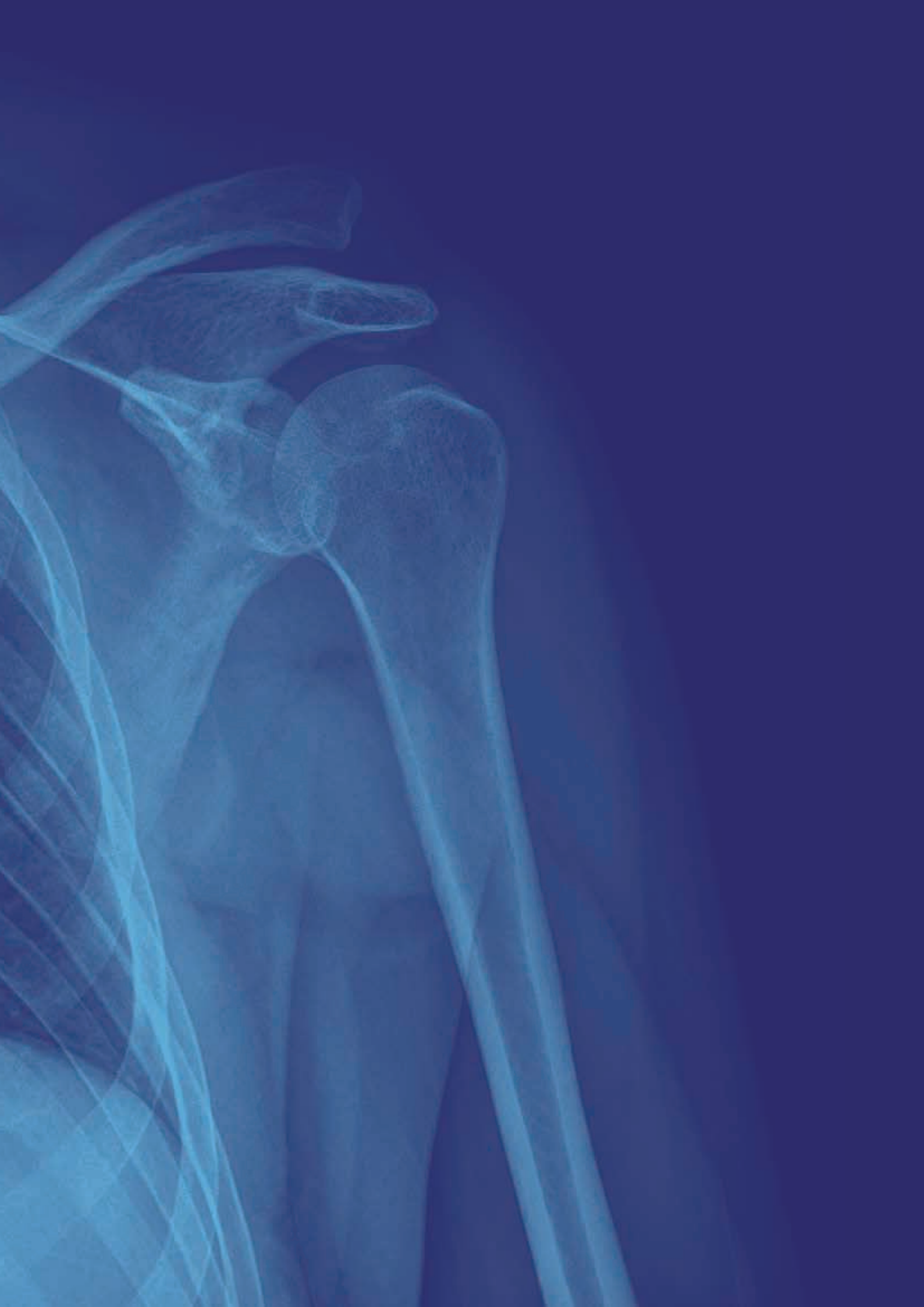
LUIS GERARDO NATERA CISNEROS

DIRECTOR

JOAN CARLES MONLLAU GARCÍA

UAB

Universitat Autònoma de Barcelona



Rotura de los ligamentos coracoclaviculares: trascendencia clínica y estrategias anatómicas de reconstrucción

AUTOR
LUIS GERARDO NATERA CISNEROS

DIRECTOR Y TUTOR DE TESIS
DR. JOAN CARLES MONLLAU GARCÍA

Departament: Cirurgia.
Programa de Doctorat: Cirurgia i Ciències Morfològiques
Universitat Autònoma de Barcelona

Barcelona 2019

UAB
Universitat Autònoma de Barcelona

La tesis doctoral titulada:

ROTURA DE LOS LIGAMENTOS CORACOCLAVICULARES: TRASCENDENCIA CLÍNICA Y ESTRATEGIAS ANATÓMICAS DE RECONSTRUCCIÓN

Ha sido realizada bajo mi dirección, y está en condiciones de ser leída y defendida delante del tribunal correspondiente para obtener el grado de doctor.

Y para que conste a los efectos oportunos, firmo el presente documento
en Barcelona, septiembre de 2019.

Prof. Dr. Joan Carles Monllau.

La tesis doctoral titulada:

ROTURA DE LOS LIGAMENTOS CORACOCLAVICULARES: TRASCENDENCIA CLÍNICA Y ESTRATEGIAS ANATÓMICAS DE RECONSTRUCCIÓN

Y presentada por el doctorando:

LUIS GERARDO NATERA CISNEROS

Está realizada bajo el modelo de compendio de publicaciones cumpliendo la normativa de la Universitat Autònoma de Barcelona para este tipo de tesis doctorales.

Referencias bibliográficas de los artículos incluidos, indexados en PubMed:

***Natera Cisneros LG**, Sarasquete Reiriz J. Acute high-grade acromioclavicular joint injuries: quality of life comparison between patients managed operatively with a hook plate versus patients managed non-operatively. Eur J Orthop Surg Traumatol. 2017;27(3):341-350. doi: 10.1007/s00590-016-1862-z*

***Natera-Cisneros L**, Sarasquete-Reiriz J, Escolà-Benet A, Rodriguez-Miralles J. Acute high-grade acromioclavicular joint injuries treatment: Arthroscopic non-rigid coracoclavicular fixation provides better quality of life outcomes than hook plate ORIF.Orthop Traumatol Surg Res. 2016;102(1):31-9. doi: 10.1016/j.otsr.2015.10.007.*

*Abat F, Sarasquete J, **Natera LG**, Calvo Á, Pérez-España M, Zurita N, Ferrer J, del Real JC, Paz-Jimenez E, Forriol F. Biomechanical analysis of acromioclavicular joint dislocation repair using coracoclavicular suspension devices in two different configurations. J Orthop Traumatol. 2015;16(3):215-9. doi: 10.1007/s10195-015-0346-y.*

***Natera Cisneros L**, Sarasquete Reiriz J. Unstable acromioclavicular joint injuries: Is there really a difference between surgical management in the acute or chronic setting? J Orthop. 2016;14(1):10-18.*

***Cisneros LN**, Reiriz JS. Prevalence of remaining horizontal instability in high-grade acromioclavicular joint injuries surgically managed. Eur J Orthop Surg Traumatol. 2017;27(3):323-333. doi: 10.1007/s00590-016-1898-0.*

***Natera L**, Sarasquete J, Abat F. Anatomic reconstruction of chronic coracoclavicular ligament tears: arthroscopic-assisted approach with nonrigid mechanical fixation and graft augmentation. Arthrosc Tech 2014;3(5):583–588. doi:10.1016/j.eats.2014.06.014*

***Cisneros LN**, Sarasquete Reiriz J, Besalduch M, Petrica A, Escolà A, Rodriguez J, Fallone JC. Horizontal and Vertical Stabilization of Acute Unstable Acromioclavicular Joint Injuries Arthroscopy-Assisted. Arthrosc Tech. 2015 Nov 23;4(6):e721-9. doi: 10.1016/j.eats.2015.07.014.*

***Cisneros LN**, Reiriz JS. Management of acute unstable acromioclavicular joint injuries. Eur J Orthop Surg Traumatol. 2016;26(8):817-830.*

***Cisneros LN**, Reiriz JS. Management of chronic unstable acromioclavicular joint injuries. J Orthop Traumatol. 2017;18(4):305-318. doi: 10.1007/s10195-017-0452-0.

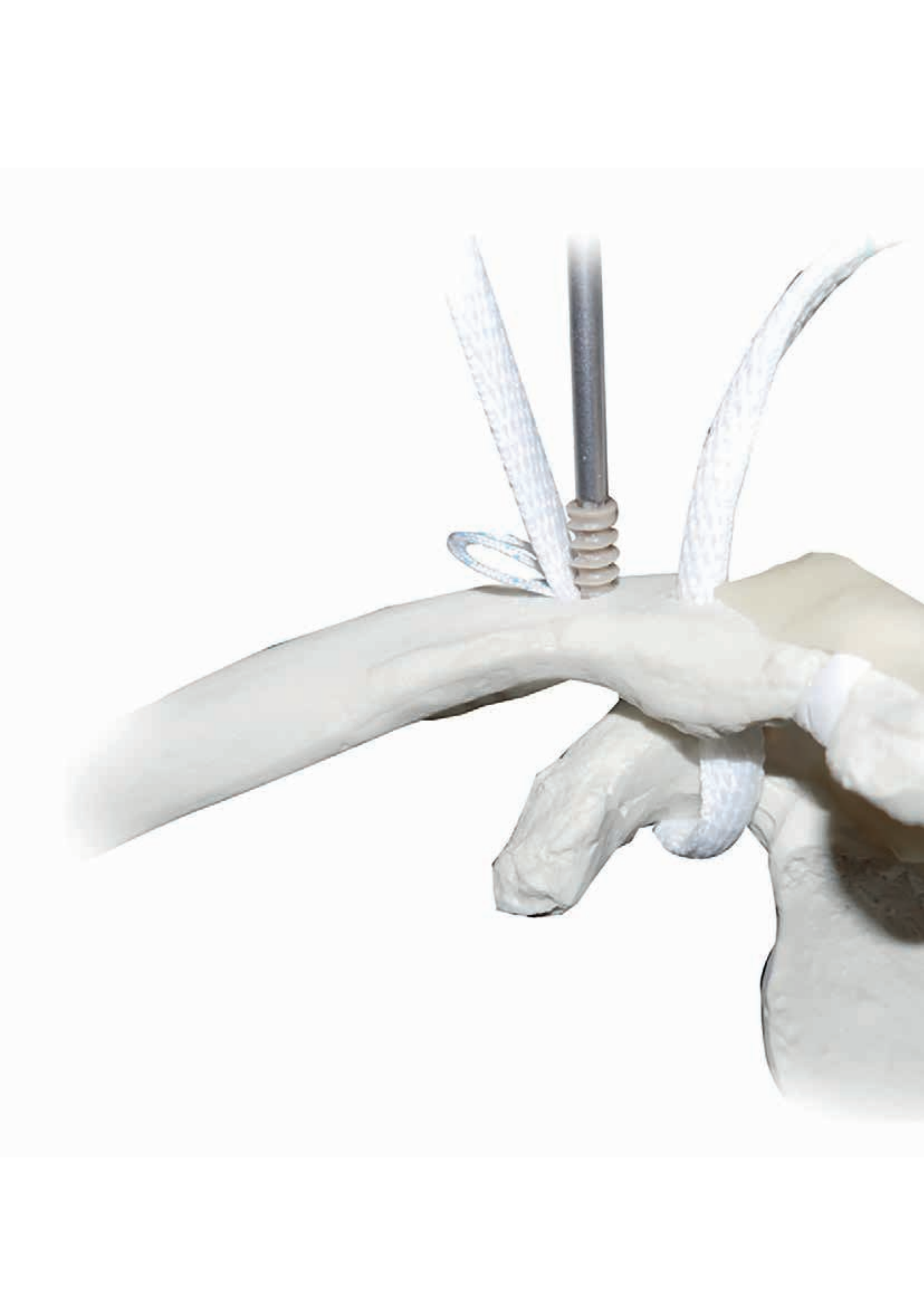
Agradecimientos

Al Dr. Joan Carles Monllau, por haberme motivado para iniciarme en este proyecto.

A Juan Sarasquete, por haber sido mi primer mentor en cirugía de hombro, y por haberme dado buena parte de las ideas que dieron pie al desarrollo de este trabajo.

A Marc, Martina y Esther, por haberme regalado todo el tiempo que he necesitado para llevar a término esta ambiciosa empresa.

Índice



1

FUNDAMENTO DE LA TESIS

1 Fundamento de la tesis

Los ligamentos coracoclaviculares (CC) son los principales elementos suspensorios de la extremidad superior, y representan el vínculo entre la clavícula y la escápula necesario para que se produzca una dinámica funcional sincronizada[1]. Recientemente se ha descrito que en la mayoría de los pacientes con antecedente de luxación acromioclavicular (AC) de alto grado que han sido tratados de forma conservadora, se producen una serie de cambios en la orientación anatómica de la escápula que condicionan alteraciones en la trayectoria cinemática de los grupos musculares de la cintura escapulo-humeral, que se pueden traducir finalmente en disfunción articular y dolor crónico[2].

En relación al tratamiento quirúrgico, se han descrito muchas técnicas diferentes: fijaciones provisionales con implantes metálicos, fijación o reconstrucción con dispositivos de suspensión CC no rígidos, procedimientos anatómicos y no anatómicos, y procedimientos realizados mediante cirugía abierta o asistida por artroscopia[3,4]. El tratamiento quirúrgico con implantes metálicos representa una restricción del movimiento articular AC normal, y por ende una alteración de la biomecánica, lo cual implica un segundo procedimiento quirúrgico para la extracción del implante una vez que se haya completado el proceso de cicatrización de los ligamentos[5]. La mayoría de los estudios que han comparado el tratamiento quirúrgico con el tratamiento conservador, contemplaron procedimientos de reducción abierta y fijación interna (RAFI) con implantes metálicos [6–20]. En la mayoría de estos estudios que incorporaron implantes metálicos, se describieron mejores resultados clínicos en los grupos de pacientes tratados de forma conservadora. Por otro lado, en estudios previos a la realización de esta tesis doctoral, hemos evidenciado que el tratamiento quirúrgico mediante un dispositivo de suspensión CC podría ofrecer mejores resultados clínicos que el tratamiento conservador[12].

En relación a los dispositivos no rígidos de suspensión CC, se han descrito resultados clínicos satisfactorios sin la necesidad de una segunda intervención para retirar el material de fijación[21]. Estos dispositivos tienen el objetivo de reducir el espacio CC, afrontando de esta manera los cabos de los ligamentos rotos, permitiendo así la cicatrización de estas estructuras. La implantación de estos dispositivos puede ser mediante cirugía abierta o mediante cirugía artroscópica. Las ventajas que la cirugía artroscópica podría ofrecer por sobre las técnicas abiertas son: un abordaje quirúrgico menor, la posibilidad de diagnosticar y tratar lesiones glenohumerales asociadas[22], y la

posibilidad de tener una visualización directa y un mejor control de la porción inferior de la base de la apófisis coracoides, situación conveniente al colocar sistemas de fijación CC.

Entre las opciones de estabilización con dispositivos CC no rígidos, están la reconstrucción anatómica con 2 dispositivos y doble túnel tanto en la clavícula como en la apófisis coracoides, y la fijación isométrica con solo 1 dispositivo y un único túnel tanto en la clavícula como en la coracoides, en el punto medio de inserción de ambos ligamentos[23]. Estudios biomecánicos han demostrado la importancia que tiene la reconstrucción anatómica de los ligamentos CC en los casos de luxaciones AC de alto grado[24]. Dicha importancia radica en el hecho de que los ligamentos conoide y trapezoide tienen funciones distintas entre sí, que dependen de su localización y orientación anatómica[25]. La fijación anatómica con 2 dispositivos pretende emular los ligamentos conoide y trapezoide, así como mejorar la resistencia biomecánica de la fijación[26], pero también supone una mayor dificultad técnica y un mayor riesgo de fractura a nivel de la apófisis coracoides[23].

Muchas de las estrategias quirúrgicas actualmente aceptadas para el tratamiento de las luxaciones AC de alto grado no contemplan la reconstrucción anatómica de los ligamentos CC[27], e incluso algunos autores no especifican si dichas técnicas se han empleado en la fase aguda o en la fase crónica tras la producción de la lesión[18]. El enfoque terapéutico de la inestabilidad AC crónica es muy diferente al de la inestabilidad AC aguda. En la fase aguda se acepta que los ligamentos AC y CC aún tienen potencial biológico, por lo que se puede contemplar el empleo de técnicas quirúrgicas que afronten los extremos de los ligamentos rotos mientras tiene lugar el proceso de cicatrización[28]. La inestabilidad AC crónica supone la presencia de unos ligamentos que ya han perdido su capacidad de cicatrizar, motivo por el cual cualquier estrategia quirúrgica debe de contemplar el empleo de un aporte tisular[29]. Dicho aporte tisular habría de estar complementado por una estabilización mecánica primaria[30] que proteja al injerto durante el proceso de integración a los túneles óseos.

Estudios biomecánicos han demostrado que la reconstrucción aislada de los ligamentos CC no proporciona suficiente estabilidad horizontal a la articulación AC, con lo que hoy en día se acepta la obligatoriedad de una fijación AC adicional[31,32]. El rol de la cápsula de AC y los ligamentos de CC en la estabilidad horizontal de la clavícula ha sido descrito previamente[33]. También se ha descrito que los pacientes que se han sometido a una cirugía por inestabilidad AC y presentan inestabilidad post-quirúrgica anteroposterior remanente pueden tener resultados clínicos significativamente peores[34].

1 FUNDAMENTO DE LA TESIS

Ante este escenario, cada uno de los artículos que componen esta tesis por compendio de publicaciones se centró en el estudio de los siguientes cinco puntos clave en el tratamiento de la inestabilidad AC.

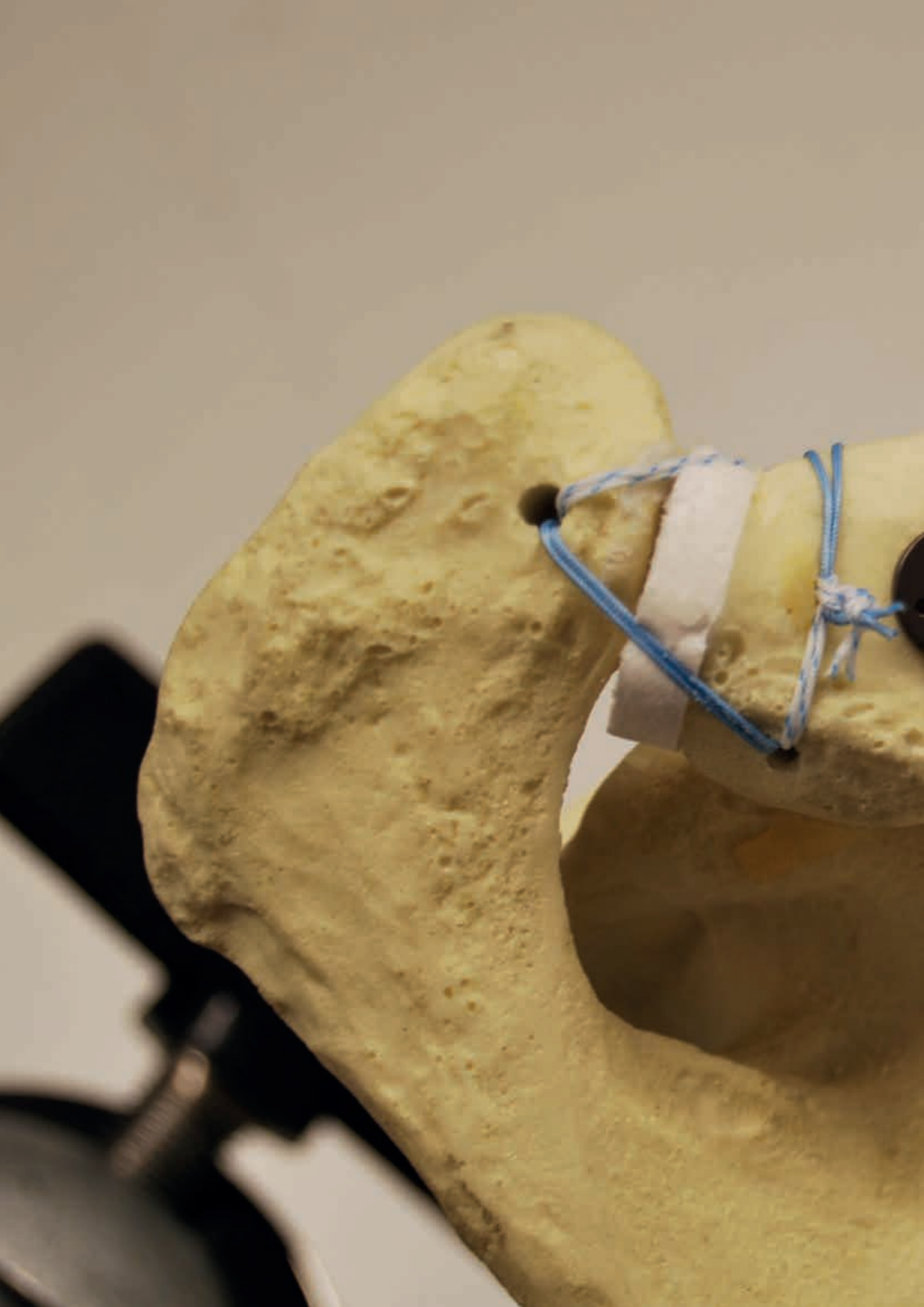
A. Comparación de los resultados clínicos y radiológicos del tratamiento conservador versus el tratamiento quirúrgico mediante fijación con placa gancho (Natera Cisneros LG, Sarasquete Reiriz J. Acute high-grade acromioclavicular joint injuries: quality of life comparison between patients managed operatively with a hook plate versus patients managed non-operatively. Eur J Orthop Surg Traumatol. 2017;27(3):341-350. doi: 10.1007/s00590-016-1862-z.)

B. Comparación de los resultados clínicos y radiológicos de 2 métodos de tratamiento quirúrgico: fijación con placa gancho versus fijación con dispositivo de suspensión coracoclavicular no rígido (Natera-Cisneros L, Sarasquete-Reiriz J, Escolà-Benet A, Rodriguez-Miralles J. Acute high-grade acromioclavicular joint injuries treatment: Arthroscopic non-rigid coracoclavicular fixation provides better quality of life outcomes than hook plate ORIF. Orthop Traumatol Surg Res. 2016;102(1):31-9. doi: 10.1016/j.otsr.2015.10.007.)

C. Comparación de la resistencia biomecánica de un dispositivo de suspensión coracoclavicular no rígido en disposición anatómica versus 2 dispositivos de suspensión coracoclavicular en disposición anatómica (Abat F, Sarasquete J, Natera LG, Calvo Á, Pérez-España M, Zurita N, Ferrer J, del Real JC, Paz-Jimenez E, Forriol F. Biomechanical analysis of acromioclavicular joint dislocation repair using coracoclavicular suspension devices in two different configurations. J Orthop Traumatol. 2015;16(3):215-9. doi: 10.1007/s10195-015-0346-y.)

D. Comparación de los resultados clínicos y radiológicos de los pacientes tratados quirúrgicamente mediante reconstrucción coracoclavicular anatómica, ya sea en fase aguda o en fase crónica (Natera Cisneros L, Sarasquete Reiriz J. Unstable acromioclavicular joint injuries: Is there really a difference between surgical management in the acute or chronic setting? J Orthop. 2016;14(1):10-18.)

E. Valoración del impacto clínico de la inestabilidad horizontal remanente tras el manejo quirúrgico de la inestabilidad AC (Cisneros LN, Reiriz JS. Prevalence of remaining horizontal instability in high-grade acromioclavicular joint injuries surgically managed. Eur J Orthop Surg Traumatol. 2017;27(3):323-333. doi: 10.1007/s00590-016-1898-0).



2

INTRODUCCIÓN

2 Introducción

2.1 Anatomía acromioclavicular y coracoclavicular

La articulación acromioclavicular (AC) es una articulación diartrodial: está rodeada por una cápsula, tiene una sinovial intraarticular y cartílago articular. El cartílago articular hialino se convierte en fibrocartílago en el lado acromial de la articulación, a la edad de 17 años en promedio, y en el lado clavicular a la edad de 24[35–37]. Entre las porciones óseas se encuentra un disco cartilaginoso que puede variar en tamaño y forma[38]. En estudios anatómicos se han descrito dos tipos de disco: un disco completo (muy raro) y un disco similar a un menisco[39–41]. El grosor de este puede variar de 1.5 a 4mm[42]. El disco intraarticular desarrolla cambios degenerativos importantes ya para la cuarta década de la vida[42,43], lo cual desempeña un papel importante en el desarrollo de la artrosis AC, observada en pacientes de edad relativamente temprana[41,44–47].

El deltoides, el trapecio y el pectoral mayor tienen vínculos importantes con la clavícula[48]. El deltoides se inserta en la superficie anterior del tercio lateral de la clavícula y el trapecio se inserta en su cara posterior. El pectoral mayor se inserta en la superficie anterior de los dos tercios mediales[48]. El ligamento coracoacromial tiene fibras que se mezclan medialmente con el ligamento AC inferior[40,49].

2.1.1 Irrigación e inervación acromioclavicular

Las ramas de la arteria supraescapular, que se origina a partir de la arteria subclavia; así como las arterias toracoacromiales, que se originan de la arteria axilar; forman los dos vasos sanguíneos principales que proporcionan irrigación a la articulación AC[50].

La inervación viene dada por ramas articulares de los nervios supraescapular, axilar y pectoral lateral[50]. Estos nervios surgen del plexo braquial. La inervación cutánea de la articulación AC se da a través de la rama sensitiva del nervio supraescapular. Esta rama discurre superior al músculo supraespinoso, dirigiéndose hacia la articulación AC. Sin embargo, el dolor proveniente de la articulación AC puede referirse al cuello, trapecio y cara lateral del hombro[50].

2.1.2 Ligamentos acromioclaviculares

La cápsula de la articulación AC es bastante delgada, pero con un soporte ligamentario importante[51]. El complejo ligamentario AC tiene 4 componentes: superior, inferior, anterior y posterior. Los ligamentos AC superior y posterior son los más potentes de este complejo, y sirven principalmente para proporcionar estabilidad horizontal[52].

En estudios cadavéricos se ha descrito que el ligamento AC superior es más grueso que el ligamento AC inferior, y tiene una inserción más definida en la clavícula distal[40]. El ligamento AC superior se fusiona con la aponeurosis musculo-tendinosa de la fascia deltotrapezoidea, y su longitud promedio se ha descrito que oscila en torno a 22.9mm[48]. Stine *et al*. han descrito que la inserción capsular de la articulación AC comienza en promedio a 2.8mm desde la porción medial del acromion hacia el centro de la articulación AC, y a 3.5mm desde la porción distal de la clavícula hacia el centro del articulación AC[53]. El ancho capsular promedio se ha descrito que puede variar de 1.6 a 2.9mm[53]. Se ha descrito que la superficie promedio de la articulación AC del adulto es de 9mm (cráneo-caudal) por 19mm (anteroposterior)[38,54]. La superficie lateromedial de la articulación AC puede variar de 1mm a 3mm y disminuye con la edad, independientemente del sexo[55].

2.1.3 Ligamentos coracoclaviculares

El complejo de los ligamentos coracoclaviculares (CC) consiste en los ligamentos conoide y trapezoide. Se insertan en la región posteromedial y anterolateral de la superficie inferior de la clavícula distal, respectivamente. El tubérculo conoide y la cresta trapezoidal representan las inserciones de estos ligamentos[38,56]. Su función principal es la estabilización vertical de la articulación AC, y la transmisión de fuerzas desde la parte superior del brazo al resto del esqueleto[1].

La inserción clavicular del ligamento conoide es aproximadamente dos veces más ancha, tanto de medial a lateral como de anterior a posterior, que su inserción coracoidea, lo que da lugar a su forma de cono invertido[56]. El ligamento trapezoide es igualmente más grueso en su extremo clavicular que en su extremo coracoideo[56]. Salter *et al*. han descrito que los ligamentos conoide y trapezoide pueden variar significativamente en longitud y anchura, y pueden existir bursas bien definidas entre ellos[40]. Incluso se ha descrito la presencia de articulaciones CC diartrodiales bien definidas en algunos

individuos[55,57]. El ligamento trapezoide puede variar de 0.8 cm a 2.5 cm tanto en longitud como en grosor, mientras que el ligamento conoide puede variar de 0.7 cm a 2.5 cm de longitud y de 0.4 cm a 0.95 cm de grosor[40]. Varios estudios[25,58–60] han descrito que el centro del ligamento trapezoide y el centro del ligamento conoide se localizan en promedio a 2.5cm y 4.5cm del borde lateral de la clavícula, respectivamente[25] (figuras 1 y 2). Se ha descrito que los bordes laterales del ligamento trapezoide y del ligamento conoide se hallan a 11.8mm y 25.3mm del extremo distal de la clavícula, respectivamente[40].

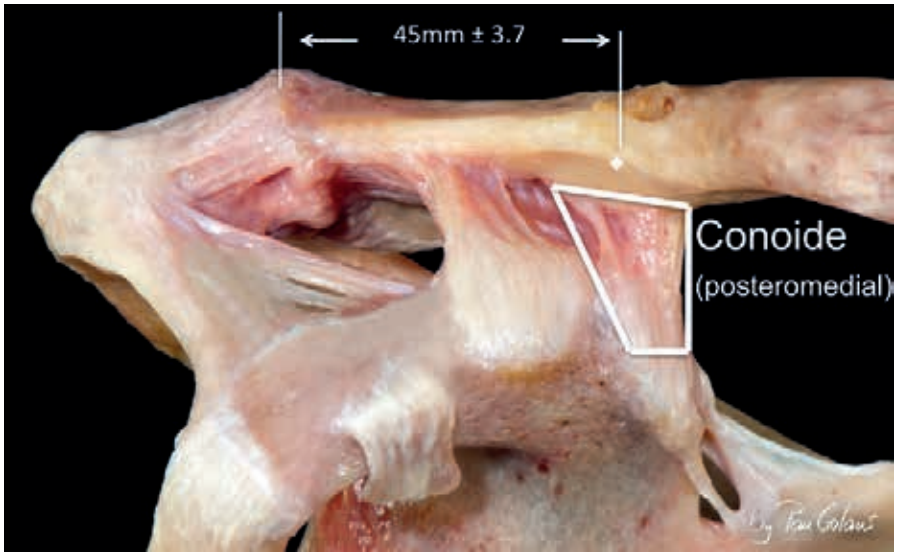


Figura 1. Preparación anatómica de una articulación acromioclavicular derecha, en la que se observa la distancia que se ha descrito existe entre la articulación acromioclavicular y el centro de la inserción clavicular del ligamento conoide. Imagen cedida por el Dr. Pau Golans al Dr. Juan Sarasquete.

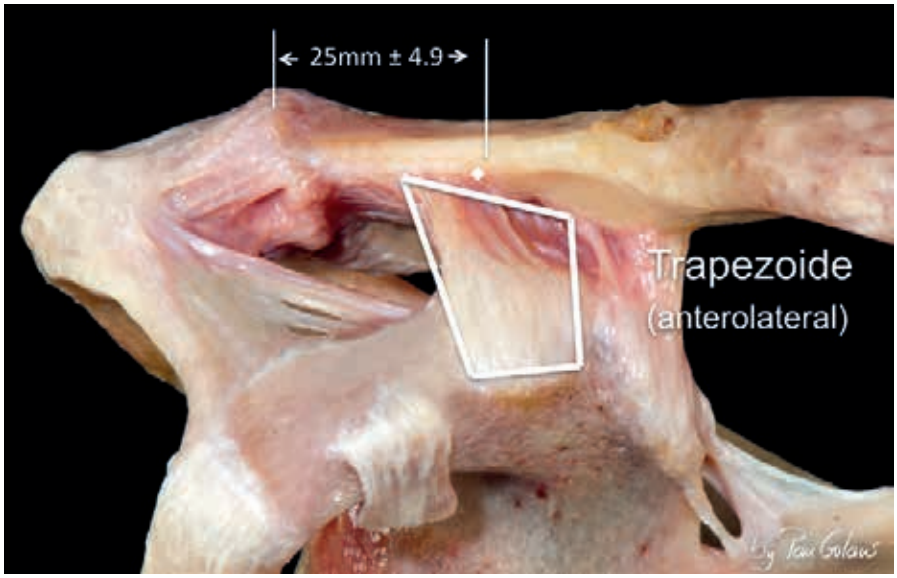


Figura 2. Preparación anatómica de una articulación acromioclavicular derecha, en la que se observa la distancia que se ha descrito existe entre la articulación acromioclavicular y el centro de la inserción clavicular del ligamento trapezoide. Imagen cedida por el Dr. Pau Golans al Dr. Juan Sarasquete.

2.2 Biomecánica

Algunos autores consideran que los ligamentos conoide y trapezoide representan el soporte principal del cual se suspende la escápula de la clavícula[1]. Asimismo, se ha descrito que los ligamentos AC aportan una estabilidad tres veces mayor en el plano anteroposterior que en el plano superoinferior[33]. En un estudio biomecánico, la fuerza in situ registrada en respuesta a una carga dirigida de manera superior, sobre los ligamentos conoide y trapezoide; no cambió después de la sección de los ligamentos AC, lo cual indica que los ligamentos AC desempeñan un papel mínimo en la estabilización vertical de la clavícula[61].

En relación al complejo ligamentario AC, se ha descrito que el ligamento AC inferior solo contribuye con aproximadamente el 50% de la restricción del movimiento en respuesta a cargas dirigidas en dirección anterior, posterior y superior; en comparación con el ligamento AC superior[61,62]. Dichas descripciones concluyen que la mayor parte de la importancia biomecánica del complejo ligamentario AC recae sobre el ligamento AC superior[61,62].

En relación a los ligamentos CC, una vez que se ha seccionado el complejo ligamentario AC en especímenes cadavéricos en los que se ha sometido el complejo CC a cargas en diferentes direcciones, el ligamento conoide ha servido como restricción primaria contra la carga anterior y superior, mientras que el ligamento trapezoide ha servido como restricción primaria contra la carga posterior[63,64]. Por ende, un desplazamiento superior significativo de la clavícula distal implicaría inicialmente una rotura del ligamento conoide[52]. Dichos estudios han permitido concluir que la orientación anatómica de estos dos ligamentos da lugar a funciones biomecánicas diferentes entre sí[52,61,65,66]. A pesar de que cuando el complejo ligamentario AC se rompe los ligamentos CC sufren un aumento de las fuerzas y tienen un comportamiento biomecánico diferenciado en el plano antero-posterior; los ligamentos CC aislados son insuficientes para controlar adecuadamente la traslación anteroposterior y las rotaciones en el eje axial de la clavícula distal[61,62].

En relación a la estabilización dinámica de la articulación AC, cabe destacar que las fibras del deltoides y el trapecio se solapan con las fibras del ligamento AC superior[35], pero su contribución exacta a la estabilización de la clavícula distal aún no ha sido plenamente descrita[67]. Esta es una limitación importante de muchos de los estudios biomecánicos que han empleado especímenes cadavéricos desprovistos por defecto del comportamiento muscular dinámico, y ello podría explicar el por qué *in vivo* los síntomas a menudo están clínicamente ausentes después de luxaciones AC de grado III (sin disrupción de la fascia deltotrapezoidea). De hecho, se ha descrito que la inserción de las fibras del deltoides anterior (mediales a la articulación AC) previene la migración excesiva de la clavícula distal después de la rotura de los ligamentos AC y CC[68], y es por ello que actualmente se tiende a diferenciar las lesiones de grado V de las lesiones del grado III, en función de la disrupción o no de la fascia deltotrapezoidea, respectivamente[69]. De hecho, la imbricación de la fascia sobre la articulación AC se empieza a considerar como un gesto añadido de mucha importancia al tratar este tipo de lesiones[35,70].

2.3 Proceso diagnóstico, semiología y clasificación de las lesiones

2.3.1 Valoración clínica

Durante la primera exploración semiológica, se ha de realizar un examen físico exhaustivo que contemple todas las maniobras de valoración de la inestabilidad AC y la dinámica escapular. Asimismo, en fase crónica se ha de llevar a cabo una exploración completa del hombro con el propósito de diagnosticar posibles lesiones glenohumerales concomitantes.

La exploración ha de realizarse idealmente con el paciente de pie, de tal manera que la acción de la gravedad sobre la extremidad superior le represente un vector de estrés caudal a la articulación AC. Esta situación hará que la deformidad sea más evidente, y que una posible lesión de la fascia deltotrapezoidea pueda ser evidenciada. Además, el dolor y la tumefacción a nivel de la articulación AC se incrementarán con el paciente en bipedestación. El dolor a la palpación de la articulación AC se incrementará con el "cross-arm adduction test" (brazo elevado a 90 grados, y aducción forzada con el codo flexionado a 90 grados). La infiltración de un anestésico local puede conseguir la remisión del dolor, lo cual permitiría concluir con certeza que la articulación AC representa la única fuente de dolor. El "cross-arm" test tiene una sensibilidad del 77%, el "AC resistance test" del 72%, y el "active compression test" del 41%[69]. La combinación de estos 3 test suma una especificidad de 95%[69].

Las luxaciones AC grado III inestables según la ISAKOS (grado IIIB) pueden comportar dolor persistente (habitualmente en el margen anterior del acromion, en la cofia, y en el borde escapular medial[69]). Asimismo, estas lesiones podrían comportar debilidad durante la exploración del manguito rotador, una disminución del recorrido articular en la elevación frontal y abducción, y semiología de discinesia escapular[69].

2.3.2 Valoración radiológica y clasificación

La exploración radiológica ha de incluir (en ambos hombros) una proyección anteroposterior (AP) estricta, una proyección de Zanca (angulación de la fuente del rayo 10-15º en dirección superior), una proyección de Alexander (perfil de escápula con el brazo en aducción forzada) y una proyección axilar. Se ha de contar con una radiografía AP en la que se puedan apreciar ambos hombros a la vez. Dicha radiografía permitirá comparar la distancia CC del hombro lesionado con respecto al hombro sano, y dará de entrada una idea de la magnitud de descenso de la escápula (figura 3) en relación con la clavícula. Las lesiones grado III y grado V se diferencian entre sí en concordancia con lo establecido por Rockwood[35]. Una luxación AC es catalogada como de grado III si la distancia CC del hombro lesionado se encuentra incrementada un 25-100% en relación al hombro contralateral, una lesión grado V si la distancia CC del hombro lesionado se encuentra incrementada un 100-300% en relación al contralateral (ambas valoraciones en proyecciones AP estrictas bilaterales). Actualmente la diferenciación más práctica de las lesiones de grado III y grado V, y más fiel a la lesión estructural, se basa en la presencia o no de una disrupción de la fascia deltotrapezoidea (grado V)[69]. Una lesión se clasifica como grado IV si en la proyección axilar la clavícula se encuentra luxada hacia posterior en relación con el acromion[69]. Las luxaciones AC grado III se diferencian en IIIA y IIIB según la diversificación hecha por la ISAKOS a la clasificación de Rockwood[69]. Las luxaciones AC grado IIIB se definen como aquellas lesiones en las que hay evidencia de solapamiento del tercio distal de la clavícula sobre el acromion, y por consiguiente inestabilidad en el plano horizontal, en la proyección de Alexander (figura 4), situación que no ocurre en las luxaciones AC grado IIIA.

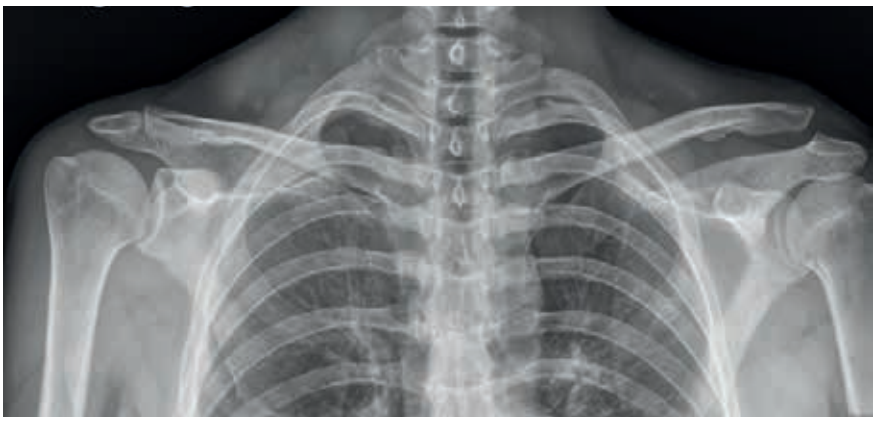


Figura 3. Radiografía en proyección anteroposterior en la cual se pueden apreciar ambos intervalos

coracoclaviculares. Nótese como en el hombro izquierdo la distancia coracoclavicular se encuentra aumentada al compararla con el hombro derecho, a expensas de un descenso de la escápula y todo el brazo izquierdo.

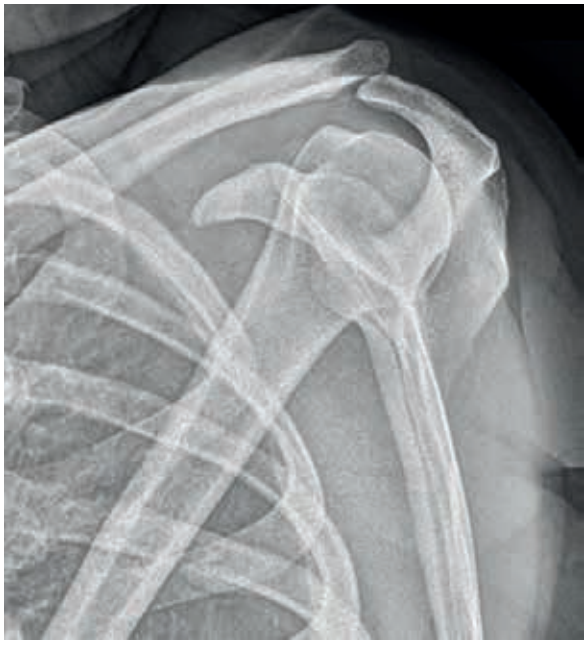


Figura 4. Radiografía en proyección de Alexander o Basamania de hombro izquierdo, en la que se aprecia que la proyección radiográfica comporta un perfil de escápula con el brazo en aducción forzada. En este caso se puede apreciar como hay solapamiento del tercio distal de la clavícula con respecto al acromion, lo cual denota inestabilidad horizontal, y en casos de luxaciones acromioclaviculares Rockwood grado III, permite concluir que se trata de una luxación acromioclavicular grado IIIB.

2.4 Indicaciones de tratamiento

Actualmente se acepta que una alternativa razonable de tratamiento de las luxaciones AC grado III es el manejo conservador. Una segunda valoración (6 semanas tras haberse producido la lesión) ha

de llevarse a cabo para valorar la evolución de la sintomatología. Para las luxaciones AC grado III, se acepta que durante los 3 primeros meses tras la producción de la lesión, alrededor de un 80% de los pacientes habrían recuperado ya una función completa y asintomática del hombro[69].

En aquellos pacientes con luxaciones AC grado III en los que se evidencie dolor persistente y disfunción escapulo-humeral que interfiera con las actividades cotidianas o deportivas, si tras tres meses desde la producción de la lesión (ya en fase crónica), aún hay semiología de discinesia escapular (figura 5), además de solapamiento del tercio distal de la clavícula sobre el acromion en la proyección de Alexander, el tratamiento quirúrgico podría ser contemplado[69]. Los pacientes con inestabilidad AC crónica (luxaciones AC Rockwood grado III-V) sintomática, han de ser informados de la existencia de recomendaciones internacionalmente aceptadas, respecto al tratamiento quirúrgico de este tipo de lesiones una vez que el tratamiento conservador ha fracasado.

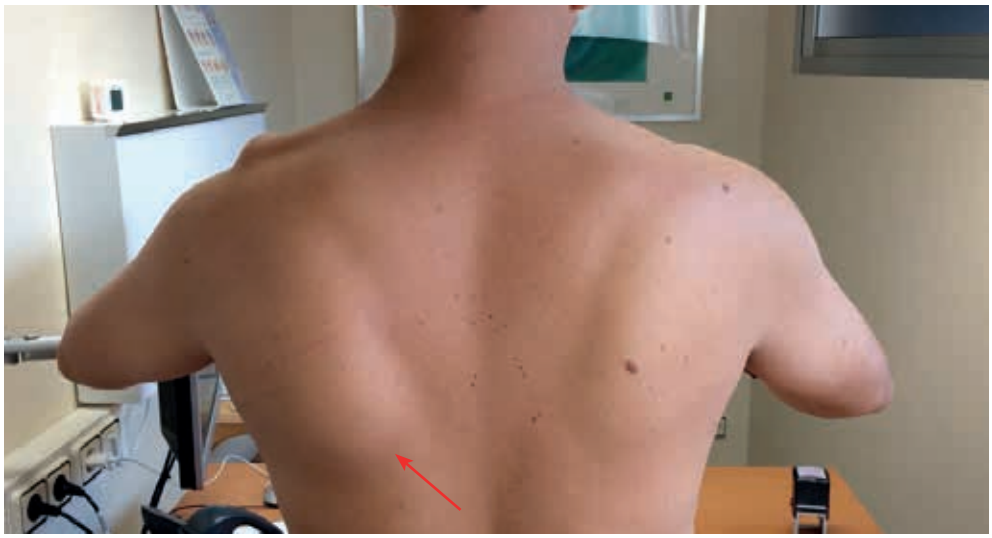


Figura 5. Fotografía clínica en perspectiva posterior, de un paciente con historia de inestabilidad acromioclavicular crónica a nivel del hombro izquierdo. Nótese la deformidad acromioclavicular a nivel de la porción superior del hombro, y nótese asimismo como la escápula izquierda muestra una prominencia acentuada del borde inferomedial (flecha roja), con respecto a la escápula derecha.

2.5 Tratamiento en agudo versus tratamiento en fase crónica

La literatura contempla 6 estudios que comparan los resultados del tratamiento quirúrgico realizado en fase aguda versus los resultados del tratamiento quirúrgico realizado en fase crónica[28,71–75]. Los 6 estudios tienen un nivel de evidencia III (retrospectivos comparativos).

Weinstein *et al*. definieron como punto de corte para diferenciar el tratamiento de la inestabilidad AC aguda versus la crónica, en 3 semanas desde la producción de la lesión[28]. En su estudio comparativo la técnica quirúrgica empleada fue el Weaver-Dunn modificado en 15 de los 27 casos tratados en fase aguda y en 14 de los 17 casos tratados en fase crónica. El resto de las reparaciones se llevaron a cabo mediante la utilización de suturas AC irreabsorbibles. Se obtuvieron resultados satisfactorios en 96% de los casos tratados en fase aguda y en 76% de los casos tratados en fase crónica. Las diferencias fueron estadísticamente significativas a favor del tratamiento de la inestabilidad AC aguda[28].

Rolf *et al*. compararon un grupo de pacientes tratados inmediatamente tras haberse producido la lesión (29 pacientes, mediante la fijación AC con agujas, a la que se añadió una fijación CC con suturas) versus un grupo de pacientes tratados quirúrgicamente tras el fracaso del tratamiento conservador (20 pacientes, mediante la técnica de Weaver-Dunn modificada)[71]. Los resultados obtenidos favorecieron de forma estadísticamente significativa al grupo de pacientes del tratamiento quirúrgico realizado en fase aguda[71].

Mignani *et al*. compararon 25 pacientes tratados en fase aguda versus 15 pacientes tratados en fase crónica[73]. En ambos grupos el tratamiento consistió en el empleo de fijaciones AC y CC temporales con agujas de Kirschner (AK) y resecciones concomitantes del tercio distal de la clavícula. Reportaron resultados satisfactorios en el 100% de los pacientes tratados en fase aguda versus 93% de los pacientes tratados en fase crónica, sin diferencias estadísticamente significativas[73].

Dumontier *et al*. compararon 32 paciente tratados en fase aguda (primeras 3 semanas) versus 24 pacientes tratados en fase crónica (más de 3 semanas)[74]. Todos los pacientes fueron tratados mediante transposición del ligamento CA. Los resultados fueron favorables en 81% de los pacientes del grupo

tratado en fase aguda versus 79% en el grupo de los pacientes tratados en fase crónica[74]. El estudio no reportó diferencias significativas entre grupos.

Von Heideken *et al*. compararon 22 pacientes tratados en fase aguda (dentro de las 4 primeras semanas tras la producción de la lesión) versus 15 pacientes tratados en fase crónica (después de un mínimo de 4 meses de tratamiento conservador)[72]. La técnica empleada fue la fijación con una placa gancho. Los resultados obtenidos favorecieron de forma significativa, tanto en el aspecto clínico como en el radiológico, al grupo de pacientes tratados en fase aguda[72].

Aunque los estudios anteriormente descritos sugieren que el tratamiento quirúrgico en fase aguda puede que ofrezca resultados superiores a los que se obtendrían con el tratamiento quirúrgico en fase crónica, la calidad de la evidencia limita la potencia de esta conclusión. 5 de los 6 estudios incorporaron técnicas no anatómicas, y no contemplaron la probable presencia de lesiones intraarticulares asociadas. El trabajo número 4 de esta tesis doctoral se enfoca en este aspecto, y se describe más adelante[75].

2.6 Tipos de reconstrucción

Los tipos de reconstrucción AC y CC en función de si se trata de un caso en fase aguda o un caso en fase crónica, se encuentran contemplados en 2 artículos de revisión incluidos en los artículos de soporte de esta tesis doctoral[76,77].

2.6.1 Tipos de tratamiento en fase aguda

2.6.1.1 Fijación provisional con placa gancho

Una de las alternativas clásicas para el tratamiento de las luxaciones AC agudas, es la fijación AC mediante placa gancho[78]. Dicho sistema representa una fijación provisional metálica, en la cual el extremo medial de la placa se atornilla a la clavícula, y el extremo lateral de la placa se apoya en la

porción inferior del acromion (figura 6). De esta manera, se consigue "suspender" la escápula de la clavícula de manera transitoria, afrontando así los extremos de los ligamentos rotos mientras tiene lugar el proceso de cicatrización. Dicha técnica comporta la desventaja de que implica una segunda cirugía obligatoria para la retirada de la placa (figura 7), y no ofrece la posibilidad de realizar una valoración intraarticular del hombro, con lo que las lesiones asociadas pasarían desapercibidas. Gille *et al*. describieron la asistencia artroscópica en la colocación de la placa gancho[79]. Concluyeron que la fijación con placa gancho asistida por artroscopia podía ofrecer todas las ventajas de un procedimiento quirúrgico mínimamente invasivo, así como la posibilidad de diagnosticar y tratar lesiones glenohumerales concomitantes[79]. Estos autores describen que en el tiempo subacromial de la artroscopia, el gancho del sistema se coloca bajo control visual. Los resultados iniciales (n=3) se describen como prometedores, con buenos resultados tras una mediana de tiempo de seguimiento después del procedimiento de 7 meses. Los inconvenientes de esta estrategia son la necesidad obligatoria de una segunda operación, y las alteraciones biomecánicas implícitas en este tipo de fijación rígida temporal.

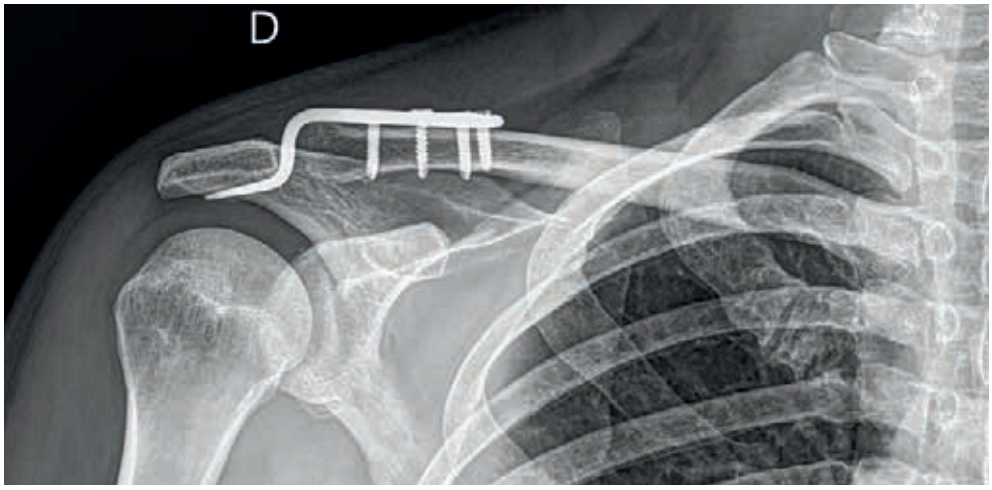


Figura 6. Radiografía anteroposterior de hombro derecho, en la cual se puede apreciar una fijación acromioclavicular con placa gancho. La placa se atornilla a la clavícula, y el gancho del sistema se apoya en la porción inferior del acromion. De esta manera, la escápula queda suspendida del gancho del sistema, con lo que se consigue corregir la incongruencia AC.

Figura 7. Fotografía clínica intraoperatoria en perspectiva superior de un hombro derecho, de un paciente con historia de inestabilidad acromioclavicular que fue tratada mediante placa gancho. Previo a la retirada del implante, nótese la fibrosis tisular adyacente a la placa y por encima del gancho del sistema.

2.6.1.2 Procedimiento de Bosworth

Esta técnica consiste en la fijación CC mediante un tornillo, cuyo objetivo es el de cerrar el intervalo CC para así afrontar los extremos de los ligamentos durante el proceso de cicatrización[80]. Rolla *et al.* describieron la asistencia artroscópica en la colocación un tornillo canulado entre la clavícula y la coracoides, sin necesidad de control radiográfico intraoperatorio[81]. El procedimiento descrito se realizó en 9 pacientes, en los cuales se describieron buenos resultados funcionales. Estos autores argumentaron que las ventajas de la asistencia artroscópica es que ofrece la posibilidad de evaluar la articulación glenohumeral para diagnosticar y tratar lesiones asociadas, y también tiene los beneficios de no exponer al paciente o al equipo quirúrgico a radiación ionizante[81]. Con respecto al procedimiento de Bosworth *per se*, se ha demostrado que representa una fijación rígida que no respeta la biomecánica de la articulación AC, lo cual implica la necesidad de extracción obligatoria del tornillo 10-12 semanas tras su colocación ya que el intervalo CC es dinámico y comporta movimientos en varias direcciones, con lo que la permanencia indefinida del tornillo implicaría un riesgo de fractura a nivel de la clavícula o de la coracoides[80].

2.6.1.3 Fijación acromioclavicular provisional con agujas de Kirschner.

La fijación AC con agujas de Kirschner o procedimiento de Phemister[82], consiste en la reducción AC abierta, exeresis del disco intraarticular, y transfixión de las superficies articulares con dos agujas de Kirschner. Después de 8 semanas de fijación provisional, se asume que tanto los ligamentos AC como los ligamentos CC han cicatrizado, con lo que se procede con la retirada de las agujas. Calvo *et al.* y describieron una alta tasa de artrosis AC en los pacientes tratados mediante exeresis del disco y transfixión articular, con lo que actualmente se tiende a desaconsejar esta estrategia de tratamiento[15].

2.6.1.4 Dispositivo no rígido de suspensión coracoclavicular

El uso de un dispositivo CC de suspensión no rígido (figura 8) representa una estrategia que no contempla la necesidad obligatoria de una segunda cirugía para la extracción del implante. La mayoría de los procedimientos asistidos por artroscopia que incorporan un dispositivo de suspensión CC tienen como objetivo reducir el espacio CC, afrontando así los cabos de los ligamentos CC rotos. Con el uso de un dispositivo de suspensión ubicado en el punto isométrico de los ligamentos CC, en casos de luxaciones AC de alto grado, se han descrito buenos resultados clínicos, pero las subluxaciones secundarias han sido motivo de preocupación[83]. Solo 1 dispositivo de suspensión CC en posición isométrica no reproduce la biomecánica de los ligamentos de CC, y la fijación que proporciona no parece ser suficiente para mantener la reducción de la articulación AC[84]. En relación a los desplazamientos secundarios, las razones que se han descrito han sido principalmente mecánicas[84]. El concepto y la importancia de una reconstrucción anatómica de las estructuras lesionadas para así conseguir emular su función, fue una técnica descrita posteriormente; por lo que el uso de un solo dispositivo de suspensión comenzó a ser reemplazado por el uso de dos dispositivos de suspensión colocados en disposición anatómica[34]. Extrapolando este concepto, en nuestro grupo hemos descrito la reconstrucción artroscópica del ligamento conoide, en casos de fracturas inestables del tercio distal de la clavícula[85,86].

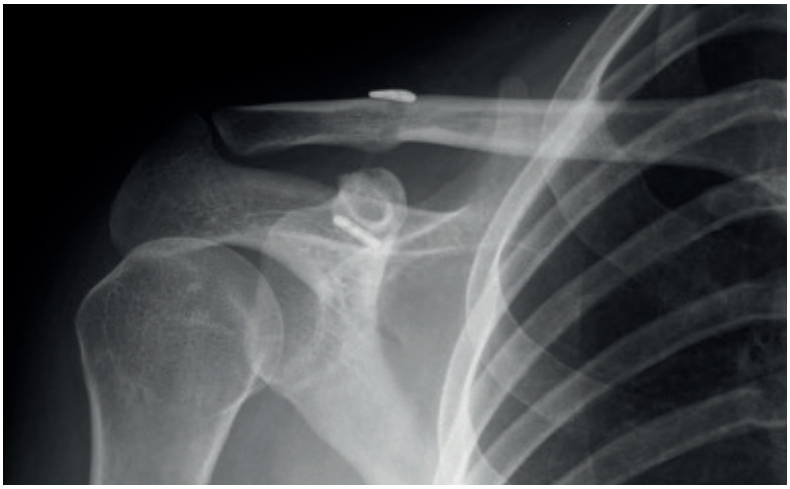


Figura 8. Radiografía anteroposterior de hombro derecho en un paciente con historia de inestabilidad acromioclavicular aguda, en la que se puede apreciar un dispositivo de suspensión coracoclavicular.

2.6.1.5. Dos dispositivos de suspensión coracoclavicular con disposición anatómica

Estudios biomecánicos han demostrado la importancia de la reconstrucción anatómica de los ligamentos conoide y trapezoide en los casos de inestabilidad AC[26]. Esta importancia se basa en el hecho de que tienen diferentes funciones que dependen de sus ubicaciones anatómicas nativas[25]. Para reproducir la orientación anatómica de los ligamentos conoide y trapezoide, y mejorar así la biomecánica de la fijación, se han desarrollado técnicas artroscópicas que incorporan un segundo dispositivo de suspensión CC[34] (figura 9). Es importante tener en cuenta que si dicho procedimiento se realiza con asistencia artroscópica (figura 10), es fundamental asegurar que la fascia deltotrapezoidea no se encuentre interpuesta entre la clavícula y el acromion. Esto solo puede garantizarse mediante un abordaje directo en la porción superior de la articulación AC.

Walz *et al*. han demostrado en un estudio biomecánico que la reconstrucción de los ligamentos conoide y trapezoide mediante 2 dispositivos de suspensión CC ofrece a resultados *in vitro* con resistencias biomecánicas incluso superiores a las de los ligamentos CC nativos[26]. En el trabajo n.3 de esta tesis doctoral estudiamos este aspecto. El grupo de Scheibel *et al*. ha demostrado en una serie consecutiva de 28 pacientes con un seguimiento medio de 26.5 meses, con luxaciones AC de alto grado en fase

aguda; que la técnica de doble dispositivo CC asistida por artroscopia y control radiográfico intraoperatorio, representa un procedimiento que proporciona resultados clínicos y radiológicos excelentes, a pesar de la presencia de inestabilidad horizontal parcial remanente[34]. Posteriormente, el grupo de Imhoff *et al*. reafirmó esta conclusión al describir los resultados de su serie de 23 pacientes consecutivos, con un seguimiento medio de 58 meses, que fueron tratados mediante fijación anatómica con 2 dispositivos de suspensión implantados mediante asistencia artroscópica[87].

Se ha descrito que la reconstrucción de los ligamentos CC como estructura única puede ser suficiente para controlar las fuerzas de estrés vertical, pero puede no ser suficiente para prevenir la traslación anteroposterior, y por lo tanto puede permitir cierto grado de inestabilidad horizontal remanente, y contribuir al dolor postoperatorio y a resultados clínicos inferiores[61]. Debido a la evidencia clínica y biomecánica actualmente disponible con respecto al manejo de estas lesiones en fase aguda, se puede considerar que una reconstrucción anatómica sintética de los ligamentos conoide y trapezoide mediante el uso de 2 dispositivos de suspensión ubicados en los orígenes nativos de las estructuras rotas, podría representar la estrategia que mejor respeta las propiedades y funciones individuales de los ligamentos. Tomando en cuenta toda la evidencia clínica y biomecánica disponible, en uno de los artículos de soporte de esta tesis doctoral se puede apreciar la descripción técnica detallada del procedimiento propuesto tanto para la estabilización vertical como para la estabilización horizontal de una luxación AC en fase aguda[88].

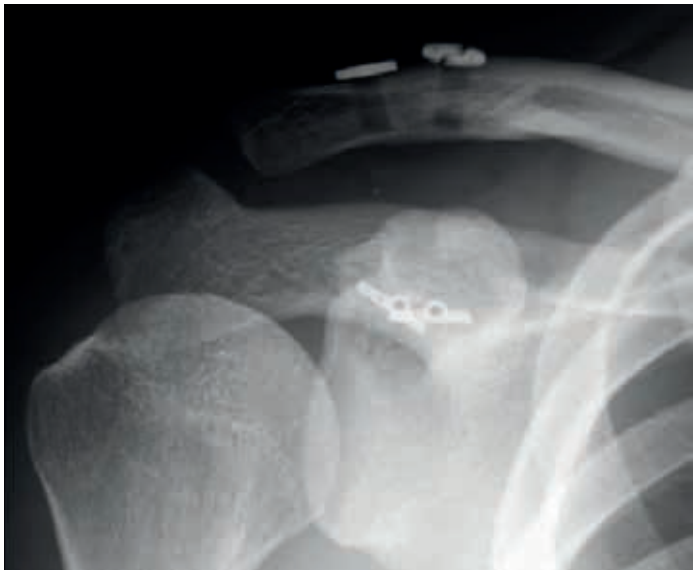


Figura 9. Radiografía anteroposterior de hombro derecho, de un paciente con historia de inestabilidad acromioclavicular aguda, que fue tratada mediante 2 dispositivos de suspensión coracoclavicular.

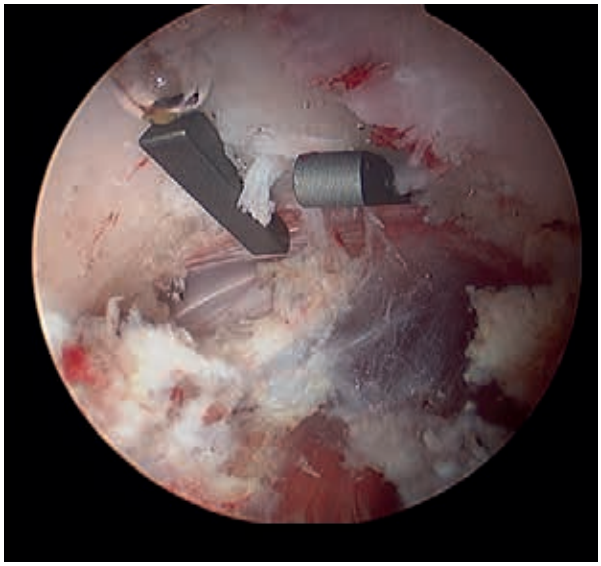


Figura 10. Visión artroscópica de la porción inferior de la coracoides, en la que se puede apreciar el apoyo subcoracoideo de los 2 dispositivos de suspensión.

2.6.2 Tipos de tratamiento en fase crónica

2.6.2.1 Transposición del ligamento coracoacromial

El clásico procedimiento para el tratamiento de la inestabilidad AC crónica es la técnica que contempla la transposición del ligamento coracoacromial (CA)[89,90]. La técnica descrita por Weaver y Dunn supone la resección del extremo distal de la clavícula, la desinserción del ligamento CA del acromion, y la transferencia de dicho ligamento al tercio distal de la clavícula[90] (figura 11). Las modificaciones hechas al procedimiento original de Weaver-Dunn han ido abocadas a aumentar la estabilidad mecánica primaria de la fijación por medio de la adición de una fijación CC mediante lazos sub-coracoideos con sutura[91], anclajes coracoideos con sutura[92], o injertos tendinosos. Otra modificación ha consistido en la adición de una placa gancho[93].

Los resultados clínicos reportados con cualquiera de las modificaciones han sido satisfactorios[91–93]. Sin embargo, cabe mencionar que el empleo de la placa gancho se ha asociado a una mayor tasa de complicaciones; incluyendo infección y necesidad de reintervención[93]. Los anclajes coracoideos con sutura se han relacionado con una mayor tasa de desplazamientos secundarios[92].

Se han comparado dos de las modificaciones hechas a la técnica de Weaver-Dunn (fijación CC con sutura tipo PDS versus placa gancho)[91]. Los resultados clínicos obtenidos han sido similares, pero los autores de entrada exponen que la ventaja que comporta la fijación CC con PDS con respecto a la placa gancho, es que no se requiere de una segunda intervención para retirar el implante[91].

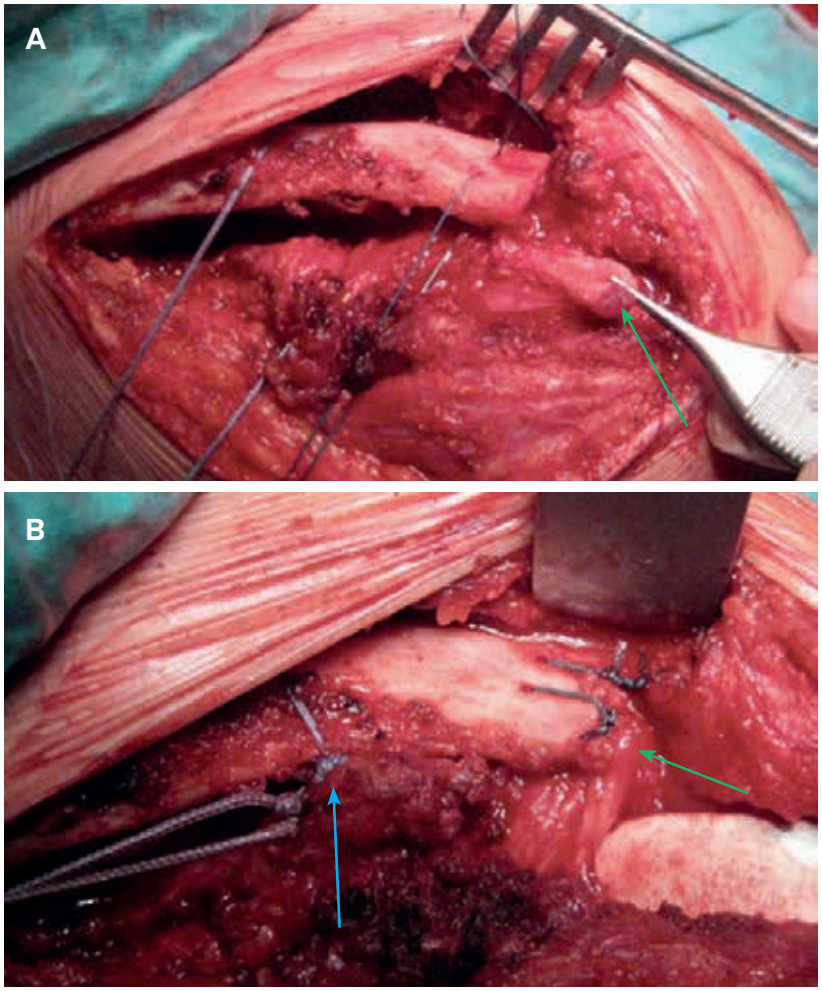


Figura 11A. Fotografía intraopetatoria desde perspectiva anterior, en la que se observa un abordaje transverso hecho sobre un hombro izquierdo con historia de inestabilidad acromioclavicular crónica, al que se le realizó un procedimiento de Weaver-Dunn modificado. Nótese como se ha resecado ya el tercio distal de la clavícula, y como se ha despegado ya el ligamento coracoacromial (flecha) de su inserción acromial.

Figura 11B. Obsérvese como ya se ha hecho la transposición del ligamento coracoacromial, y como el mismo ya ha sido suturado al tercio distal de la clavícula (flecha verde). Obsérvese asimismo como se ha protegido la transposición, mediante una fijación coracoclavicular con sutura de alta resistencia (flecha azul).

2.6.2.2 Reconstrucción anatómica de los ligamentos coracoclaviculares y/o acromioclaviculares

Numerosos estudios biomecánicos han demostrado la superioridad de las reconstrucciones anatómicas con respecto a otro tipo de procedimientos, en relación al potencial de emular las propiedades biomecánicas y funcionales de los ligamentos nativos[94]. Carofino y Mazzocca emplean una técnica reconstructiva que supone una fijación del injerto tendinoso en la clavícula mediante la realización de túneles ubicados en las localizaciones nativas de los ligamentos CC, y tornillos interferenciales de biotenodesis. Dichos autores proponen el paso subcoracoideo del injerto tendinoso (sin túnel en coracoides), y proponen el ascenso de la plastia desde la coracoides hasta la clavícula cruzando los extremos entre sí para conformar una configuración en "8". En una serie de 106 casos con un seguimiento medio de 21 meses, describen una mejoría significativa de los resultados clínicos preoperatorios[95].

Yoo *et al*. han descrito la reconstrucción anatómica de los ligamentos CC mediante la realización de 3 túneles óseos en las huellas nativas de los ligamentos: 2 en la clavícula y 1 en la coracoides[96]. Dichos autores exponen que la realización de solo 1 túnel a nivel de la coracoides minimiza el riesgo de que se produzca iatrogénicamente una fractura. La técnica que describen no contempla la utilización de un estabilizador mecánico primario que proteja al injerto durante el proceso de integración a los túneles óseos; motivo por el cual sus reconstrucciones podrían ser propensas a fuerzas distractoras que podrían a su vez comprometer la reducción AC inicialmente obtenida. De hecho, los autores reportan resultados clínicos satisfactorios, pero en el 100% de los pacientes de su serie (13/13) al final del seguimiento se observaron desplazamientos secundarios sutiles[96]. Con el objeto de mejorar la fijación mecánica primaria y así reducir la tasa de desplazamientos verticales secundarios y proteger el injerto tendinoso mientras se integra a los túneles óseos, en uno de los artículos de soporte de esta tesis doctoral se describe con detalle la técnica quirúrgica modificada en la que se ha añadido un dispositivo de suspensión a la reconstrucción con aloinjerto de los ligamentos CC[29] (figuras 12 y 13).

Figura 12. Reconstrucción coracoclavicular anatómica, representada sobre maqueta escapulo-clavicular. Nótese como se reconstruyen tanto el conoide como el trapezoide, con un solo túnel a nivel de la apófisis coracoides y 2 túneles a nivel de la clavícula. La fijación del injerto a nivel de la clavícula se realiza con tornillos de biotenodesis, y en el túnel del ligamento conoide se añade un dispositivo de suspensión coracoclavicular (se puede apreciar el apoyo subcoracoideo del flip del dispositivo).

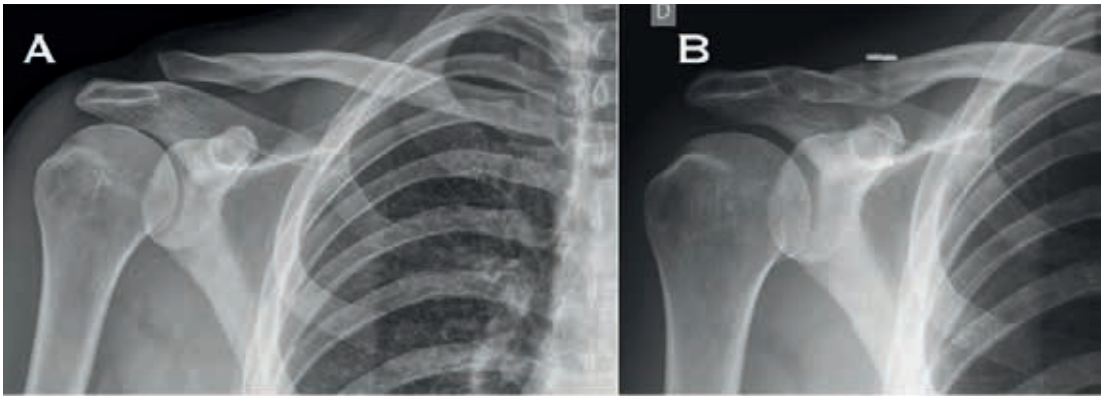


Figura 13. Radiografías de hombro derecho en proyección anteroposterior.

A.- Proyección en la que se puede apreciar luxación acromioclavicular de alto grado.

B.- Resultado radiológico a los 3 meses, tras la reconstrucción anatómica con aloinjerto tendinoso recreando el conoide y el trapezoide, y dispositivo de suspensión coracoclavicular como fijación mecánica primaria.

2.6.2.3 Plastias sintéticas

Las reconstrucciones ligamentarias con plastias sintéticas no dejan de ser una opción que se podría contemplar para el tratamiento de la inestabilidad AC crónica. Las plastias sintéticas más comúnmente empleadas son el LARS® (Ligament Advanced Reinforcement System; Surgical Implants and Devices, Arc-sur-Tille, France), el injerto de Dacron® y el Ligastic®[97,98]. Se han reportado resultados clínicos satisfactorios con el LARS®[97], e insatisfactorios con el Dacron®[97] y con el Ligastic®[98]. En cuanto a las prótesis vasculares Dacron®, Fraschini *et al*. reportaron una tasa de complicaciones de 43.3% (13 pacientes de 30), dentro de las cuales destaca un 23.3% (7 pacientes de 30) de roturas de la plastia[98]. En cuanto al LARS®, la tasa de roturas de la plastia ha sido descrita por los autores como de 3.3% (1 paciente de 30)[98]. En cuanto al Ligastic®, Mares *et al*. han descrito una tasa de osteolisis clavicular de 22% (6 de 27 pacientes)[97]. De hecho, dichos autores exponen en su estudio que actualmente desestiman el empleo de este tipo de implante, y que de hecho lo desaconsejan.

2.6.2.4 Estabilización dinámica de la articulación acromioclavicular

Esta técnica contempla la realización de una osteotomía a nivel de la apófisis coracoides y la transferencia de la misma junto con el tendón conjunto a la cara caudal del tercio distal de la clavícula[99]. De esta manera la acción del tendón conjunto se transforma en depresora de la clavícula. El problema teórico que comportaría esta técnica, es que no soluciona la patomecánica que supone una luxación AC de alto grado. Esta técnica desciende la clavícula para acercarla a la escápula, pero realmente la patomecánica de una luxación AC de alto grado consiste en un descenso de la escápula y de toda la extremidad superior[1], más que en un puro ascenso de la clavícula. A pesar de ello, se han descrito resultados satisfactorios, tanto en casos de inestabilidad AC aguda como en casos de inestabilidad AC crónica[100].

2.6.2.5 Artroplastia de resección acromioclavicular

La resección del extremo distal de la clavícula o procedimiento de Mumford, más la resección de la porción articular del acromion; pueden suponer una solución para los casos de inestabilidad AC crónica grado I-III, que cursan con clínica de dolor a nivel de la articulación AC[101]. La realización de esta técnica ha de contemplar la resección de 4mms a nivel extremo distal de clavícula y 4mms del extremo medial articular del acromion (figura 14), ya que (en casos de luxaciones AC grado I-II) el borde lateral del ligamento trapezoide se halla a 11.8mm del extremo distal de la clavícula[40], y si se realizan resecciones más generosas, la inserción clavicular de este ligamento podría verse comprometida. Se

ha descrito que las resecciones de 4mm de clavícula distal y 4mm de acromion medial son adecuadas para que no se produzca contacto hueso con hueso después del procedimiento[62].

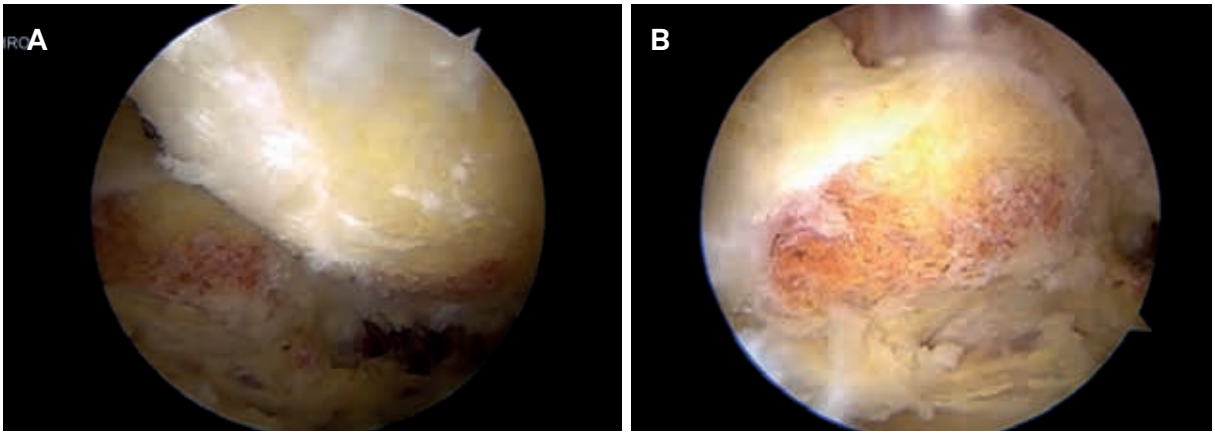


Figura 14. Visión artroscópica subacromial desde el portal posterior, de hombro derecho con antecedente de luxación acromioclavicular grado II, con mala respuesta al tratamiento conservador, en el que se realizó artroplastia de resección acromioclavicular (procedimiento de Mumford artroscópico).

A.- Obsérvese el espacio entre la clavícula y el acromion, tras 4mm de resección de cada una de las superficies.

B.- Visión frontal del tercio distal de la clavícula, desde el portal lateral. Se puede apreciar como en este caso, se evidenció ausencia del ligamento acromioclavicular superior.

2.7 Controversias en el tratamiento de la inestabilidad acromioclavicular

2.7.1 Cirugía asistida por artroscopia versus cirugía abierta

Con respecto a las ventajas que podría ofrecer la cirugía asistida por artroscopia (figura 15) sobre la cirugía abierta en casos de inestabilidad AC, cabe destacar que las lesiones glenohumerales asociadas pueden ser diagnosticadas y tratadas[29]. Algunos autores han reportado que las lesiones glenohumerales tributarias de reparación, asociadas a la inestabilidad AC de alto grado podrían presentarse en hasta 1 de cada 3 casos[102]. De la misma manera, la visualización directa del aspecto caudal de la coracoides le puede proporcionar seguridad al cirujano al momento de realizar técnicas que contemplen la realización de túneles[29].

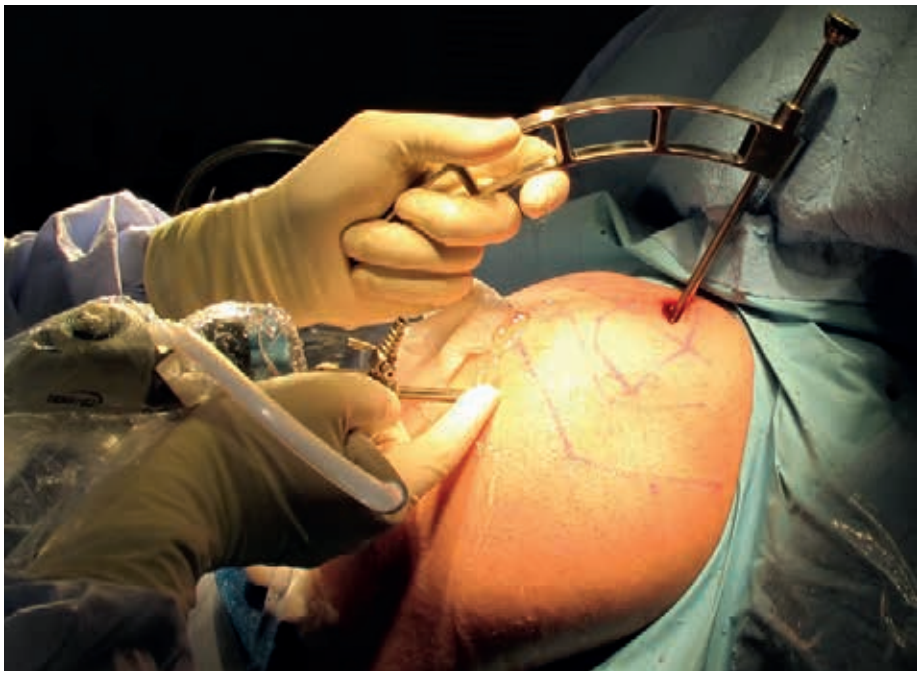


Figura 15. Fotografía intraoperatoria con perspectiva posterior de hombro izquierdo, en la que se puede apreciar la asistencia artroscópica del proceso de realización del túnel coracoclavicular.

Es importante recalcar el concepto de "asistencia artroscópica" del procedimiento de reconstruc-

ción[29]. En el tratamiento de la inestabilidad AC, reviste suma importancia el asegurar que no haya interposición de la fascia deltotrapezoidea entre la clavícula y el acromion, situación que solo puede asegurarse mediante la realización de un mini-abordaje justo encima de la articulación AC. Una vez conseguida la reducción anatómica de la articulación AC, la fascia deltotrapezoidea debe ser cuidadosamente reconstruida para de esta forma garantizar una adecuada estabilidad vertical y horizontal[29].

2.7.2 Reconstrucciones anatómicas versus no anatómicas

Como se ha mencionado anteriormente, estudios biomecánicos han demostrado la importancia de las reconstrucciones anatómicas de los ligamentos CC en los casos de inestabilidad AC crónica[103–105]. Se ha descrito que la reconstrucción de los ligamentos CC y AC mediante el empleo de injertos tendinosos podría proveer una estabilidad AC similar a aquella de una articulación AC nativa[103]. De la misma manera, hoy día queda claro que desde el punto de vista biomecánico y de resistencia de la reconstrucción, las reconstrucciones anatómicas representan una técnica superior al clásico procedimiento de Weaver-Dunn modificado[103]. Se ha descrito que, biomecánicamente, el ligamento coracoacromial tiene solo alrededor del 50% de la fuerza y rigidez del complejo CC nativo[104,106]. En un estudio clínico prospectivo y comparativo, Tauber *et al.* demostraron que la reconstrucción anatómica de los ligamentos CC permitió obtener un resultado clínico significativamente superior al que se obtuvo mediante el empleo de la técnica del Weaver-Dunn modificado[105]. En el apartado de artículos de soporte de esta tesis doctoral, se incluyen 2 descripciones técnicas detalladas de las reconstrucciones anatómicas que se proponen para el tratamiento de estas lesiones[107,108].

2.7.3 Estabilización anteroposterior

A pesar del reciente desarrollo de numerosas técnicas reconstructivas, la persistencia de inestabilidad anteroposterior posquirúrgica sigue siendo un motivo de preocupación[109]. Se ha estudiado y demostrado la importancia que comporta la reconstrucción simultánea de los ligamentos AC[33]. Se ha descrito que aquellos pacientes que han sido intervenidos quirúrgicamente por inestabilidad

AC, y que presentan una inestabilidad anteroposterior remanente, presentan resultados clínicos significativamente inferiores[34]. Asimismo, se ha descrito que la inestabilidad anteroposterior persistente representa el único factor que influye negativamente en los resultados clínicos[34]. Por este motivo, las estrategias reconstructivas han de otorgarle la misma importancia a la reconstrucción AC que a la reconstrucción CC[110] (figura 16). El trabajo n.5 de esta tesis doctoral, estudia la importancia clínica de este aspecto[111], y en uno de los artículos de soporte, describimos con detalle el procedimiento quirúrgico propuesto para abordar este problema[107].

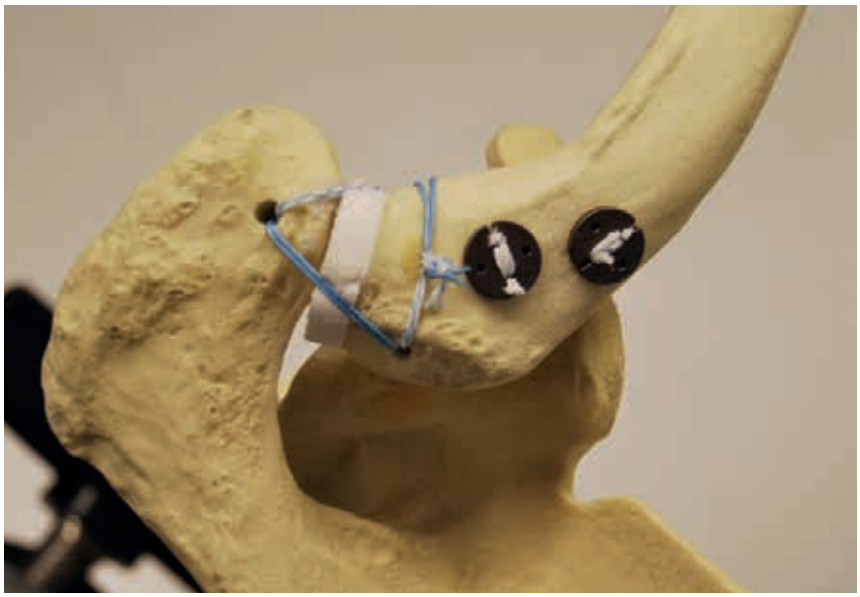


Figura 16. Fotografía con perspectiva superior de maqueta de articulación acromioclavicular, en la cual se puede apreciar la estabilización anteroposterior de la articulación mediante anclaje "todo sutura", implantado a nivel de la superficie superior del acromion, y cuyas suturas pasan a través de un túnel anteroposterior realizado a nivel del tercio distal de la clavícula. La configuración obtenida es triangular.

2.7.4 Vía de abordaje a la coracoides

Algunos autores proponen una incisión cutánea directa sobre la punta de la apófisis coracoides, para luego realizar disección roma y localización de la base, y así poder posicionar la guía de brocado[112]. Estas técnicas se llevan a cabo "a ciegas", y por ende carecen de la precisión que ofrece una visualización directa. Para garantizar una correcta visualización de la porción inferior de la base de la coracoides (figura 17) se han descrito técnicas artroscópicas que facilitan la realización de los túneles y el posicionamiento de los implantes[27,29,30]. El acceso glenohumeral contempla la necesidad de liberar los ligamentos glenohumeral superior y medio para así poder acceder a la apófisis coracoides[113]; mientras que el acceso subacromial a la coracoides tiene la ventaja por sobre el acceso glenohumeral de que no contempla la sección de los ligamentos glenohumerales superior y medio[29].

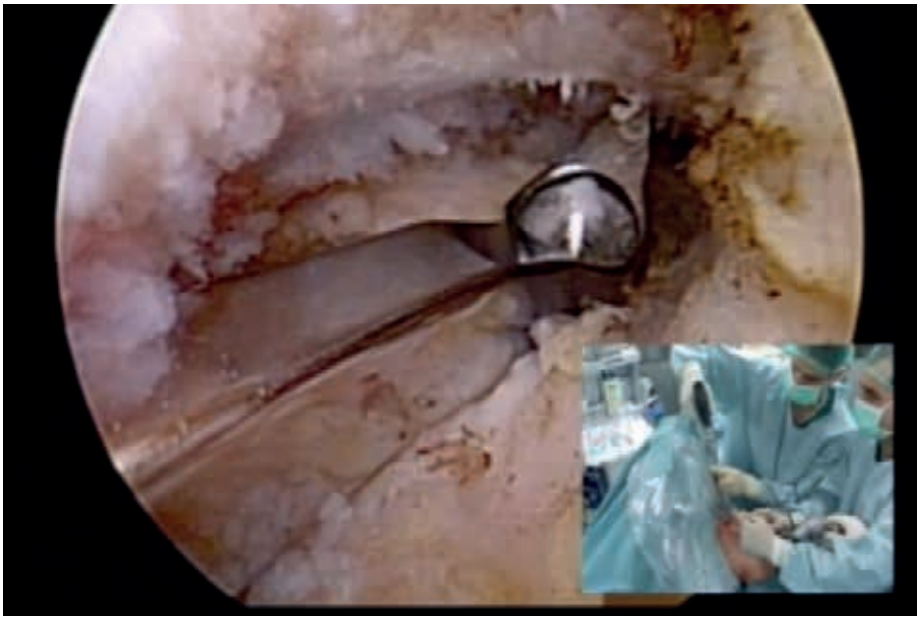


Figura 17. Visión artroscópica desde el portal anterolateral en hombro izquierdo, en la cual se puede apreciar la colocación de la guía de brocado del túnel coracoclavicular, y que permite la visualización directa de la salida de la punta la broca a través de la porción inferior de la coracoides, una vez que se ha completado el proceso de tunelización coracoclavicular.

2.7.5 Método de fijación del injerto tendinoso en la coracoides

Se ha descrito que los lazos sub-coracoideos con sutura se tienden a subluxar hacia anterior debido a la morfología de la base de la coracoides[114]. También se ha demostrado que la utilización de dichos lazos sub-coracoideos con sutura pueden suponer un efecto de cizallamiento deletéreo sobre el hueso coracoideo[115]. Otros autores proponen técnicas que no contemplan la realización de túneles, sino el paso del injerto alrededor de la porción caudal de la coracoides. Al no haber contacto entre las trabéculas del hueso esponjoso y el colágeno de la plastia tendinosa[89], se podría inferir que la integración de la plastia podría verse comprometida. Con el objetivo de garantizar una estabilidad mecánica primaria y así garantizar la fijación durante el período de integración de la plastia a los túneles, se puede contemplar la adición de un dispositivo de suspensión CC[29] (figura 18), tal y como se describe en uno de los artículos de soporte de esta tesis doctoral[108].

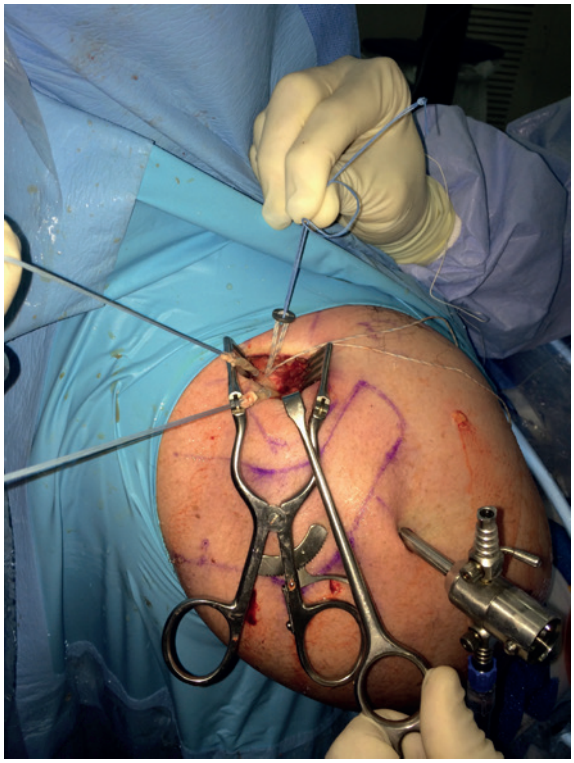


Figura 18. Fotografía intraoperatoria de hombro derecho desde perspectiva posterosuperior, en la cual se pueden apreciar detalles técnicos del tratamiento de la inestabilidad acromioclavicular crónica,

mediante reconstrucción coracoclavicular anatómica con aloinjerto tendinoso. Nótese como a través del túnel clavicular del ligamento conoide, se pasa un dispositivo de suspensión coracoclavicular, con el objetivo de actuar como fijación coracoclavicular mecánica primaria, y así proteger la reconstrucción hecha con la plastia mientras tiene lugar el proceso de integración a los túneles óseos.

2.8 Complicaciones en el manejo quirúrgico de la inestabilidad acromioclavicular

El perfil de complicaciones que se pueden esperar durante el manejo de la inestabilidad AC, dependerá de si la reconstrucción se realiza en fase aguda o crónica, del tipo de fijación, y de si la reconstrucción se realiza de forma abierta o asistida por artroscopia. En cuanto a la tasa de infecciones, una revisión sistemática de la literatura describe que la tasa global de infecciones superficiales oscila en torno a un 3.8% para los procedimientos artroscópicos[116], en comparación con una tasa de un 5% para procedimientos realizados mediante cirugía abierta[116]; y hasta un 8% en aquéllos procedimientos en los que se empleó un injerto tendinoso[103,117]. La tasa de fracasos de fijación tras el manejo con injerto tendinoso de la inestabilidad AC crónica se ha descrito que ronda el 50% o más[116,118]; mientras que la tasa de fracaso de la fijación tras el manejo de la inestabilidad AC aguda oscila en torno al 26.8%[116]. Se ha reportado que estas diferencias pueden obedecer al hecho de que las plastias tendinosas tienden a elongarse con el paso del tiempo, además de que tienden a emular un efecto "parabrisas" a nivel de los túneles claviculares, situación que finalmente termina suponiendo el ensanchamiento de los túneles[119]. En cuanto a la incidencia de fracturas a nivel de la coracoides, se ha reportado que la tasa global (tanto para técnicas mono-túnel como para técnicas doble-túnel) oscila en torno al 5.3%[116].

2.9 Manejo no quirúrgico de la inestabilidad acromioclavicular

Gumina *et al*. han descrito que la prevalencia de discinesia escapular en pacientes con inestabilidad AC crónica Rockwood grado III puede ser de hasta un 70.6%[120], y que la prevalencia de SICK escápula[121] (Scapular malposition, Inferior medial border prominence, Coracoid pain and malposition, and dysKinesis of scapular movement) puede ser de hasta un 58.3%[120]. Los pacientes con este síndrome pueden referir omalgia anterior a nivel de la coracoides, dolor escapular posterosuperior a veces con irradiación a la región paravertebral cervical y a la cara lateral del brazo, dolor a nivel de la articulación AC e incluso síntomas radiculares.

Carbone *et al*. propusieron un protocolo de rehabilitación para los pacientes con discinesia escapular[122]. Dicho protocolo consta de 12 ejercicios de potenciación de la escápula. Los autores describen una serie de 24 pacientes con antecedente de inestabilidad AC crónica grado III, en la que un 100% (24/24) tenían discinesia escapular y 58.33% (14/24) tenían SICK escápula[122]. Tras 12 meses de haber finalizado el protocolo de rehabilitación propuesto por los autores, 21.73% (5/23) presentaban aún discinesia escapular y 17.4% (4/23) aún presentaban SICK escápula. Dichos autores concluyen que, si el protocolo de rehabilitación está siendo eficaz, la remisión de la discinesia escapular y de la SICK escápula secundarias a la inestabilidad AC crónica, tendría que hacerse evidente tras 6 semanas de haber iniciado el protocolo de rehabilitación propuesto.

3

HIPÓTESIS DE TRABAJO

3 Hipótesis de trabajo

Las hipótesis de trabajo de esta tesis doctoral se basan en cinco estudios relacionados con el tratamiento de las luxaciones AC agudas de alto grado (Rockwood III-V), y con la reconstrucción de los ligamentos CC.

El primer estudio (Natera Cisneros LG, Sarasquete Reiriz J. Acute high-grade acromioclavicular joint injuries: quality of life comparison between patients managed operatively with a hook plate versus patients managed non-operatively. Eur J Orthop Surg Traumatol. 2017;27(3):341-350. doi: 10.1007/s00590-016-1862-z.) compara la calidad de vida de los pacientes con antecedente de luxación AC aguda de alto grado tratada quirúrgicamente con placa gancho versus la calidad de vida de los pacientes tratados de forma conservadora, 24 meses o más después de haberse producido la lesión.

Seguidamente se presenta el segundo trabajo (Natera-Cisneros L, Sarasquete-Reiriz J, Escolà-Benet A, Rodriguez-Miralles J. Acute high-grade acromioclavicular joint injuries treatment: Arthroscopic non-rigid coracoclavicular fixation provides better quality of life outcomes than hook plate ORIF. Orthop Traumatol Surg Res. 2016;102(1):31-9. doi: 10.1016/j.otsr.2015.10.007.), el cual compara la calidad de vida de los pacientes con antecedente de luxación AC aguda de alto grado tratados con placa gancho versus la calidad de vida de los pacientes tratados artroscópicamente mediante fijación CC no rígida con dispositivo de suspensión, 24 meses o más después de la cirugía.

El tercer trabajo (Abat F, Sarasquete J, Natera LG, Calvo Á, Pérez-España M, Zurita N, Ferrer J, del Real JC, Paz-Jimenez E, Forriol F. Biomechanical analysis of acromioclavicular joint dislocation repair using coracoclavicular suspension devices in two different configurations. J Orthop Traumatol. 2015;16(3):215-9. doi: 10.1007/s10195-015-0346-y.) evalúa el comportamiento biomecánico vertical de dos técnicas de reconstrucción anatómica de los ligamentos CC con dispositivos de suspensión no rígidos.

El cuarto trabajo (Natera Cisneros L, Sarasquete Reiriz J. Unstable acromioclavicular joint injuries: Is there really a difference between surgical management in the acute or chronic setting? J Orthop. 2016;14(1):10-18.) proporciona evidencias sobre los resultados clínicos y radiológicos de las luxaciones AC de alto grado tratadas mediante reconstrucción anatómica de los ligamentos CC asistida por artroscopia, tanto en fase aguda como en fase crónica.

Por último se presenta el quinto trabajo (Cisneros LN, Reiriz JS. Prevalence of remaining horizontal instability in high-grade acromioclavicular joint injuries surgically managed. Eur J Orthop Surg Traumatol. 2017;27(3):323-333. doi: 10.1007/s00590-016-1898-0.) el cual determina la prevalencia de inestabilidad horizontal remanente en luxaciones AC de alto grado que han sido tratadas quirúrgicamente, y evalúa la relación de la inestabilidad horizontal con los resultados clínicos.

Hipótesis trabajo 1

Los pacientes con historia de luxación AC de alto grado que han sido tratados de forma conservadora presentan resultados clínicos comparables a los de los pacientes que han sido tratados quirúrgicamente mediante fijación AC con placa gancho.

Hipótesis trabajo 2

Los pacientes con historia de luxación AC de alto grado que han sido tratados artroscópicamente con una fijación CC no rígida presentan resultados clínicos superiores a los de los pacientes tratados mediante fijación AC con placa gancho.

Hipótesis trabajo 3

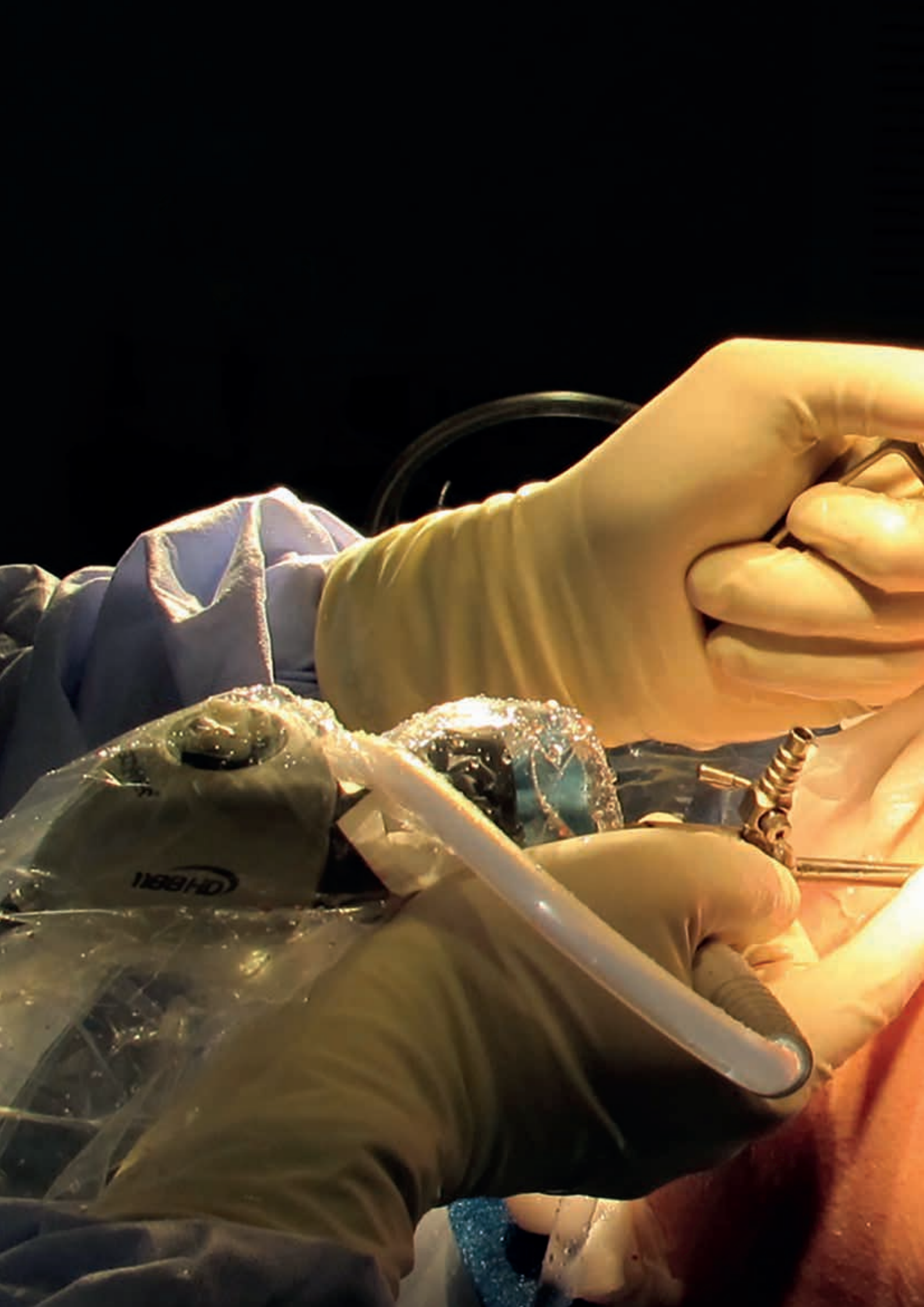
La reconstrucción CC anatómica con 2 dispositivos de suspensión no rígidos, con doble túnel tanto en la apófisis coracoides como en la clavícula, ofrece una resistencia biomecánica similar a la del complejo CC nativo.

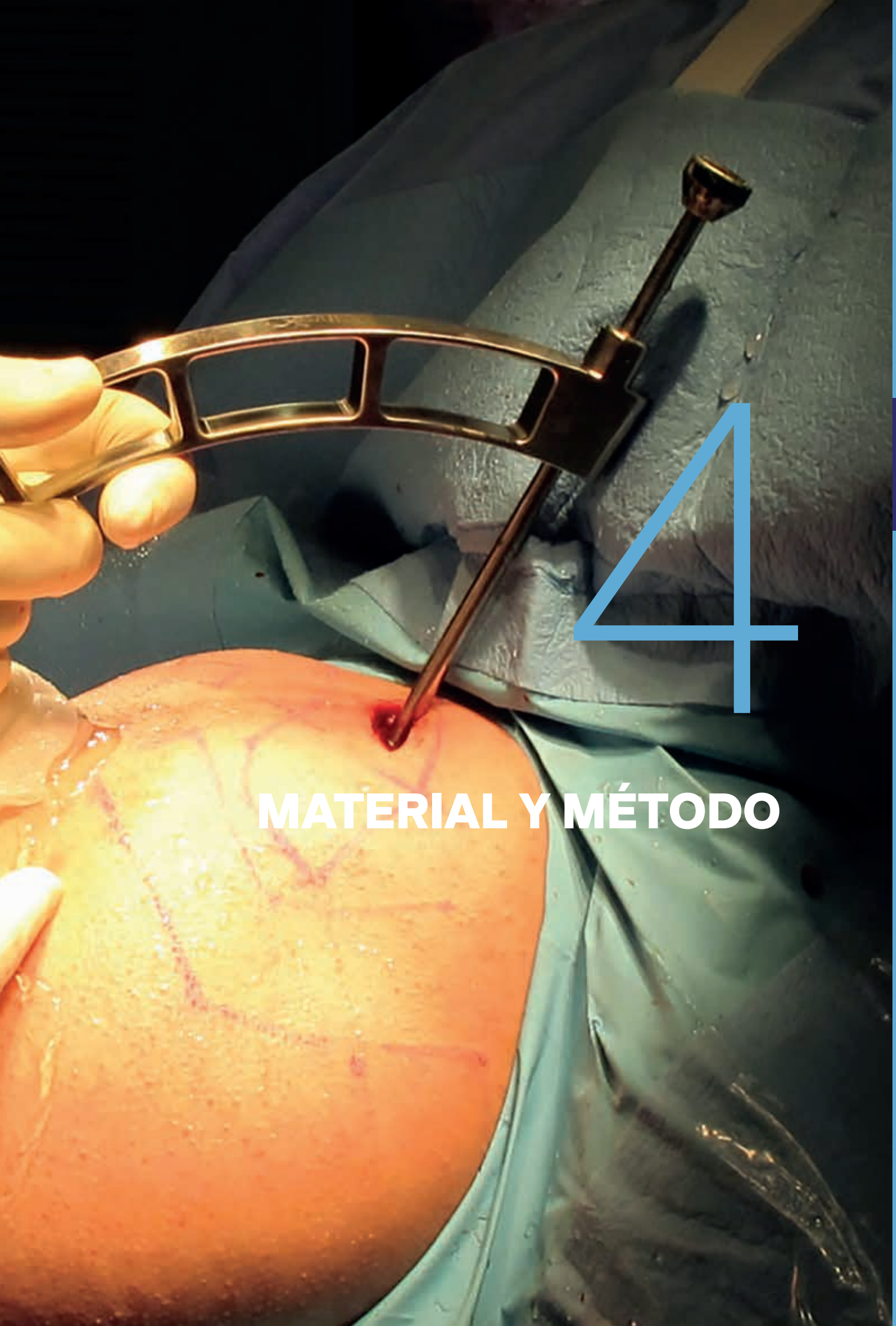
Hipótesis trabajo 4

Los pacientes con historia de luxación AC de alto grado que han sido tratados mediante reconstrucción anatómica de los ligamentos CC con 2 dispositivos de suspensión implantados en fase aguda, tienen resultados clínicos similares a los de los pacientes que han sido tratados mediante reconstrucción anatómica de los ligamentos CC con aloinjerto tendinoso más dispositivo de suspensión, realizada en fase crónica.

Hipótesis trabajo 5

La inestabilidad AC horizontal posquirúrgica remanente está relacionada con peores resultados clínicos.





4

MATERIAL Y MÉTODO

4. Material y método

El apartado material y método de esta tesis doctoral se corresponde con lo desarrollado en cada uno de los trabajos de investigación que la conforman. La población estudiada se obtuvo a partir de los registros clínicos de 3 instituciones diferentes. Los estudios clínicos de esta tesis doctoral, son retrospectivos con recogida prospectiva de los datos.

Los trabajos 1, 2, 4 y 5 de análisis clínico, se realizaron a partir de la información clínica y radiológica de cinco grupos de pacientes. Pacientes tratados de forma conservadora, pacientes tratados mediante fijación AC con placa gancho, pacientes tratados mediante fijación CC con 1 dispositivo de suspensión, pacientes tratados mediante fijación CC con 2 dispositivos de suspensión, y pacientes tratados mediante reconstrucción CC con aloinjerto tendinoso más dispositivo de suspensión. En el trabajo número 1 se comparan el grupo tratado de forma conservadora y el grupo tratado mediante fijación AC con placa gancho; en el trabajo número 2 se comparan el grupo tratado mediante fijación AC con placa gancho y el grupo tratado mediante fijación CC con 1 dispositivo de suspensión; en el trabajo número 4 se compara el grupo tratado mediante fijación CC con 2 dispositivos y el grupo tratado mediante reconstrucción CC con aloinjerto tendinoso mas 1 dispositivo; y en el trabajo número 5 se agrupan todos los pacientes tratados de forma quirúrgica, y dicho grupo se subdivide según hubiese o no evidencia de inestabilidad horizontal posquirúrgica remanente.

Tomando en cuenta que metodología científica de los trabajos 1, 2, 4 y 5 es similar, siete de los apartados del material y método fueron comunes entre ellos, con lo que se agrupan a continuación:

Instrumentos de medición de la calidad de vida percibida por los pacientes

Los cuestionarios aplicados en la última visita de seguimiento fueron:

(a) El SF36, físico y mental,

(b) La escala visual analógica (EVA) del hombro lesionado: ''0'' corresponde a ''no dolor'' y ''10'' corresponde a ''el peor dolor imaginable''.

(c) El cuestionario de “Disabilities of the arm, shoulder and hand” (DASH),

(d) El test de Constant, y

(e) La escala ''Satisfacción General” (escala de calificación numérica de 0 a 10; 0, no satisfecho con el tratamiento y 10, completamente satisfecho con los resultados del tratamiento).

La última visita de seguimiento de todos los pacientes que fueron intervenidos quirúrgicamente, se llevó a cabo 24 meses o más después de la cirugía; y en el grupo de pacientes que fueron tratados de forma conservadora, la última visita de seguimiento se realizó 24 meses o más después de haberse producido la lesión.

Clasificación del grado de inestabilidad acromioclavicular según Rockwood

La clasificación e interpretación de la magnitud de la lesión, se realizó tras la observación de la radiología realizada en la primera visita de seguimiento, posterior a la lesión. El examen clínico en el contexto agudo no se consideró para estadificar la clasificación. Se realizaron radiografías de ambos hombros en todos los pacientes. El protocolo radiográfico incluyó en todos los casos: proyección anteroposterior (AP) estricta de ambos hombros, proyección de Zanca (ambos hombros) y

proyección axilar (solamente del hombro lesionado). La proyección en perfil de escápula con aducción forzada (proyección de Alexander o Basamania) se realizó en todos los pacientes, excepto en el grupo que fue tratado quirúrgicamente mediante placa gancho (dicha proyección no estaba incluida en el protocolo radiográfico de la institución en la que este grupo de pacientes fue tratado). Por dicho motivo, la clasificación de Rockwood de las luxaciones AC no pudo ser actualizada, tal y se realizó previamente en una de las publicaciones de nuestro grupo de estudio[12], de acuerdo con la diversificación de la clasificación propuesta en 2014 por ISAKOS[69]. En todos los pacientes se realizaron proyecciones axilares con el paciente en decúbito prono, y la abducción del hombro necesaria para la realización de la radiografía, se realizó de forma pasiva mediante manipulación por el técnico realizador.

Las luxaciones AC grado III y grado V, se diferenciaron entre sí de acuerdo con la clasificación tradicional de Rockwood[35]. Un grado III si la distancia CC del hombro lesionado se incrementó entre el 25 y el 100% en comparación con el hombro no lesionado; y un grado V si la distancia CC del hombro lesionado se incrementó entre 100 y 300% en comparación con el hombro no lesionado[69]. Estas estimaciones se realizaron en proyecciones radiográficas de Zanca. El diagnóstico de las luxaciones AC Rockwood grado IV se realizó mediante observación en la proyección axilar, de un desplazamiento posterior de la clavícula en relación con el acromion[35]. En el trabajo número 4, la clasificación de Rockwood si que pudo actualizarse en función de las radiografías realizadas en la primera visita de seguimiento, y de acuerdo a lo propuesto por ISAKOS[69], tal y como lo habíamos hecho previamente[12]. Las luxaciones AC Rockwood IIIB fueron aquellas en las que hubo evidencia de solapamiento del tercio distal de la clavícula sobre el acromion en la proyección de Alexander[69].

Toma de decisiones sobre el tratamiento

No se realizó aleatorización en ninguno de los grupos de tratamiento. La muestra estuvo conformada por todos los pacientes que durante el período de cada estudio, cumplieron con los criterios de inclusión específicos de cada uno de los trabajos. La indicación de tratamiento quirúrgico se basó en todos los estudios, en la magnitud radiológica del desplazamiento entre la clavícula y el acromion. En aquellos pacientes con el doble de distancia CC a nivel del hombro lesionado con respecto al hombro sano, se concluyó que había rotura de los ligamentos CC y disrupción de la fascia deltotrapezoidea[5,29,107]. Los pacientes con luxaciones AC agudas Rockwood grado IV-V fueron

informados respecto a las recomendaciones aceptadas en relación al manejo quirúrgico en este tipo de lesiones[123]; y los pacientes con luxaciones AC Rockwood grado III fueron informados de la ausencia de evidencia científica categórica con respecto a la indicación de tratamiento, y de las recomendaciones de tratamiento quirúrgico en pacientes activos con altas demandas funcionales a nivel del hombro[123].

Los trabajos clínicos de esta tesis doctoral (trabajos 1, 2, 4 y 5) incluyeron pacientes con luxaciones AC de alto grado, tratados en 3 instituciones diferentes. Tanto los pacientes tratados de forma conservadora, como los pacientes tratados quirúrgicamente con asistencia artroscópica, fueron controlados e intervenidos por el mismo cirujano de hombro (JS) de 2 de estas 3 instituciones. El grupo de pacientes con luxaciones AC de alto grado del trabajo número 1 tratados de forma conservadora, se conformó por los pacientes que prefirieron no ser intervenidos quirúrgicamente, a pesar de que fueron informados sobre las recomendaciones de tratamiento internacionalmente aceptadas para este tipo de lesiones. El grupo de pacientes tratados mediante fijación AC con placa gancho, fue conformado por individuos con luxaciones AC agudas de alto grado, tratadas por la unidad de traumatología general de la tercera institución. Las cirugías realizadas en este grupo de pacientes se llevaron a cabo por varios cirujanos.

En los trabajos 2, 4 y 5, se incluyeron pacientes con luxaciones AC agudas de alto grado tratadas artroscópicamente por la unidad de hombro de dos de las tres instituciones. El grupo tratado mediante fijación CC con 1 dispositivo de suspensión implantado artroscópicamente, incluyó pacientes tratados entre enero de 2008 y enero de 2012; mientras que el grupo de pacientes tratados mediante fijación CC con 2 dispositivos de suspensión implantados artroscópicamente, incluyó individuos manejados entre febrero de 2012 y enero 2013. El protocolo de tratamiento de estas dos instituciones evolucionó en el año 2012. Hasta ese momento las luxaciones AC agudas de alto grado eran tratadas quirúrgicamente con 1 dispositivo de suspensión, y a partir de 2012 se empezaron a tratar con 2 dispositivos de suspensión con disposición anatómica. La adición de un segundo dispositivo de suspensión CC tuvo como objetivo reducir la tasa de desplazamientos secundarios.

El grupo de pacientes tratados mediante reconstrucción CC anatómica con aloinjerto tendinoso más dispositivo de suspensión (trabajos 4 y 5), incluyó individuos con luxaciones AC crónicas de alto grado. Este grupo de pacientes inicialmente rechazó el tratamiento quirúrgico en fase aguda, y

el tratamiento quirúrgico se indicó una vez que se consideró que el tratamiento conservador había fracasado. Todos estos pacientes fueron controlados por el mismo cirujano ortopédico. Ninguno de los individuos de este grupo de pacientes tratados en fase crónica fue obtenido del grupo de pacientes tratado de forma conservadora incluido en el trabajo 1 de esta tesis doctoral.

Las luxaciones AC se consideraron agudas si la decisión para el tratamiento quirúrgico se tomó dentro de las primeras tres semanas después de producida la lesión; y crónicas, si la decisión se tomó después de haber pasado tres semanas tras producida la lesión[123].

El grupo de pacientes tratados mediante fijación AC con placa gancho, fue informado de que la placa tendría que extraerse 12 -16 semanas después de la implantación. Los pacientes tratados mediante cirugía artroscópica fueron informados de la posibilidad de requerir un tratamiento concomitante de posibles lesiones glenohumerales que fueran diagnosticadas durante el procedimiento.

Período de rehabilitación posterior al tratamiento

En todos los pacientes incluidos en los trabajos clínicos de esta tesis doctoral (trabajos 1, 2, 4 y 5) se indicó inmovilización con cabestrillo del hombro lesionado durante 3-4 semanas (después de la cirugía en los pacientes intervenidos quirúrgicamente, y una vez decidido el tratamiento conservador en los pacientes tratados no quirúrgicamente). La movilización activa del codo, muñeca y mano se inició de forma inmediata. Los movimientos pendulares del hombro se indicaron tras la primera semana post tratamiento en todos los pacientes. A los pacientes tratados mediante fijación con placa gancho se les inició movilización pasiva del hombro a no más de 90° de elevación en el plano de la escápula después de la primera semana, y a los pacientes tratados mediante reconstrucción de los ligamentos CC (tanto en fase aguda como en fase crónica) la movilización pasiva se les indicó a partir de la tercera semana tras la intervención. La fase de movilización activa progresiva se indicó a partir de la sexta semana en adelante en todos los pacientes. Los ejercicios para recuperar la fuerza se iniciaron una vez que el paciente tenía un rango de movimiento pasivo y activo completo, sin dolor, y los ejercicios se enfocaron principalmente en el fortalecimiento de la musculatura periescapular. La vuelta al trabajo sin restricciones se autorizó una vez transcurridas 12-14 semanas, y se evitaron los deportes de contacto o los esfuerzos importantes durante 4-6 meses en los pacientes tratados de forma quirúrgica (en el grupo de pacientes tratados me-

diante placa gancho, después de la extracción de la placa), y en el grupo de pacientes tratados de forma conservadora los esfuerzos físicos se autorizaron una vez que el hombro se encontraba completamente asintomático.

Protocolo radiográfico realizado en la última visita de seguimiento

Se realizaron radiografías de ambos hombros. El protocolo de proyecciones radiográficas fue el mismo que se contempló en la primera visita del seguimiento: proyección anteroposterior (AP) estricta de ambos hombros, proyección de Zanca (ambos hombros), proyección axilar (solamente del hombro lesionado) y proyección de Alexander. Se evaluó la presencia o no de inestabilidad AC vertical remanente. Para los fines de este estudio, en el grupo de pacientes tratados mediante placa gancho, estas evaluaciones radiográficas se realizaron una vez retirado el implante. La inestabilidad AC vertical remanente se valoró en proyecciones de Zanca bilaterales. En los pacientes que fueron tratados quirúrgicamente, el desarrollo de desplazamiento vertical secundario se evaluó radiológicamente de acuerdo con la clasificación modificada de Rosenørm y Pedersen[6]. La articulación AC se consideró reducida cuando no se registró desplazamiento en comparación con el lado no lesionado, subluxada cuando había menos de 50% de desplazamiento de la clavícula en relación con la altura caudo-craneal del acromion, y completamente luxada si el desplazamiento superior de la clavícula representaba más del 50% de la altura del acromion[6]. No se midió la distancia CC.

En todos los grupos de pacientes se evaluó el desarrollo de artrosis AC, la presencia de calcificaciones de los ligamentos CC, y el desarrollo de osteolisis del tercio distal de la clavícula.

En el trabajo número 5, la inestabilidad horizontal posquirúrgica remanente se evaluó mediante la observación del solapamiento o no del tercio distal de la clavícula por sobre el acromion en las radiografías de Alexander realizadas en la última visita de seguimiento; y/o mediante observación en la proyección axilar, de alineación o no del borde anterior del acromion y el borde anterolateral de la clavícula distal.

Eventos adversos relacionados con el tratamiento y complicaciones

La presencia o no de discinesia escapular se evaluó en la última visita de seguimiento, por medio del método "si / no" descrito por el grupo de Kibler[124]. Este método consiste en la valoración del movimiento escapular por parte del explorador cuando el paciente realiza flexión anterior activa del hombro. Dicho método supone una simplificación de los cuatro tipos de discinesia escapular descritos previamente por el mismo grupo de Kibler[125], y simplifica los tipos I-III de discinesia en una sola categoría de "sí" (presencia de discinesia), y el tipo IV se cataloga como "no" (movimiento escapular normal). Se buscó en los registros clínicos el desarrollo de complicaciones perioperatorias.

Análisis estadístico

En ninguno de los estudios de esta tesis doctoral se realizó una estimación previa del tamaño de la muestra. En todos los artículos, la muestra estuvo conformada por todos los pacientes de los períodos de estudio que cumplieron con los criterios de inclusión.

Las variables continuas se presentan como media y desviación estándar, o media y rango. Las variables categóricas se presentan como porcentajes y frecuencias. La relación entre las variables categóricas se analizó con tablas de contingencia, y la inferencia se estudió con la prueba de Chi cuadrado o la prueba exacta de Fisher según lo que correspondiese. El “T test” o el “Mann-Whitney U test” se utilizaron para analizar variables cuantitativas en 2 grupos de tratamiento, y el análisis de la varianza (ANOVA) se empleó para analizar variables cuantitativas cuando habían más de dos grupos a comparar. Las comparaciones entre los diferentes tratamientos se realizaron solo con respecto al hombro lesionado. No se realizaron comparaciones entre la función de los hombros lesionados y los hombros ilesos.

En el trabajo número 4, se calculó la mediana con rango intercuartílico (percentil 25 al 75). En el trabajo número 5, los pormenores estadísticos serán reflejados de forma independiente. El nivel de significación se estableció en 5% (α=0.05). Los datos se analizaron mediante el uso de SPSS 19 (SPSS Inc., Chicago, IL).

TRABAJO n.1: Natera Cisneros LG, Sarasquete Reiriz J. Acute high-grade acromioclavicular joint injuries: quality of life comparison between patients managed operatively with a hook plate versus patients managed non-operatively. Eur J Orthop Surg Traumatol. 2017;27(3):341-350. doi: 10.1007/s00590-016-1862-z

Diseño del estudio

Se realizó un estudio de cohortes retrospectivo en tres hospitales de tercer nivel. Se incluyeron pacientes diagnosticados de luxaciones AC de alto grado (Rockwood grado III-V) tratados quirúrgicamente (reducción abierta y fijación interna con placa gancho) y tratados de forma conservadora, mediante rehabilitación basada en fortalecimiento de la musculatura periescapular. Todos los pacientes dieron su consentimiento informado por escrito, y accedieron a que la información de sus historias clínicas pudiera ser utilizada para los propósitos de esta investigación.

Población

La población de estudio se obtuvo a partir de las bases de datos de estudios previamente publicados por nuestro grupo[12,126]. Con respecto a las radiografías que se realizaron en la última visita de seguimiento en el grupo de pacientes que fueron tratados de forma conservadora, se contó con la aprobación del Comité de Ética del Hospital de la Santa Creu i Sant Pau (código: IIBSP-ROT-2014-003). Dicho documento se encuentra anexado en la sección de apéndices al final de esta tesis.

Se revisaron todos los registros de las historias clínicas electrónicas de estas tres instituciones, codificados como "luxación AC" entre el 1 de enero de 2008 y el 31 de enero de 2012. Los pacientes se incluyeron en el estudio siguiendo estos criterios: (a) cualquier sexo; (b) diagnóstico radiográfico de luxación AC de alto grado (grado III-V de Rockwood) en la radiología realizada en la primera visita posterior a la lesión; (c) con edad comprendida entre 18 y 55 años de edad en el momento de producción de la lesión; (d) tratados quirúrgicamente mediante reducción abierta y fijación interna con placa gancho (grupo-GANCHO) ó; (e) conservadoramente (grupo-CONS); (f) con una historia clínica y un examen radiológico completo y disponible en el momento de revisión de los registros; y (g) con un seguimiento mínimo de 24 meses después del tratamiento. Los criterios de exclusión fueron: (a) tratamiento quirúrgico realizado 3 semanas después de la lesión AC (que se acepta

como el punto de corte para diferenciar las lesiones agudas de las crónicas[12]), (b) historia de lesiones previas en el hombro en cuestión y (c) técnicas quirúrgicas diferentes a la fijación AC con placa gancho. Para los efectos de esta revisión, la información sobre los pacientes del grupo-CONS se obtuvo a partir de otro estudio realizado por nuestro grupo de investigación[12]. Se compararon los resultados clínicos y radiológicos de ambos grupos.

Tratamiento

Técnica quirúrgica. Grupo-GANCHO

Se realizó un abordaje anterior estándar a la clavícula. Se expuso la luxación AC y se redujo bajo visualización directa. Se utilizaron placas gancho (Synthes, West Chester, EE. UU.) En todos los pacientes. El gancho se pasó por debajo del acromion y luego se aplicó la placa a la clavícula. Las placas se fijaron a la clavícula con cuatro o cinco tornillos de cortical de 3.5mm. La reducción y la fijación se verificaron con fluoroscopia. La fascia deltotrapezoidea se suturó cuidadosamente para garantizar una cobertura apropiada de la placa. La piel se cerró con grapas en todos los casos.

El tratamiento del grupo-CONS consistió en la inmovilización del brazo del hombro lesionado mediante un cabestrillo hasta la remisión del dolor agudo, antiinflamatorios y fisioterapia con protocolo estandarizado basado en la estabilización escapular.

TRABAJO n.2: Natera-Cisneros L, Sarasquete-Reiriz J, Escolà-Benet A, Rodriguez-Miralles J. Acute high-grade acromioclavicular joint injuries treatment: Arthroscopic non-rigid coracoclavicular fixation provides better quality of life outcomes than hook plate ORIF. Orthop Traumatol Surg Res. 2016;102(1):31-9. doi: 10.1016/j.otsr.2015.10.007.

Diseño del estudio

Se realizó un estudio de cohortes retrospectivo en tres hospitales de tercer nivel. Se incluyeron pacientes diagnosticados de luxaciones AC de alto grado (Rockwood grado III-V) tratados quirúrgicamente mediante una fijación CC no rígida con 1 dispositivo de suspensión, implantado mediante

asistencia artroscópica; y los pacientes tratados mediante reducción abierta y fijación interna con placa gancho. Todos los pacientes dieron su consentimiento informado por escrito, y accedieron a que la información de sus historias clínicas pudiera ser utilizada para los propósitos de esta investigación.

Población de estudio

El grupo de pacientes tratados mediante fijación CC no rígida con 1 dispositivo de suspensión se obtuvo a partir de la base de datos de un estudio publicado previamente por nuestro grupo de investigación[12]. Todos los registros de las historias clínicas de estas tres instituciones, codificadas como "luxaciones AC" entre el 1 de enero de 2008 y el 31 de enero de 2012 fueron revisados. Los pacientes se incluyeron en el estudio siguiendo estos criterios de inclusión: (a) cualquier sexo; (b) diagnóstico radiográfico de luxación AC de alto grado (grado III-V de Rockwood) en la radiología realizada en la primera visita posterior a la lesión; (c) con edad comprendida entre 18 y 55 años de edad en el momento de producción de la lesión; (d) tratados quirúrgicamente mediante una fijación CC no rígida con 1 dispositivo de suspensión, implantado mediante asistencia artroscópica (grupo-ARTRO) ó; (e) mediante reducción abierta y fijación interna con placa gancho (grupo-GANCHO); (f) con una historia clínica y un examen radiológico completo y disponible en el momento de revisión de los registros; y (g) con un seguimiento mínimo de 24 meses después del tratamiento; (h) operado dentro de las primeras tres semanas después de producida la lesión.

Los criterios de exclusión fueron: (a) diagnóstico de luxación AC Rockwood grado I-II; (b) tratamiento quirúrgico realizado 3 semanas después de la lesión AC (que se acepta como el punto de corte para diferenciar las lesiones agudas de las crónicas[28]), (c) lesiones previas en el hombro en cuestión; y (d) técnicas quirúrgicas diferentes a la fijación con placa gancho o fijación CC no rígida con 1 dispositivo de suspensión implantado mediante asistencia artroscópica.

Se contactó a los pacientes que cumplían con estos criterios de elegibilidad, y se les propuso su inclusión en el estudio. Una vez que los pacientes aceptaron, firmaron un consentimiento informado. En la última visita de seguimiento (visita de recogida prospectiva de datos) se registró la información clínica (cuestionarios) y radiológica.

En este trabajo, los ítems del test de Constant (rango de movimiento, fuerza y grado de limitación) se han estratificado y se presentan por separado. Con la finalidad de poder hacer diferencias dicotómicas entre grupos; al momento de analizar el grado de limitación según lo establecido en el test de Constant; las limitaciones "graves" y "moderadas" fueron agrupadas en una sola categoría ("sí"), y el grado de limitación “no o sutilmente” se estableció como (“no”). Sin embargo, a los efectos de calcular el puntaje de Constant en sí mismo, estos elementos se consideraron según lo descrito por los autores que definieron dicho cuestionario[127].

Tratamiento quirúrgico. Grupo-ARTRO

Esta técnica de fijación CC isométrica con 1 solo dispositivo ha sido descrita previamente por nuestro grupo de trabajo[12]. Los pacientes fueron colocados en posición de silla de playa, tras realización de bloqueo interescalénico y anestesia general. El brazo se fijó a un soporte mecánico con el hombro elevado a 45-50° y con 2-3kg de tracción. Se utilizaron tres portales artroscópicos estándar: posterior, anterolateral y lateral. Se realizó una valoración glenohumeral inicial con el fin de diagnosticar lesiones concomitantes. Con visión artroscópica lateral, se realizó exeresis de la bursa subacromial a través del portal anterolateral para así visualizar el ligamento coracoacromial (CA). Esta estructura fue seguida hasta su origen en la base de la coracoides. Se realizó una limpieza de la superficie inferior de la base de la coracoides. Posteriormente se realizó una incisión de 3cm, en la porción superior de la clavícula, y en dirección perpendicular al eje axial de la misma. Bajo visualización artroscópica directa se apoyó la guía AC en la porción inferior de la base de la coracoides cerca de la pared de la escápula; y el tubo deslizante de la guía se ubicó en la parte superior de la clavícula con un ángulo de 80-90° en el centro de lo que deberían ser los orígenes nativos de los ligamentos CC (reconstrucción isométrica), 3cm medial al borde lateral de la clavícula[12,88]. Se pasó una aguja de Kirschner (AK) de 2.4mm de diámetro a través de la guía AC, desde la clavícula hasta la coracoides, y posteriormente el túnel isométrico se hizo sobre la AC con una broca canulada de 4.5mm. Se retiró la AK, y se dejó la broca canulada. Se introdujo una sutura monofilamento transportadora a través de la broca canulada desde la porción clavicular del túnel, y se recuperó desde el portal anterior. A la sutura transportadora se le anudó una sutura de alta resistencia en su extremo caudal. Se tiró de la porción superior de la sutura transportadora en dirección craneal, y así se intercambió la sutura monofilamento por una sutura de alta resistencia. Con cuidado de no dañar la sutura de alta resistencia, se procedió a retirar la broca canulada. El dispositivo de suspensión

CC (TightRope, Arthrex, Inc., Naples, Florida, EE. UU.) se anudó al extremo caudal de la sutura de alta resistencia, y se introdujo de forma retrógrada desde la coracoides hasta la clavícula. El flip de titanio se apoyó en la base de la apófisis coracoides, y el botón en la parte superior de la clavícula. La articulación AC se redujo manualmente por los ayudantes, empujando el codo hacia arriba y la clavícula hacia abajo al mismo tiempo. Se tiró de las suturas del sistema de forma alternativa, hasta que la arandela clavicular se bloqueó. La reducción AC se confirmó mediante visualización directa y palpación. La fascia deltotrapezoidea se suturó cuidadosamente para asegurar la reducción. Se suturó la piel y se colocó un cabestrillo inmovilizador.

La técnica quirúrgica detallada y con ilustraciones gráficas, que contempla la colocación de 2 dispositivos de suspensión, se encuentra contemplada en uno de los artículos de soporte de esta tesis doctoral[107].

Técnica quirúrgica. Grupo-GANCHO

Esta técnica ya ha sido descrita en el trabajo 1.

TRABAJO n.3: Abat F, Sarasquete J, Natera LG, Calvo Á, Pérez-España M, Zurita N, Ferrer J, del Real JC, Paz-Jimenez E, Forriol F. Biomechanical analysis of acromioclavicular joint dislocation repair using coracoclavicular suspension devices in two different configurations. J Orthop Traumatol. 2015;16(3):215-9. doi: 10.1007/s10195-015-0346-y.

Se emplearon 18 hombros cadavéricos humanos (9 hombres, 9 mujeres) de individuos con una edad media de 58 años (rango 41-63) al momento del fallecimiento. En ninguno de los especímenes estudiados constaba historia de traumatismo AC. Las piezas fueron almacenadas a -20° C y posteriormente preparadas antes de iniciar estudio. Se seccionaron los hombros y se extirparon los tejidos blandos, esqueletizando todo el complejo osteoligamentario, hasta obtener una articulación AC con los ligamentos AC intactos, y una escápula con los ligamentos CC intactos. Posteriormente se seccionaron los ligamentos AC en todos los especímenes, y en los especímenes en los que se iba

a reconstruir el complejo CC, se seccionaron selectivamente los ligamentos CC nativos con bisturí.

Se formaron tres grupos: grupo I (n = 6), grupo control (ligamentos CC nativos); grupo II (n = 6), reconstrucción CC con doble túnel tanto a nivel de la clavícula como a nivel de la coracoides (con dos dispositivos de suspensión CC); grupo III (n = 6), reconstrucción en configuración de ''V'' con dos túneles en la clavícula y uno en la coracoides (con un dispositivo de suspensión CC). En todos los casos de los grupos II y III se utilizó el dispositivo de suspensión CC ZipTight (Biomet, Varsovia, IN, EE. UU.).

Técnicas de reconstrucción

Para la reconstrucción CC de los especímenes del grupo II, se realizaron 2 túneles a nivel de la clavícula y otros 2 túneles a nivel de la base de la apófisis coracoides, en las posiciones anatómicas de los ligamentos CC nativos (4.5cm hacia medial desde el extremo acromial de la clavícula para túnel del ligamento conoide y 2.5cm para el trapezoide[23,25,26,35,128]). Se realizó una reconstrucción anatómica individualizada tanto del ligamento conoide como del trapezoide (figuras 19 y 20).

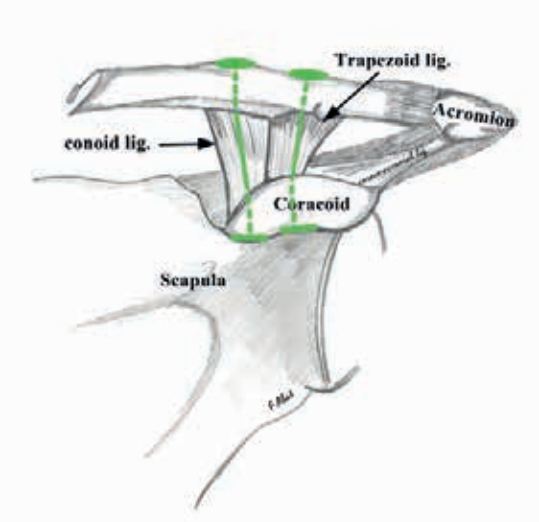


Figura. 19. Ilustración de la reconstrucción anatómica del conoide y del trapezoide con dos dispositivos de suspensión CC, con doble túnel tanto en clavícula como en coracoides.

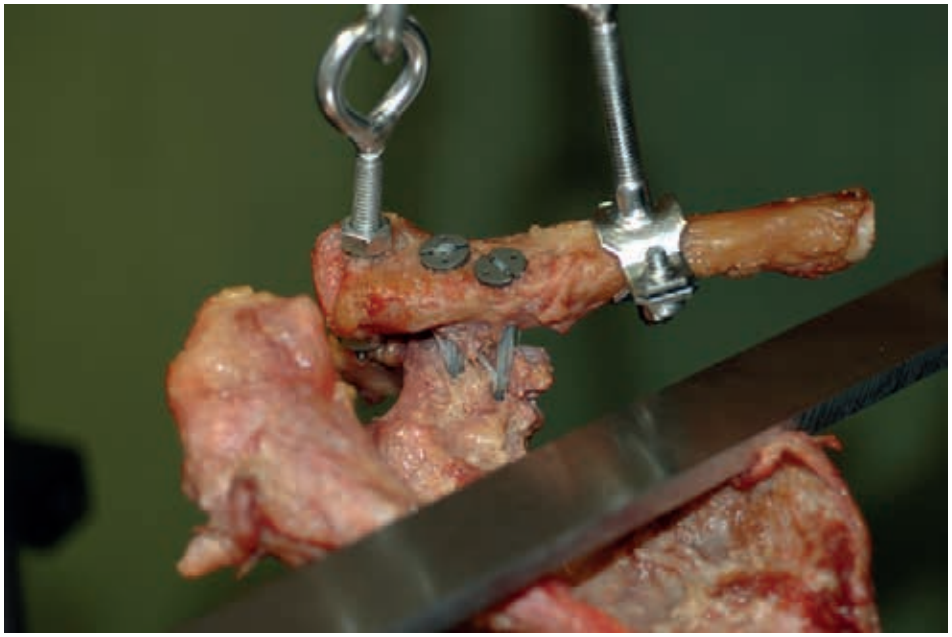


Figura 20. Fotografía realizada desde perspectiva anterior, de la realización de la reconstrucción anatómica del conoide y el trapezoide con 2 dispositivos de suspensión, en un hombro derecho del grupo II.

Para la reconstrucción CC de los especímenes del grupo III, se utilizó una configuración en “V” del dispositivo de suspensión (figura 21). Se realizaron 2 túneles en la clavícula, en las inserciones anatómicas de los ligamentos CC nativos[25], y 1 solo túnel a nivel de la coracoides, en el punto medio de la inserción de ambos ligamentos. El flip de titanio del dispositivo de suspensión se apoyó en el aspecto caudal de la base de la coracoides, luego de pasar en dirección retrógrada cada uno de los 2 bucles de sutura del sistema. Cada bucle del dispositivo se pasó posteriormente por los túneles respectivos a nivel de la clavícula, obteniendo así una configuración en ''V'' de la reconstrucción de los ligamentos CC con un implante único.

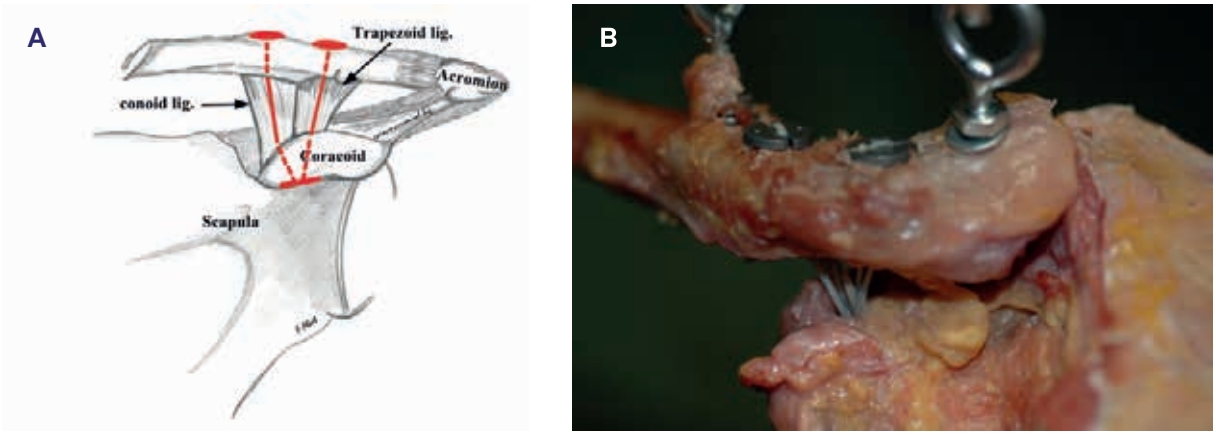


Figura. 21A. Ilustración de la reparación anatómica de los ligamentos CC con configuración en ''V'', con un único túnel en la coracoides y 2 túneles a nivel de la clavícula.

Figura 21B. Fotografía realizada desde perspectiva posterior, de uno de los especímenes cadavéricos del grupo III (hombro derecho), en la que se puede apreciar la reconstrucción anatómica en "V", con un dispositivo de suspensión y 2 arandelas claviculares.

Protocolo de estudio biomecánico

Las piezas cadavéricas estudiadas se colocaron en una máquina universal de medición (Electro Puls 3000, Instron, Boulder, MA, EE. UU.) con las mordazas de sujeción en posición vertical. La escápula se fijó a la pinza mediante un sistema de compresión utilizando dos placas con puntas de tornillo para asegurar una fijación adecuada (figura 22). Una barra que contactaba el borde superior de la escápula estaba ajustada para evitar el movimiento vertical durante las mediciones. Para analizar el comportamiento vertical de los complejos CC, se colocaron dos anillas en la clavícula (una lateral y otra medial al complejo CC, nativo o reconstruido), que estaban conectadas por dos cadenas a la abrazadera de movimiento vertical. Las pruebas de tracción se realizaron a una velocidad de 15 mm / min. Se realizó un pretensado a 15 Newtons antes de iniciar la tracción vertical. La prueba se detuvo cuando la fuerza de tensión cayó en un 60% con respecto a la fuerza máxima aplicada (Fmax 60%) o cuando se observó movimiento del espécimen o fracaso de los implantes. En cada prueba, se registró la fuerza máxima necesaria para hacer fracasar el complejo CC (en Newtons). El grupo I (control) se testó primero, obteniendo así los valores de referencia. Los grupos II y III fueron testados posteriormente.

Figura 22. Montaje de uno de los especímenes del grupo II en la máquina universal de medición. Obsérvese como la escápula se encuentra fijada mediante un sistema de compresión de dos placas con puntas de tornillo, y obsérvese asimismo la barra que contacta el borde superior de la escápula para evitar el movimiento vertical durante las mediciones. Se pueden apreciar también las dos anillas en la clavícula conectadas por dos cadenas a la abrazadera de movimiento vertical.

Análisis estadístico

Se calcularon las medias ± DE de las fuerzas necesarias para hacer fracasar el vínculo CC en cada uno de los grupos. La comparación entre grupos se realizó con un análisis de varianza usando el Tukey post-hoc test. El nivel de significación se estableció en 5% (α=0.05). Los datos se analizaron mediante el uso de SPSS 19 (SPSS Inc., Chicago, IL).

TRABAJO n.4: Natera Cisneros L, Sarasquete Reiriz J. Unstable acromioclavicular joint injuries: Is there really a difference between surgical management in the acute or chronic setting? J Orthop. 2016;14(1):10-18.

4 MATERIAL Y MÉTODO

Diseño del estudio

Se realizó un estudio de cohortes retrospectivo en 2 hospitales de tercer nivel. Se incluyeron pacientes diagnosticados de luxaciones AC de alto grado (grado IIIB-V de acuerdo con la clasificación de Rockwood) tratados quirúrgicamente mediante reconstrucción anatómica de los ligamentos CC asistida por artroscopia, realizada en fase aguda y en fase crónica. El período de inclusión fue desde enero de 2011 hasta enero de 2013.

Población de estudio

Los pacientes se incluyeron en el estudio siguiendo estos criterios de inclusión: (a) cualquier sexo; (b) diagnóstico radiográfico de luxación AC de alto grado (Rockwood IIIB-IV-V); (c) físicamente activo y con una edad comprendida entre 18 y 55 al momento de la cirugía; (d) tratado artroscópicamente en fase aguda mediante reconstrucción anatómica de los ligamentos CC con 2 dispositivos de suspensión (grupo-AGUDO) ó; (e) tratado artroscópicamente en fase crónica mediante reconstrucción CC con aloinjerto tendinoso más un dispositivo de suspensión (grupo-CRÓNICO); (f) con historia clínica y examen radiológico completo y disponible en el momento de la revisión de los registros; (g) con un seguimiento mínimo de 24 meses después de la cirugía y (h) operado por el mismo cirujano de hombro. Los criterios de exclusión fueron: (a) diagnóstico radiográfico de luxación AC Rockwood grado I-II-IIIA; (b) lesiones previas a nivel del hombro en cuestión; y (c) pacientes tratados con técnicas quirúrgicas diferentes a las expuestas en los criterios de inclusión. Los pacientes que cumplieron estos criterios de elegibilidad fueron contactados y se les propuso su inclusión en el estudio. Una vez que los pacientes aceptaron participar en el estudio, firmaron un consentimiento informado, y se realizó la recogida prospectiva de la información clínica (cuestionarios) y radiológica.

Tratamiento quirúrgico según el tiempo transcurrido desde la lesión

Una vez que se realizó el diagnóstico de luxación AC de alto grado (figura 23A), los pacientes fueron informados sobre las diferentes opciones de tratamiento. El punto de corte entre las lesiones agudas y crónicas, así como los pormenores de técnica quirúrgica, se establecieron en concordancia con consensos internacionales en cirugía de hombro[123]. Las luxaciones AC agudas se trataron con dos dispositivos CC de suspensión colocados anatómicamente, dentro de las 3 primeras semanas después de producida la lesión (figura 23B); y las luxaciones AC crónicas (figura 23C) fueron

tratadas quirúrgicamente después de la tercera semana tras la producción de la lesión, mediante reconstrucción anatómica de los ligamentos CC con aloinjerto tendinoso (figura 23D). Aquellos pacientes que en la primera visita de seguimiento accedieron a someterse al tratamiento quirúrgico pocos días tras haberse producido la lesión fueron incluidos en el grupo-AGUDO. Los pacientes que inicialmente rechazaron el tratamiento quirúrgico en fase aguda, que fueron manejados mediante terapia rehabilitadora, y que finalmente tras el fracaso del tratamiento conservador requirieron una intervención quirúrgica, fueron incluidos en el grupo-CRÓNICO.

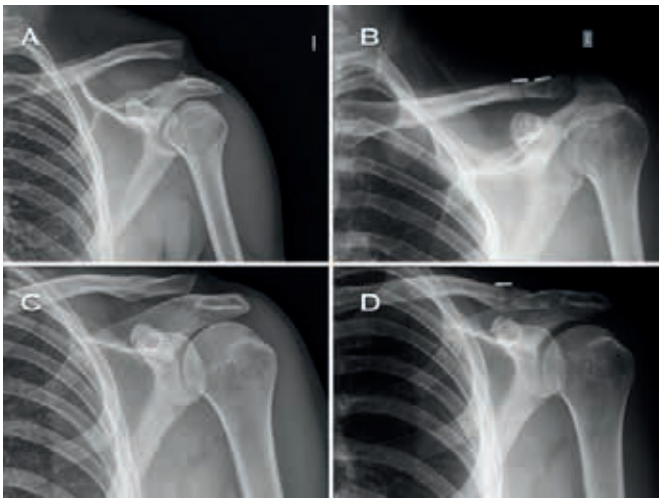


Figura 23.

A.- Radiografía anteroposterior de un hombro izquierdo en el que se observa una luxación AC grado V según Rockwood.

B.- Radiografía anteroposterior del hombro izquierdo, tras realización de una fijación CC anatómica en fase aguda con dos dispositivos de suspensión.

C.- Radiografía anteroposterior de un hombro izquierdo en el que se observa una luxación AC grado V según Rockwood.

D.- Radiografía anteroposterior del hombro izquierdo, tras realización de reconstrucción anatómica en fase crónica de los ligamentos CC, con aloinjerto de tendón más dispositivo de suspensión.

Técnica quirúrgica. Grupo-AGUDO

La técnica realizada implica la colocación de dos dispositivos de suspensión CC mediante un procedimiento asistido por artroscopia. Esta técnica se describe en uno de los artículos de soporte de esta tesis doctoral, pero añadiendo una fijación AC adicional, con el objetivo de conseguir una estabilización en el plano anteroposterior[107]. En la serie de pacientes de este estudio, no se realizó ningún gesto de estabilización anteroposterior. En la versión electrónica de esta tesis doctoral, clicando en el siguiente enlace se puede apreciar una video-técnica detallada del procedimiento descrito:

https://www.arthroscopytechniques.org/cms/10.1016/j.eats.2015.07.014/attachment/b5e565d2-0c1c-4f08-bcf8-32942241c25f/mmc1.mp4

Con el artroscopio en el portal lateral, se sigue el ligamento coracoacromial (CA) hasta su inserción en la coracoides. La porción caudal base de la coracoides se limpia con un vaporizador. Los dos dispositivos de suspensión se pasan en una dirección retrógrada, con lo que el flip subcoracoideo no tiene que atravesar todo el túnel CC. La dirección retrógrada (de coracoides a clavícula) implica hacer túneles CC con un diámetro de 3.5mm, minimizando así la probabilidad de fractura de coracoides. 2cm medial al borde lateral de la clavícula, se realiza una incisión transversal con una longitud de 3cm. Esta incisión se realiza en un punto intermedio de donde los orígenes nativos de los ligamentos conoide y trapezoide se encontrarían a nivel de la cara inferior de la clavícula. El origen nativo del conoide es 4.5cm medial al borde lateral de la clavícula, y el del trapezoide de 2.5cm y ligeramente anterior cuando se compara con el conoide[25]. Se realiza una sección transversal de la fascia deltotrapezoidea. Se libera la tracción y se coloca una guía AC de Biomet® apoyándose en la porción inferior de la base de la coracoides adyacente a la pared de la escápula, con una angulación de 80-90°, con el tubo deslizante de la guía ubicado en la cara superior de la clavícula, 4.5cm medial la articulación AC (lugar de inserción subclavicular anatómica del conoide) (figura 24A). Se pasa una AK de 2.4mm. Posteriormente, en la porción superior de la clavícula, el tubo deslizante debe ubicarse en el lugar de inserción anatómica del ligamento trapezoide, que se encuentra 2.5cm medial a la articulación AC y ligeramente anterior al compararlo con la ubicación de la AK del conoide[25]. En la porción inferior de la coracoides, la guía de AC se coloca medial al borde lateral de la coracoides, y ligeramente anterior cuando se compara con la ubicación de la AK del conoide. Se pasa una AK de 2.4mm a través de la guía de AC desde la clavícula hasta la coracoides, siguiendo la orientación

anatómica del ligamento trapezoide (figura 24B). Desde el aspecto superior de la clavícula, se puede apreciar la dirección convergente de las 2 AK (figura 24C). La distancia entre las AK en la porción inferior de la coracoides debe ser de aproximadamente 1.5cm (figura 24D).

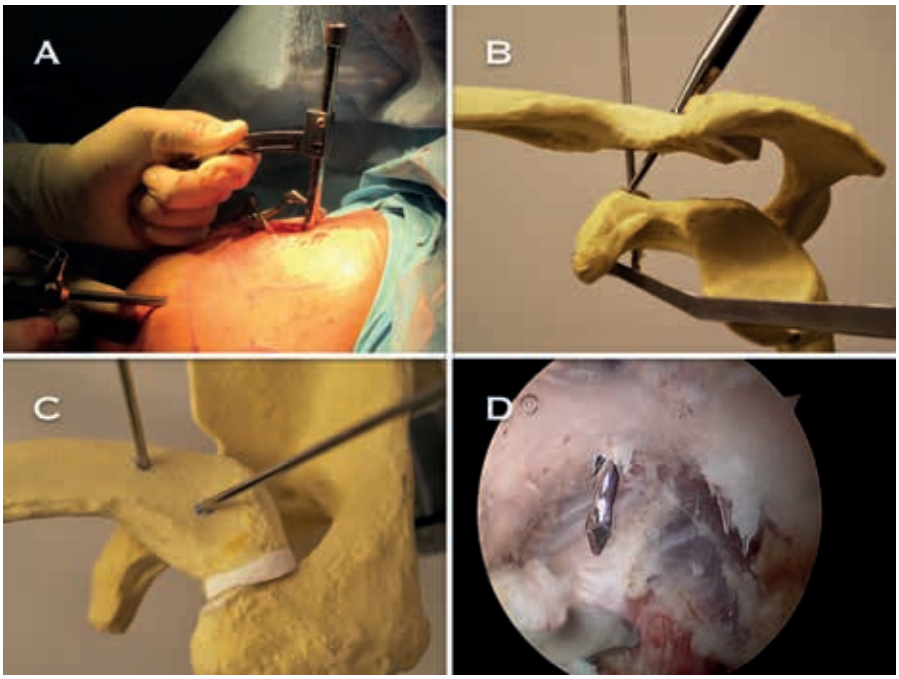


Figura 24.

A. Perspectiva posterior de un hombro izquierdo en el que se introduce la guía de AC a través del portal anterior con el tubo deslizante apoyado en la porción superior de la clavícula. El artroscopio se introduce a través del portal anterolateral.

B. Maqueta AC de hombro izquierdo, en la que se puede observar que ya se ha pasado la AK del conoide y la guía AC se encuentra ya orientada mientras se introduce la AK del túnel para el trapezoide.

C. Maqueta AC de hombro izquierdo en la que se aprecian desde perspectiva superior las 2 AK colocadas en las ubicaciones anatómicas de los ligamentos CC.

D. Visión subcoracoidea de un hombro derecho a través del portal anterolateral. Obsérvense las 2 AK emergiendo a través de la cara inferior de la base de la coracoides.

Posteriormente, se pasa una broca canulada de 3.5mms sobre la AK del conoide, hasta que la broca emerge en la cara inferior de la coracoides, donde la guía de AC la recibe. Se retira la AK, y la broca canulada se mantiene en posición. Una sutura transportadora (1mm PDS, Ethicon, Somerville, NJ) se pasa desde la clavícula hasta la coracoides a través de la broca canulada, y es entonces recuperada a través del portal anterior. Una sutura de alta resistencia (No. 2 MaxBraid, Arthrotek, Biomet) se anuda al extremo distal del PDS que pasa a través del túnel del conoide, y luego se tira del PDS cranealmente para hacer que la sutura de alta resistencia pase por el túnel. Se retira la broca canulada con cuidado de no dañar la sutura.

Posteriormente, la broca canulada de 3.5mms se pasa sobre la AK del trapezoide. La AK se retira, y se mantiene la broca canulada en posición. Se pasa otra sutura transportadora tipo PDS de 1mm desde la clavícula hasta la coracoides a través de la broca canulada, y es recuperada desde el portal anterior. Se anuda otra sutura de alta resistencia al cabo distal del PDS que pasa a través del túnel del trapezoide, y se tira del PDS cranealmente para hacer que la sutura de alta resistencia pase por el túnel. Se retira la broca canulada del trapezoide con cuidado de no dañar la sutura. El dispositivo de suspensión (ZipTight, referencia 904834; Biomet) del conoide es el primero que se pasa por el túnel. El cabo distal de la sutura de alta resistencia que se utilizará como transportadora, se anuda provisionalmente a las suturas deslizantes del dispositivo de suspensión. La sutura transportadora de alta resistencia que está saliendo del túnel del conoide a nivel de la clavícula, se debe extraer cranealmente para hacer que el dispositivo de suspensión pase por el túnel (figura 25A). El mismo procedimiento se repite en el túnel del trapezoide. Una vez que ambos dispositivos de suspensión han pasado a través de cada uno de los túneles, se revisa que los flips subcoracoideos de titanio de ambos dispositivos están correctamente dispuestos en la cara inferior de la coracoides (figura 25B). Antes de tensar los dispositivos de suspensión (figura 25C), las suturas deslizantes del sistema se deben acoplar en las arandelas para hacerlas descender hasta que estas toquen la clavícula. Posteriormente, los ayudantes han de realizar la reducción AC empujando el codo hacia arriba y la clavi-

cula hacia abajo al mismo tiempo. Una vez que el flip subcoracoideo del conoide se ha posicionado adecuadamente en la cara inferior de la coracoides, el sistema se fija tirando alternativamente en dirección craneal de ambos cabos de las suturas deslizantes para hacer que la arandela descienda hasta tocar la clavícula y bloquearse. Se repite el mismo procedimiento para el sistema de suspensión del trapezoide. Una vez que se han bloqueado ambos dispositivos de suspensión (figura 25D), la reducción final de la articulación AC puede ser comprobada con fluoroscopia intraoperatoria, o visualización artroscópica directa. Se cortan los remanentes de las suturas deslizantes de los sistemas de suspensión. La fascia deltotrapezoidea se reconstruye con un No. 1.0 Vicryl (Ethicon).

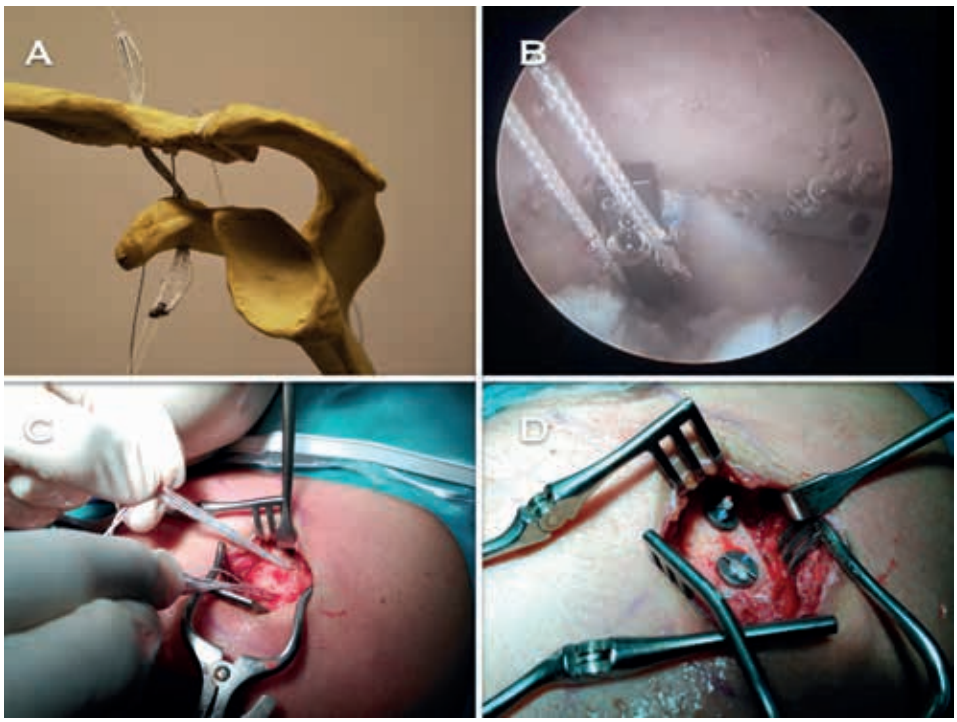


Figura 25.

A. Maqueta AC de hombro izquierdo en la que se aprecia como el dispositivo de suspensión para el conoide se está pasando por el túnel CC en dirección retrógrada.

B. Visión subcoracoidea de un hombro derecho a través del portal anterolateral. Obsérvense los dos flips subcoracoideos de los dos dispositivos de suspensión.

C. Perspectiva superior de un hombro izquierdo en el que se pueden observar las suturas deslizantes de ambos dispositivos de suspensión después de haber sido pasadas por los 2 túneles CC en dirección retrógrada.

D. Perspectiva superior de un hombro izquierdo en el que se pueden observar las arandelas de ambos dispositivos de suspensión, una vez que han sido bloqueadas.

Grupo CRÓNICO

Esta técnica se describe en uno de los artículos de soporte de esta tesis doctoral[29].

En la versión electrónica de este documento, clicando en el siguiente enlace se puede apreciar una video-técnica detallada del procedimiento descrito:

https://www.arthroscopytechniques.org/cms/10.1016/j.eats.2014.06.014/attachment/e1eca-b5b-7d2d-4ef8-80e0-bc4f5cec8e14/mmc1.mp4

Se realiza una reconstrucción anatómica de los ligamentos CC empleando un aloinjerto de tendón semitendinoso. La técnica contempla la realización de un túnel a nivel de la coracoides, y 2 túneles a nivel de la clavícula, en las localizaciones anatómicas de los ligamentos CC. Asimismo, se añade un dispositivo de suspensión CC para garantizar la estabilidad primaria de la reconstrucción. Se realiza la reconstrucción con asistencia artroscópica, para así tener la posibilidad de diagnosticar y tratar posibles lesiones glenohumerales asociadas, y para poder tener una correcta visualización del aspecto inferior de la base de la coracoides en el momento de realización del túnel.

Se realiza un abordaje subacromial artroscópico a la base de la coracoides. Se asocia un procedimiento de Mumford. Se realiza una incisión cutánea transversal sobre la clavícula. Se realiza una sección transversal de la fascia deltotrapezoidea y se coloca la guía AC en la base de la coracoides y en la porción superior de la clavícula, 4.5cm medial a su extremo distal (origen nativo del conoide). Se pasa una AK de 2.4mm. Se pasa una broca canulada guiada por la AK. Se retira la AK y se

mantiene la broca canulada en posición. Se pasa una sutura transportadora (monofilamento tipo PDS) a través de la broca canulada. Se atan dos suturas de alta resistencia al extremo distal del PDS que pasa a través de la coracoides. Posteriormente se realiza el mismo procedimiento para el túnel clavicular del trapezoide. La AK y la broca del trapezoide atraviesan la clavícula, y llegan hasta un punto lateral a la coracoides, sin perforarla. Una vez que se han pasado las suturas de alta resistencia a través de la broca canulada, se retiran cuidadosamente ambas brocas. Una de las suturas de alta resistencia que pasa a través del túnel del conoide es provisionalmente atada a la sutura de uno de los extremos del injerto tendinoso. La sutura del otro extremo de la plastia es atada provisionalmente al PDS que proviene del túnel del trapezoide en la clavícula y sale a través del portal anterior.

Se pasa la plastia tirando cranealmente de la sutura de alta resistencia que proviene del túnel del conoide. Posteriormente, se tira en dirección craneal del PDS que proviene del túnel del trapezoide en la clavícula; así la plastia se dirige lateral y superiormente, configurando la morfología anatómica en “V” de la reconstrucción (figura 26A).

Se ata el dispositivo de suspensión a la sutura de alta resistencia que está aún libre en el túnel del conoide. Se tira cranealmente de esta sutura para así pasar el dispositivo de suspensión en dirección retrógrada (figura 26B). Se enhebra la arandela con las suturas deslizantes del sistema, para así poder hacerla descender hasta que se aplique en la clavícula. En la cara inferior de la coracoides, el flip subcoracoideo del dispositivo de suspensión ha de estar correctamente posicionado (figura 26C). Los ayudantes deben reducir la articulación AC, empujando el codo hacia arriba y la clavícula hacia abajo al mismo tiempo. Se fija el dispositivo de suspensión. Posteriormente la plastia se fija en la porción clavicular de los túneles con tornillos interferenciales de biotenodesis. El aspecto final de la reconstrucción se puede apreciar en la figura 26D. Se reconstruye cuidadosamente la fascia deltotrapezoidea.

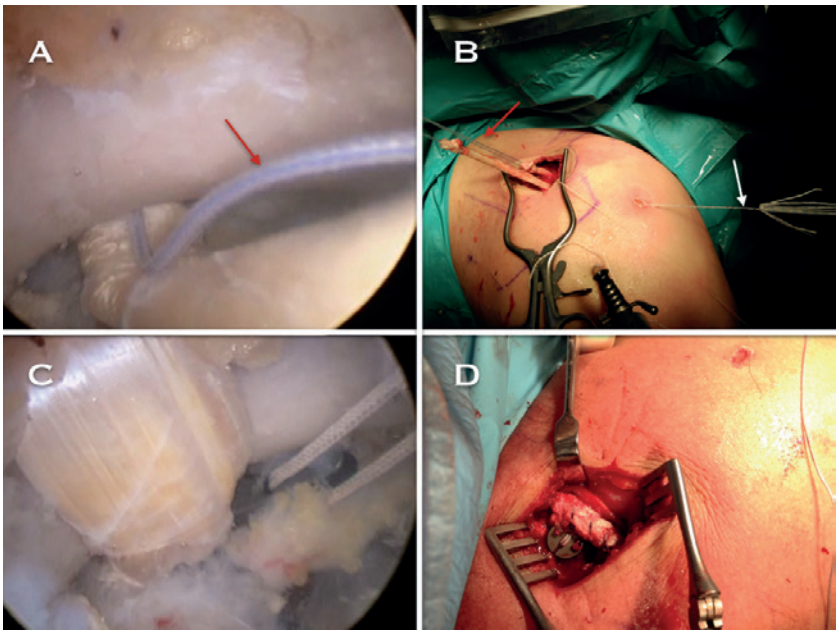


Figura 26.

A. Visión subcoracoidea de un hombro derecho a través del portal anterolateral. Observe el aloinjerto tendinoso proveniente del túnel del conoide. Este tendón se extrae a través del túnel del trapezoide a nivel de la clavícula. La flecha roja señala la sutura transportadora, que se utilizará para pasar el dispositivo de suspensión a través del túnel del conoide.

B. Perspectiva superior de un hombro derecho en el que los 2 cabos del aloinjerto tendinoso se están tirando cranealmente (flecha roja). El dispositivo de suspensión está provisionalmente atado a la sutura transportadora (flecha blanca), que se pasa a través del túnel CC, tirando cranealmente de la sutura transportadora en la parte superior del túnel del conoide en la clavícula.

C. Visión subcoracoidea de un hombro derecho a través del portal anterolateral. Obsérvese el aloinjerto tendinoso emergiendo del túnel conoide y rodeando la coracoides antes de ascender al túnel trapezoidal en la clavícula. El flip subcoracoideo del dispositivo de suspensión se encuentra correctamente posicionado.

D. Perspectiva superior de un hombro derecho en el que se puede observar el aspecto final de la reconstrucción.

La técnica descrita proporciona las ventajas de cirugía mínimamente invasiva, evita las desventajas biomecánicas relacionadas con los procedimientos que emplean implantes metálicos rígidos, ofrece una mayor resistencia biomecánica minimizando así el riesgo de secundario desplazamientos relacionados con técnicas no anatómicas, y combina una estabilización mecánica primaria, y una estabilización biológica definitiva representada por el injerto, una vez integrado al hueso.

TRABAJO n.5: Cisneros LN, Reiriz JS. Prevalence of remaining horizontal instability in high-grade acromioclavicular joint injuries surgically managed. Eur J Orthop Surg Traumatol. 2017;27(3):323-333. doi: 10.1007/s00590-016-1898-0.)

Diseño del estudio

Se realizó un estudio de cohortes retrospectivo en 3 hospitales de tercer nivel. Se incluyeron pacientes con luxaciones AC de alto grado (grados III-V según la clasificación de Rockwood) tratados quirúrgicamente. El período de inclusión estuvo comprendido enero de 2008 hasta enero de 2013. La información clínica y radiológica de los grupos de tratamiento se obtuvo a partir de estudios previos[12,75,126]. Todos los pacientes incluidos en el estudio firmaron un consentimiento informado.

Características de la población

La población de estudio estuvo conformada por los siguientes grupos de tratamiento: estabilización AC aguda con 1 dispositivo de suspensión CC, asistida por artroscopia (grupo-1CC) (figuras 27A-C, 28A-D); estabilización AC aguda con 2 dispositivos de suspensión CC en disposición anatómica, asistida por artroscopia (grupo-2CC) (figuras 29A, B); reducción abierta y fijación AC realizada en fase aguda mediante placa gancho (grupo-GANCHO) (figura 30A); reconstrucción anatómica de los ligamentos CC en fase crónica, asistida por artroscopia, con aloinjerto tendinoso y dispositivo de suspensión CC (grupo-TENDON) (Figuras 31A, B).

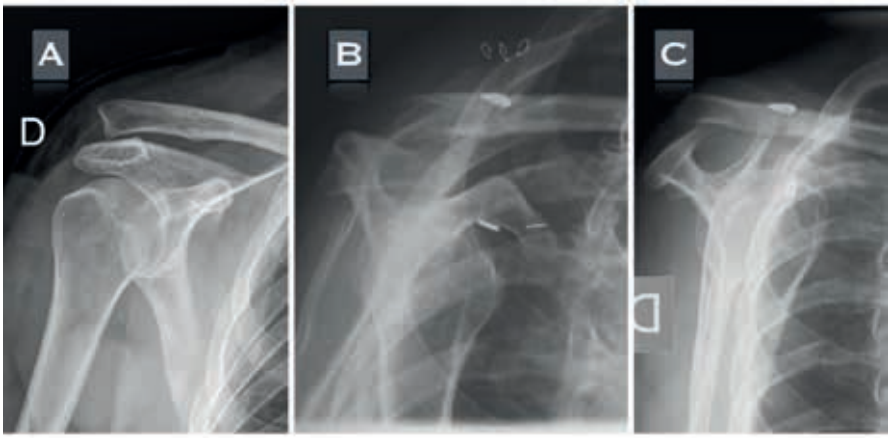


Figura 27.

A.- Radiografía en proyección anteroposterior de hombro derecho con luxación AC Rockwood grado V.

B y C.- Radiografía postoperatoria en proyección de Alexander, en la que se puede observar la inestabilidad horizontal posquirúrgica remanente. No se realizó fijación AC adicional a la fijación CC.

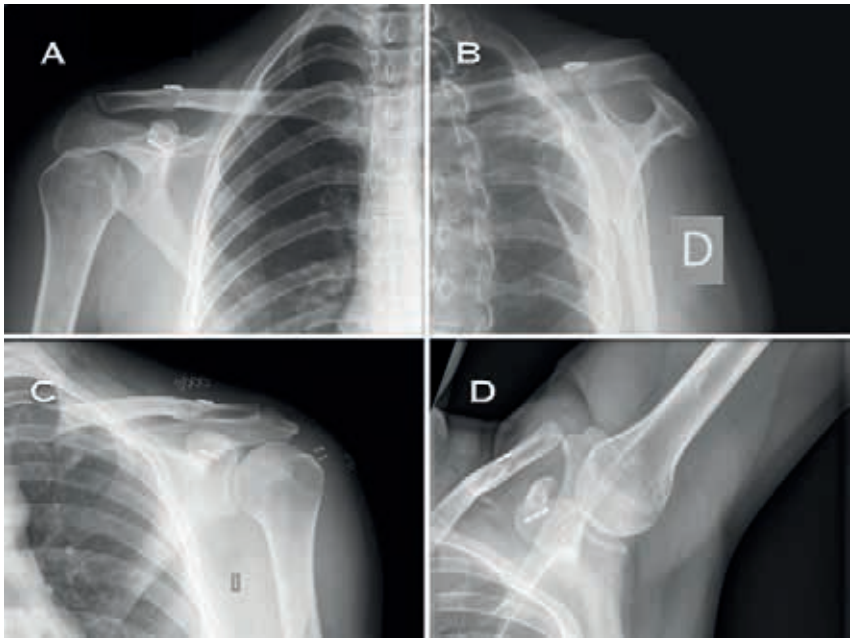


Figura 28.

A.- Radiografía en proyección anteroposterior de un hombro derecho con historia de luxación AC de alto grado que se trató con 1 dispositivo de suspensión CC. No se realizó fijación AC adicional a la fijación CC. En esta proyección radiográfica, no se puede valorar la presencia de inestabilidad horizontal.

B.- Radiografía en proyección de Alexander del mismo hombro. Obsérvese que la clavícula se solapa por encima del acromion, demostrando así la presencia de inestabilidad horizontal posquirúrgica remanente.

C.- Radiografía en proyección anteroposterior de hombro izquierdo con historia de luxación AC de alto grado que se trató mediante 1 dispositivo de suspensión CC. No se realizó fijación AC adicional a la fijación CC. En esta proyección radiográfica, no se puede valorar la presencia de inestabilidad horizontal.

D.- Radiografía en proyección axilar del mismo hombro. Obsérvese que el borde anterior de la clavícula no está alineado con el borde anterior del acromion, lo cual pone en evidencia la presencia de inestabilidad horizontal posquirúrgica remanente.

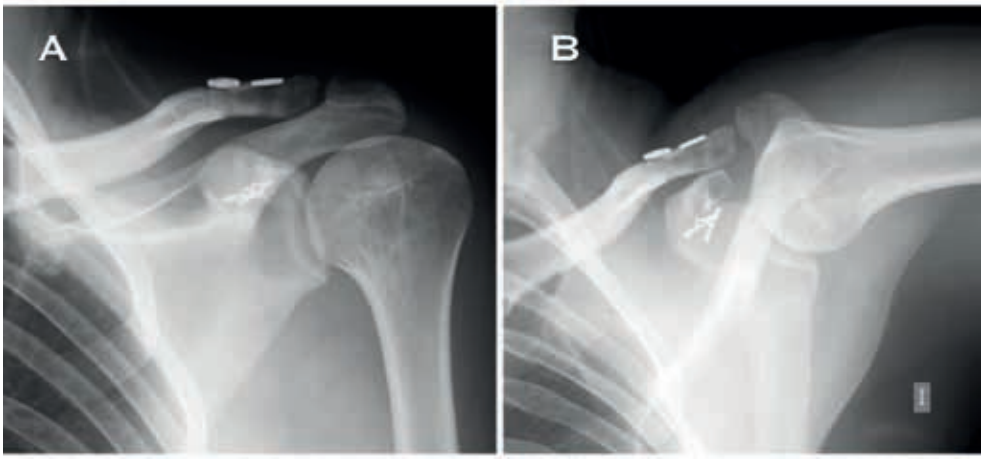


Figura 29.

A.- Radiografía en proyección anteroposterior de un hombro izquierdo con historia de luxación AC de alto grado que se trató con 2 dispositivos de suspensión CC. No se realizó fijación AC adicional a la fijación CC. En esta proyección radiográfica, no se puede valorar la presencia de inestabilidad horizontal.

B- Radiografía en proyección axilar del mismo hombro. Obsérvese que el borde anterior de la clavícula no está alineado con el borde anterior del acromion, lo que pone en evidencia la presencia de inestabilidad horizontal posquirúrgica remanente.

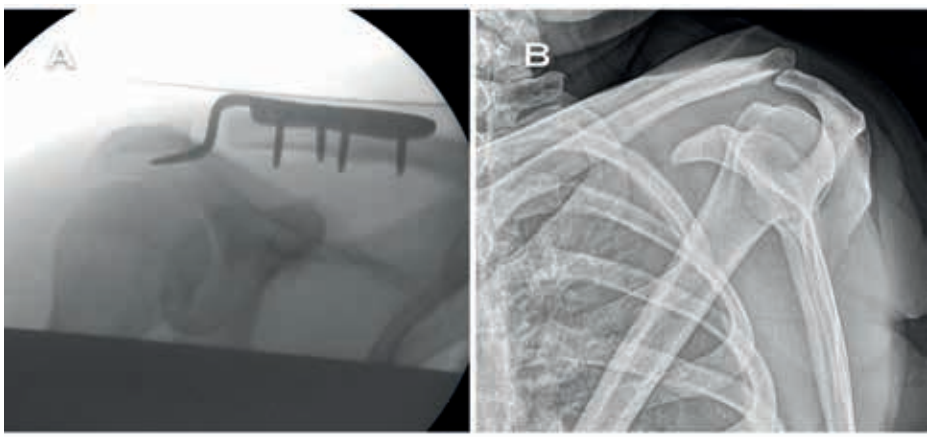


Figura 30.

A.- Radiografía en proyección anteroposterior de un hombro derecho con historia de luxación AC de alto grado tratada mediante fijación con placa gancho. No se realizó fijación AC adicional a la fijación CC.

B- Radiografía en proyección de Alexander del mismo hombro una vez retirada la placa. Obsérvese el solapamiento del tercio distal de la clavícula por sobre el acromion, poniendo en evidencia la presencia de inestabilidad horizontal posquirúrgica remanente.

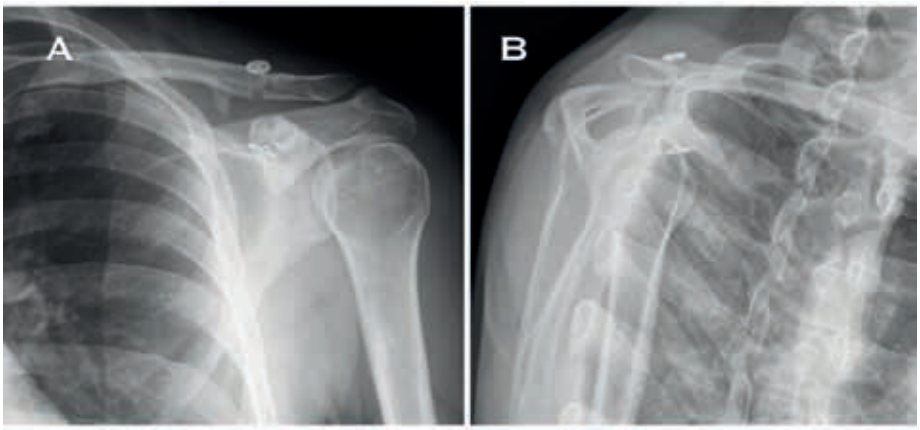


Figura 31.

A.- Radiografía en proyección anteroposterior de un hombro izquierdo con historia de luxación AC crónica de alto grado que se trató mediante reconstrucción CC anatómica con aloinjerto tendinoso más un dispositivo de suspensión CC. No se realizó fijación AC adicional a la fijación CC. En esta proyección radiográfica, no se puede valorar la presencia de inestabilidad horizontal.

B- Radiografía en proyección de Alexander del mismo hombro. Obsérvese el solapamiento del tercio distal de la clavícula por sobre el acromion, poniendo en evidencia la presencia de inestabilidad horizontal posquirúrgica remanente.

Técnicas quirúrgicas

Las técnicas han sido previamente descritas[12,29,107,126]. En ninguno de los grupos de tratamiento se realizó estabilización horizontal de la articulación AC.

Todos los pacientes fueron colocados en posición de silla de playa tras realización de bloqueo interescalénico y bajo anestesia general. En los grupos tratados con asistencia artroscópica (grupo-1CC, grupo-2CC y grupo-TENDON), se utilizaron tres portales artroscópicos estándar: posterior, anterolateral y lateral. Se realizó una exploración diagnóstica del hombro el fin de descartar lesiones glenohumerales concomitantes. La reducción anatómica se confirmó mediante visualización

directa y palpación. En el grupo-1CC, el dispositivo de suspensión CC utilizado fue el TightRope (Arthrex, Inc., Naples, Florida, EE. UU.); y en el grupo-2CC y grupo-TENDON, el dispositivo de suspensión CC utilizado fue el ZipTight (Biomet®, Varsovia, Indiana, EE. UU.). En el grupo-GANCHO, se realizó un abordaje anterior estándar a la clavícula. En este grupo, la reducción se verificó mediante control fluoroscópico. En todos los pacientes se utilizaron las placas gancho (Synthes, West Chester, EE. UU.). Se realizó una sutura de la fascia deltotrapezoidea en todos los grupos. Se suturó la piel y se colocó el brazo en un cabestrillo.

Evaluación radiológica de la inestabilidad horizontal posquirúrgica

La presencia de inestabilidad horizontal remanente se evaluó mediante proyecciones radiográficas de Alexander o axilares. Si se registró que había evidencia de solapamiento del tercio distal de la clavícula por sobre el acromion en las radiografías de Alexander realizadas en la última visita de seguimiento (figuras 27C, 28B, 30B y 31B), se consideró que la articulación AC mostraba signos de inestabilidad horizontal remanente[69]. Si el borde anterior del acromion y el borde anterolateral de la clavícula distal no estaban alineados a nivel de la articulación AC en la proyección axilar (Figuras 28D, 29B), se consideró que la articulación AC mostraba signos de inestabilidad horizontal remanente[129].

Finalmente, tras valoración de la radiología realizada en la última visita de seguimiento, la población de estudio se dividió en dos grupos: el grupo de pacientes con evidencia de inestabilidad horizontal posquirúrgica remanente (grupo-INSTAB) y el grupo de pacientes sin evidencia de inestabilidad horizontal posquirúrgica remanente (grupo NO-INSTAB). Se analizó la relación entre la inestabilidad horizontal posquirúrgica remanente y los resultados clínicos.

Relación entre variables

La relación estadística entre los cuestionarios clínicos de calidad de vida y el tipo de procedimiento quirúrgico; así como la relación entre el tipo de procedimiento y la presencia o ausencia de inestabilidad horizontal posquirúrgica remanente, se evaluaron mediante un análisis multivariante. Del mismo modo, los cuestionarios clínicos calidad de vida se estratificaron según la presencia o ausencia de la inestabilidad horizontal posquirúrgica remanente, y se realizó una comparación entre grupos.

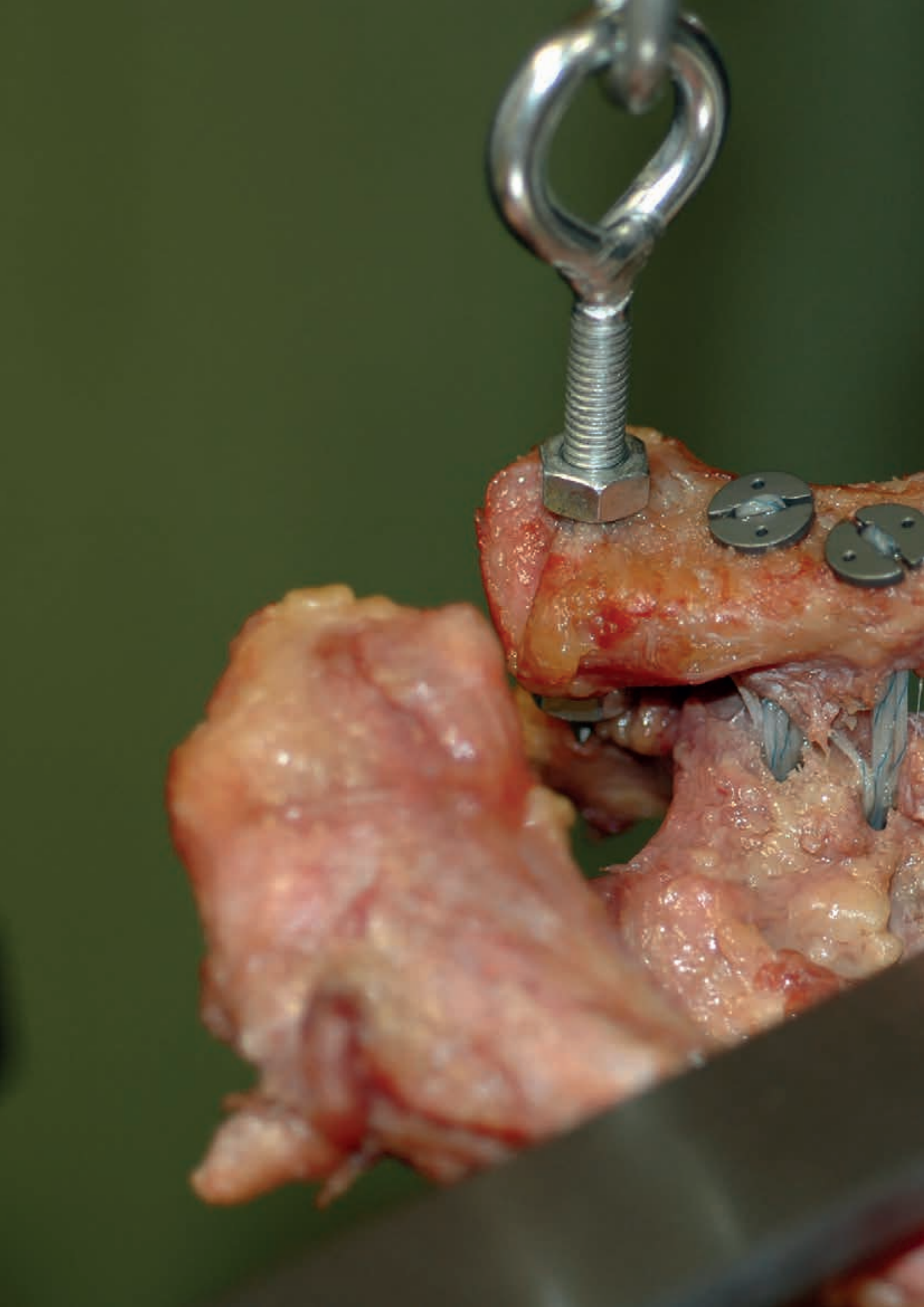
Aprobación por parte del comité de ética

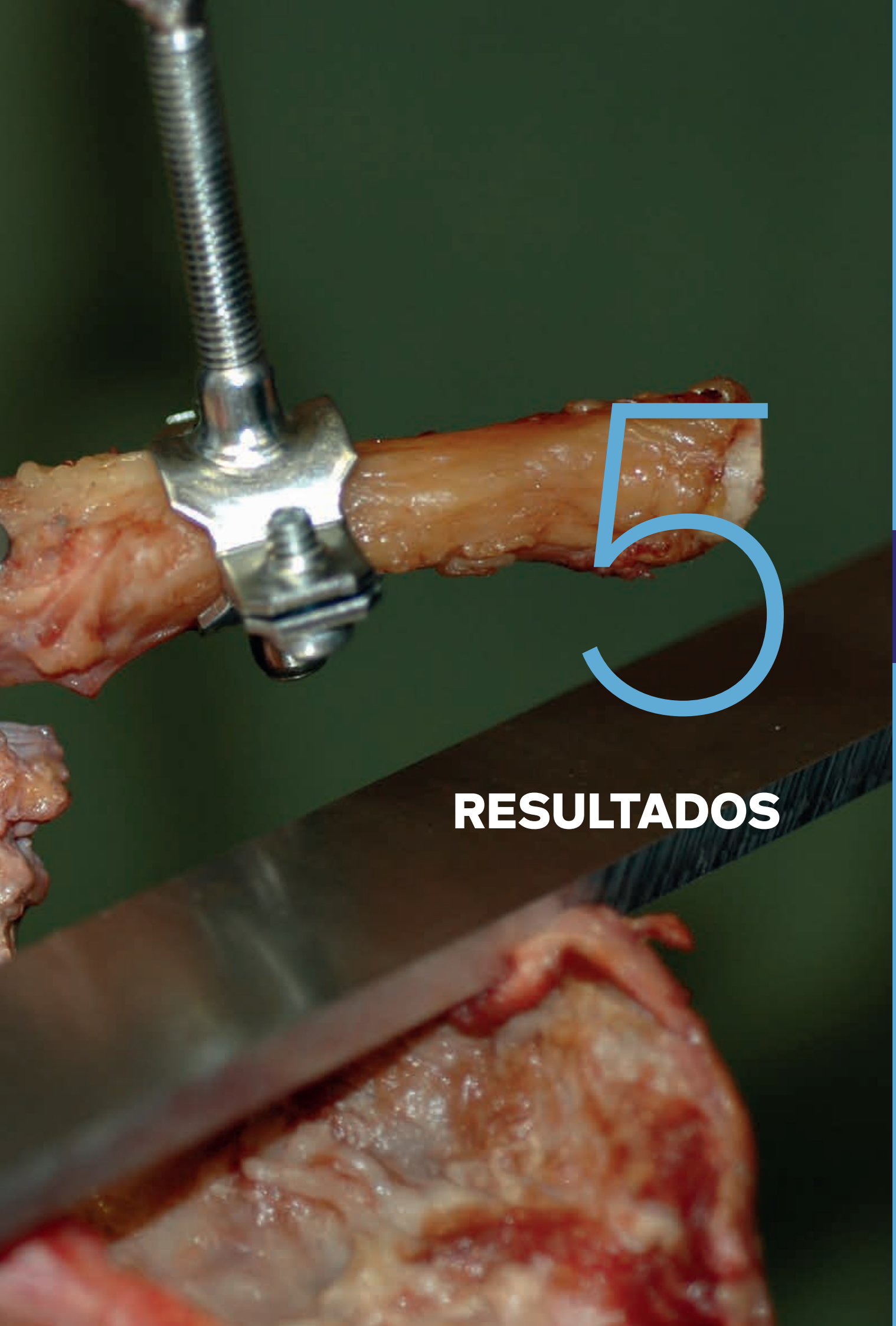
El protocolo del estudio fue aprobado por el Comité de Ética del Hospital de la Santa Creu i Sant Pau (código: IIBSP-LUX-2016-32). El estudio se realizó de acuerdo con las normas éticas de la Declaración de Helsinki (modificada en octubre de 2013), y el nivel de confidencialidad relativo a la protección de datos personales fue tal como lo exige la legislación española (LOPD 15/1999).

Análisis estadístico

Las variables continuas se presentan como media y desviación estándar (DE) o media y rango. Todas las variables continuas se probaron para determinar la normalidad utilizando la prueba de normalidad Shapiro-Wilk. Las variables categóricas se presentan como porcentajes y frecuencias. La relación entre las variables se analizó con tablas de contingencia para las categóricas, y la inferencia se estudió con la prueba X2 o la prueba exacta de Fisher según lo que correspondiera. Las pruebas de Mann-Whitney y Kruskal-Wallis se aplicaron para analizar variables cuantitativas con una distribución no normal. No se realizaron comparaciones entre la función del hombro lesionado y el ileso. Los cuestionarios de calidad de vida se estratificaron según la presencia o ausencia de inestabilidad horizontal remanente. La comparación entre el grupo-INSTAB y el grupo-NO-INSTAB en relación con los cuestionarios clínicos de calidad de vida se realizó mediante el test de Mann-Whitney. Un análisis multivariante (ANOVA bidireccional, análisis de varianza) en el que los cuestionarios de calidad de vida se consideraron como variables dependientes, y el tipo de cirugía y la presencia de inestabilidad horizontal posquirúrgica remanente

se consideraron variables independientes; se realizó para definir una correlación precisa. El nivel de significancia se estableció en 5% (a = 0.05). Los datos se analizaron mediante el uso de SPSS 19 (SPSS Inc., Chicago, Illinois).





5

RESULTADOS

5 Resultados

TRABAJO n.1: Natera Cisneros LG, Sarasquete Reiriz J. Acute high-grade acromioclavicular joint injuries: quality of life comparison between patients managed operatively with a hook plate versus patients managed non-operatively. Eur J Orthop Surg Traumatol. 2017;27(3):341-350. doi: 10.1007/s00590-016-1862-z

Características de los pacientes

Durante el periodo del estudio, se registraron 120 luxaciones AC. Finalmente se incluyó un total de 32 pacientes (29 hombres, 3 mujeres): 11 grupo-GANCHO (5 Rockwood III y 6 V) y 21 grupo-CONS (4 Rockwood III y 17 V). La figura 32 muestra el diagrama de flujo para la selección de los pacientes. En la tabla 1 se pueden apreciar las características demográficas de los pacientes del estudio estratificadas por grupos de tratamiento.

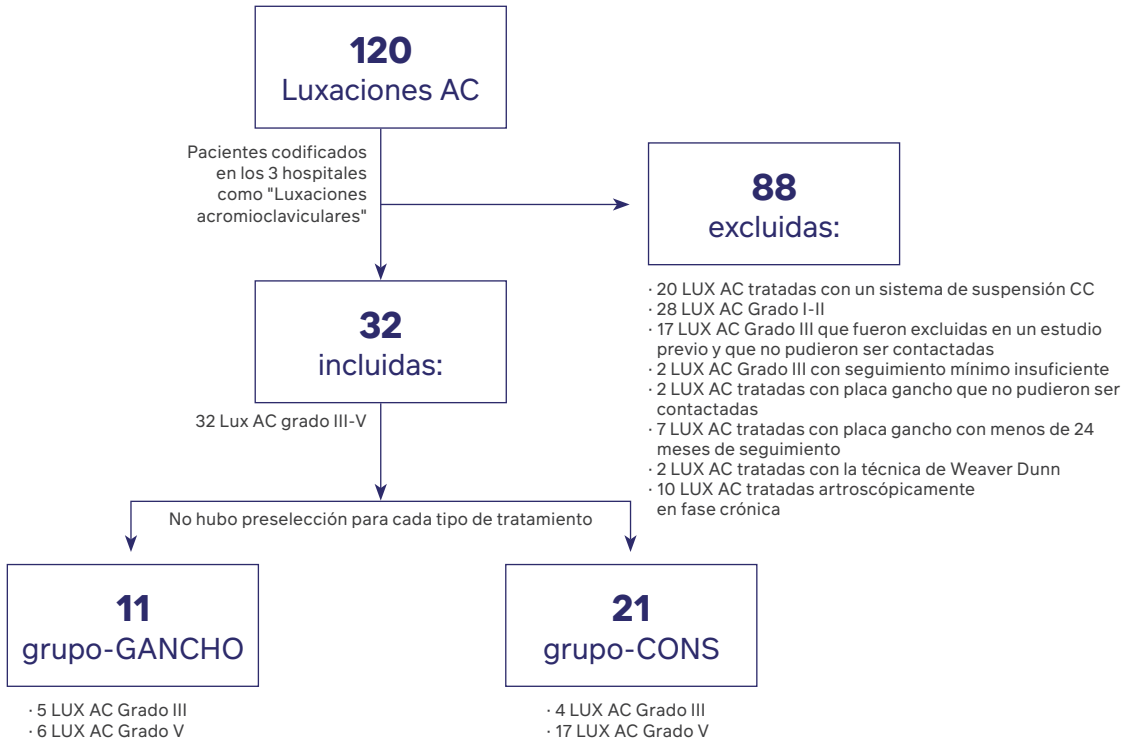


Figura 32. Diagrama de flujo que muestra el proceso de selección de los pacientes incluidos en el estudio.

		Total (n=32)	grupo-GANCHO (n=11)	grupo-CONS (n=21)	*P*
Edad (años)	[rango]	38 [19-55]	41 [19-55]	38 [19-55]	0.513
Hombre / Mujer	n(%) / n(%)	29(90.6%) / 3(9.4%)	11(100%) / 0(0%)	18(86%) / 3(14%)	0.534

Tabla 1. Características demográficas de los pacientes por grupos de tratamiento

La edad promedio fue de 41 [19-55] años para el grupo-GANCHO y 38 [19-55] para el grupo-CONS (p=0.513). El seguimiento medio fue de 32.50 ± 11.64 meses para el grupo-GANCHO y de 34.77 ±

21.98 meses para el grupo-CONS (p=0.762). El tiempo medio transcurrido desde la implantación de la placa gancho hasta su extracción fue de 3.98 ± 1.71 meses. En la figura 33A, se puede observar el hombro izquierdo de un paciente del grupo-GANCHO, y en la figura 33B, el hombro izquierdo de un paciente del grupo-CONS.

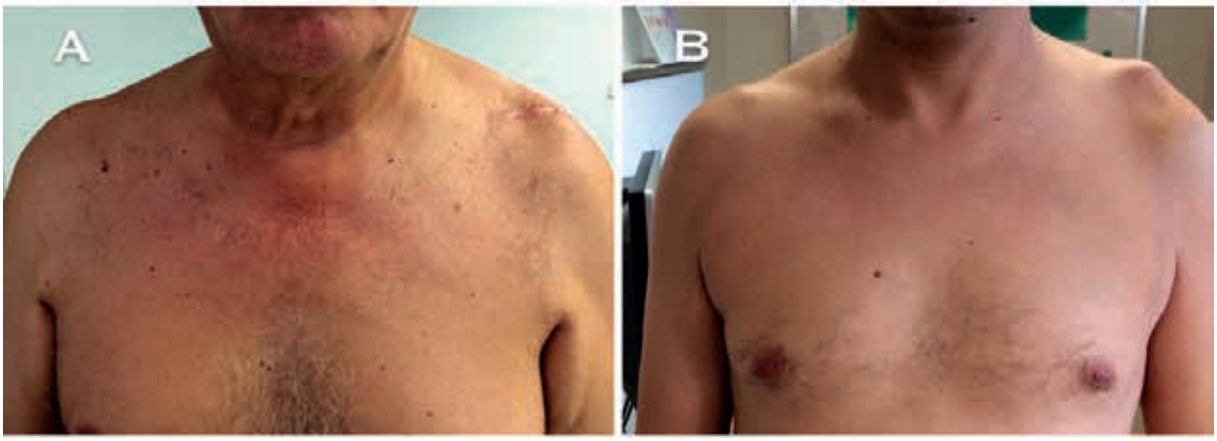


Figura 33:

A.- Imagen clínica en la que se puede observar el hombro izquierdo de un paciente del grupo-GANCHO.

B.- Imagen clínica en la que se puede observar el hombro izquierdo de un paciente del grupo-CONS.

Resultados clínicos y cuestionarios de calidad de vida

Los resultados del cuestionario SF36 físico y mental, EVA para dolor a nivel del hombro lesionado, cuestionario DASH, test de Constant y escala de satisfacción general se presentan en la tabla 2. No se encontraron diferencias estadísticamente significativas entre los dos grupos de tratamiento.

Cuestionarios	grupo-GANCHO (n=11)	grupo-CONS (n=21)	*P*
SF36 físico Media ± DE	53.70 ± 4.33	52.10 ± 6.11	0.449
SF36 mental Media ± DE	53.06 ± 6.10	56.99 ± 6.47	0.110
EVA Media ± DE	1.45 ± 1.51	1.50 ± 1.79	0.944
DASH Media ± DE	4.79 ± 5.60	5.83 ± 6.76	0.668
TEST DE CONSTANT Media ± DE	91.36 ± 6.84	91.05 ± 7.35	0.908
SATISFACCIÓN GENERAL Media ± DE	8.00 ± 1.18	8.45 ± 1.73	0.449

Tabla 2. Resultados clínicos y cuestionarios de calidad de vida.

Seguimiento radiográfico

Todos los pacientes fueron evaluados radiográficamente en la última visita de seguimiento. En el grupo-GANCHO, hubo evidencia de reducción anatómica de la articulación AC en 63.63% (7/11) de los casos; subluxaciones en 18.18% (2/11); y re-luxaciones AC de alto grado en 18.18% (2/11). Como era de esperar, todos los pacientes del grupo-CONS tenían una articulación AC completamente luxada en la última visita de seguimiento. En resumen, la proporción de pacientes con inestabilidad AC vertical en la última visita de seguimiento fue del 36,36% (4/11) en el grupo-GANCHO y del 100% (21/21) en el grupo-CONS (p=0.0001). Estos resultados se presentan en la Tabla 3. Se observó calcificación de los ligamentos CC en 27.27% (3/11) de los hombros del grupo-GANCHO y en 9.52% (2/21) de los hombros del grupo-CONS (p=0.309), figura 34A. Se observó osteolisis a nivel del tercio lateral de la clavícula en 27.27% (3/11) de los hombros del grupo-GANCHO y en 14.3% (3/21) de los hombros del grupo-CONS (p=0.389) (figuras 34A y B).

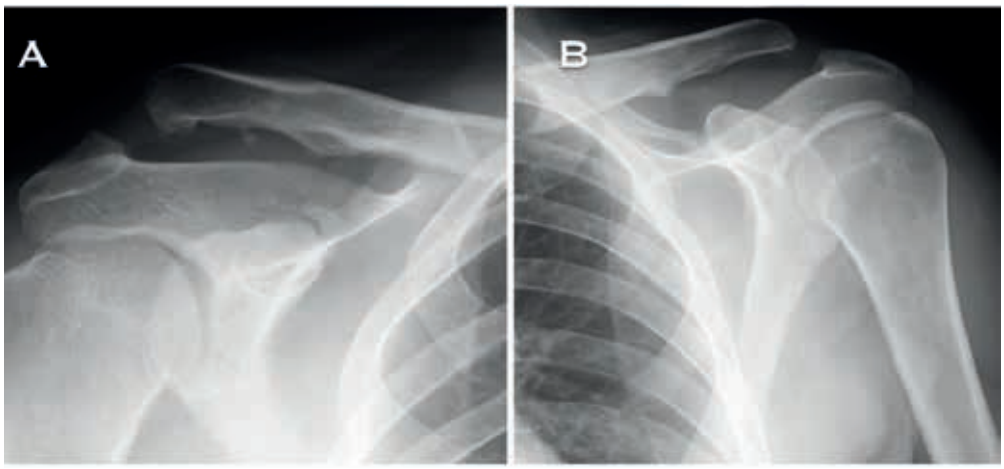


Figura 34:

A.- Radiografía en proyección anteroposterior del hombro derecho de un paciente con historia de luxación AC Rockwood grado III que se manejó de forma conservadora. Se pueden apreciar las calcificaciones CC y la osteolisis del tercio distal de la clavícula.

B.- Radiografía en proyección anteroposterior del hombro izquierdo de un paciente con historia de luxación AC Rockwood grado III que se manejó de forma conservadora. Obsérvese la osteolisis del tercio distal de la clavícula.

Eventos adversos relacionados con el tratamiento y complicaciones

En la última visita de seguimiento, hubo evidencia de discinesia escapular en 18% (2/11) de los pacientes del grupo-GANCHO y en 52.4% (11/21) de los pacientes del grupo-CONS (p=0.127). Estos resultados se presentan en la tabla 3.

		Total (n=32)	grupo-GANCHO (n=11)	grupo-CONS (n=21)	*P*
Inestabilidad AC vertical	n (%)	25 (78.13%)	4 (36.36%)	21 (100%)	0.0001
Discinesia escapular	n (%)	13 (40.63%)	2 (18%)	11 (52.4%)	0.127

Tabla 3. Inestabilidad AC vertical y discinesia escapular registradas en la última visita de seguimiento.

En el grupo-GANCHO, hubo dos complicaciones relacionadas con la cirugía: en un caso, una infección de herida que requirió un desbridamiento quirúrgico; y en otro caso, la rotura de un tornillo clavicular que no pudo ser extraído (Figuras 35A y B). Uno de los pacientes del grupo-GANCHO aquejaba un dolor persistente varios meses después de la extracción de la placa, por lo que se realizó una resonancia magnética. En dicho estudio se pudo apreciar edema óseo en la porción inferior del acromion. Se realizó una infiltración subacromial con corticoides, y la sintomatología remitió.

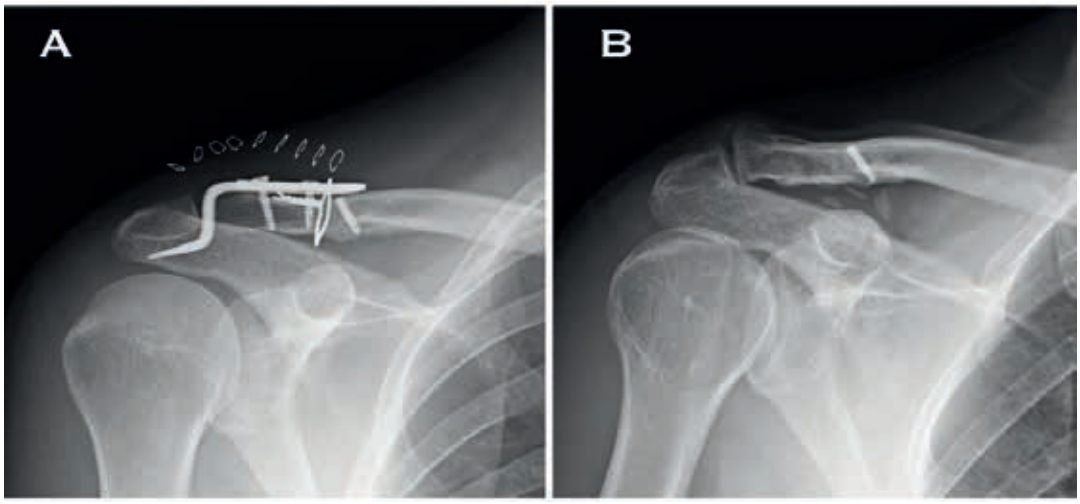


Figura 35:

A.- Radiografía en proyección anteroposterior de un hombro derecho en el que se realizó una reducción abierta y fijación interna con una placa gancho. Uno de los tornillos claviculares se rompió intraoperatoriamente y no pudo ser extraído.

B.- Radiografía en proyección anteroposterior realizada dos años después de la extracción de la placa. Se puede apreciar que se mantuvo la reducción AC, y se desarrollaron calcificaciones CC así como cambios degenerativos AC.

TRABAJO n.2: Natera-Cisneros L, Sarasquete-Reiriz J, Escolà-Benet A, Rodriguez-Miralles J. Acute high-grade acromioclavicular joint injuries treatment: Arthroscopic non-rigid coracoclavicular fixation provides better quality of life outcomes than hook plate ORIF. Orthop Traumatol Surg Res. 2016;102(1):31-9. doi: 10.1016/j.otsr.2015.10.007.

Características de los pacientes

Durante el periodo de estudio se registraron 120 luxaciones AC, de las cuales finalmente 31 cumplieron los criterios para ser incluidas en el estudio: 20 grupo-ARTRO (3 Rockwood III, 3 IV y 14 V) y 11 grupo-GANCHO (5 Rockwood III y 6 V). En la figura 36 se puede observar el diagrama de flujo del proceso de selección de los pacientes. La Tabla 4 muestra las características demográficas de los pacientes del estudio, estratificadas por grupos de tratamiento.

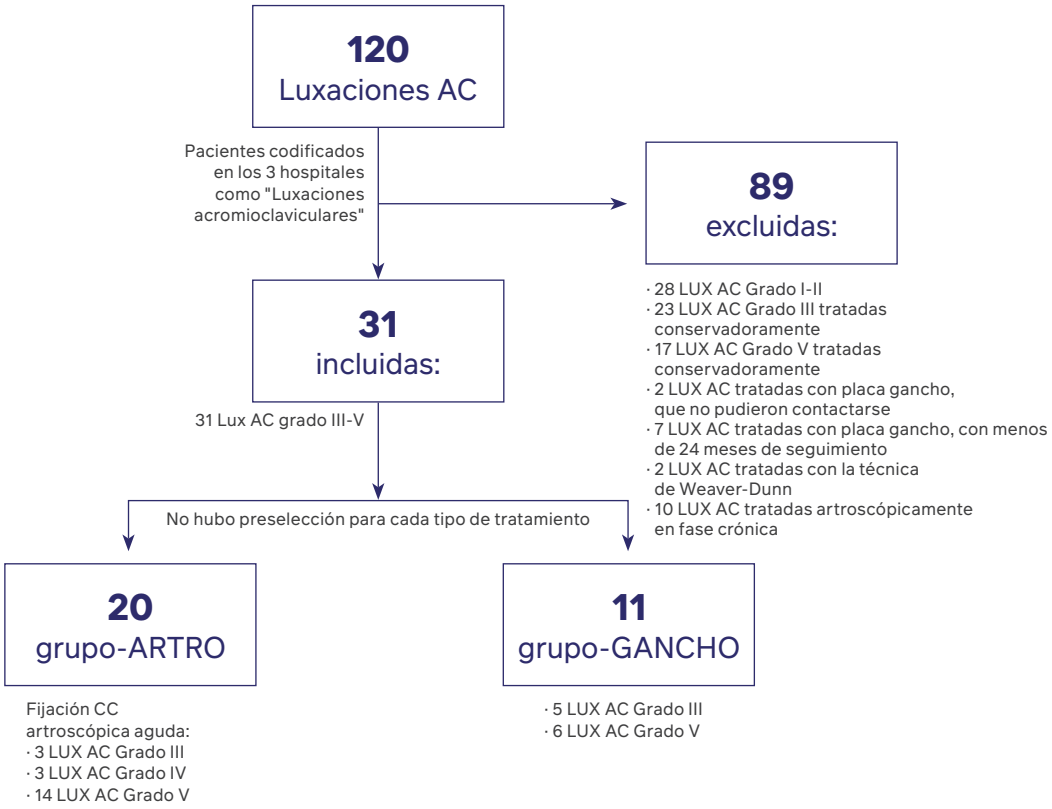


Figura 36: Diagrama de flujo del proceso de selección de los pacientes del estudio, de acuerdo con los criterios establecidos en el protocolo.

		Total (n=31)	Grupo-ARTRO (n=20)	grupo-GANCHO (n=11)	*P*
Edad (años)	[rango]	38 [19-55]	36 [25-52]	41 [19-55]	0.185
Hombre / Mujer	n(%) / n(%)	28(90%) / 3(10%)	17(85%) / 3(15%)	11(100%) / 0(0%)	0.535

Tabla 4. Características demográficas de los pacientes por grupos de tratamiento

El promedio de edad fue de 36 años [rango 25-52] para el grupo-ARTRO y 41 [19-55] para el grupo-GANCHO (p=0.185). Hubo 17 hombres en el grupo-ARTRO y 11 en el grupo-GANCHO. El seguimiento medio fue 38.40 ± 4.34 meses para el grupo-ARTRO y 32.50 ± 11.64 meses para el grupo-GANCHO (P=0.052). El tiempo medio [rango] transcurrido desde el momento de producida la luxación AC hasta la última visita de seguimiento para ambos grupos fue de 36 [24-78] meses. El tiempo medio transcurrido desde la implantación de la placa de gancho hasta su extracción fue de 3.98 ± 1.71 meses.

En el grupo-ARTRO (figura 37A), se diagnosticaron y trataron lesiones glenohumerales concomitantes en 20% (4/20) de los pacientes: 1 lesión labral posterior, 2 lesiones labrales anterosuperiores y 1 rotura del manguito rotador. Estas lesiones fueron catalogadas como agudas, por lo que se manejaron mediante fijación con anclajes y suturas. En el grupo-GANCHO, no se realizó valoración intraoperatoria de la articulación glenohumeral.

Resultados clínicos y cuestionarios de calidad de vida

Estos resultados se presentan en la Tabla 5.

Cuestionarios	grupo-ARTRO (n=20)	grupo-GANCHO (n=11)	*P*
SF36 físico Media ± DE	58.24 ± 2.16	53.70 ± 4.33	p<0.001
SF36 mental Media ± DE	56.15 ± 2.21	53.06 ± 6.10	0.049
EVA Media ± DE	0.40 ± 0.50	1.45 ± 1.51	0.007
DASH Media ± DE	2.98 ± 2.03	4.79 ± 5.60	0.200
TEST DE CONSTANT Media ± DE	95.30 ± 2.45	91.36 ± 6.84	0.026
SATISFACCIÓN GENERAL Media ± DE	8.85 ± 0.93	8.00 ± 1.18	0.035

Tabla 5. Resultados clínicos y cuestionarios de calidad de vida.

Los ítems del test del test de Constant fueron desglosados. El rango de movimiento y la fuerza se presentan en la tabla 6, y la presencia o no de dolor nocturno, así como las limitaciones en la vida cotidiana y deportiva se presentan en la tabla 7.

		Total (n=31)	Grupo-ARTRO (n=20)	Grupo-GANCHO (n=11)	*P*
Antepulsión (°)	(media ± DE)	176.2 ± 2.5	176.4 ± 3.2	175.7 ± 2.1	0.478
Abducción (°)	(media ± DE)	160.1 ± 3.6	162.4 ± 4.3	158.9 ± 2.9	0.496
Rotación externa en aducción (°)	(media ± DE)	46.3 ± 3.4	47.2 ± 2.8	45.1 ± 3.2	0.199
Rotación interna en abducción (°)	(media ± DE)	72 ± 1.8	72.2 ± 2.1	71.9 ± 1.3	0.903
Fuerza en abducción (libras)	(media ± DE)	25.1 ± 3.4	24.5 ± 2.7	25.7 ± 3.8	0.365

Tabla 6. Rango de movimiento y fuerza del hombro lesionado, registrados en la última visita de seguimiento.

		Total (n=31)	Grupo-ARTRO (n=20)	Grupo-GANCHO (n=11)	*P*
Dolor nocturno (si)	n (%)	6 (19.35%)	1 (5%)	5 (45.45%)	0.013
Limitaciones vida cotidiana (si)	n (%)	7 (22.58%)	3 (15%)	4 (36.36%)	0.209
Limitaciones deportivas (si)	n (%)	8 (25.80%)	2 (10%)	6 (54.55%)	0.012

Tabla 7. Dolor nocturno, limitaciones en actividades de la vida cotidiana y deportiva.

Seguimiento radiográfico

Se registró inestabilidad vertical remanente en 38.70% (12/31) de los pacientes (figura 37B). En el grupo-ARTRO, hubo evidencia de reducción anatómica de la articulación AC en el 60% (12/20) de los pacientes; subluxación en el 20% (4/20) de los pacientes; y luxaciones AC de alto grado en 20% (4/20). En el grupo-GANCHO (figura 38A), hubo evidencia de reducción anatómica en 63.63% (7/11) de los pacientes; subluxaciones en 18.18% (2/11) (figura 38B); y luxaciones AC de alto grado en 18.18% (2/11).

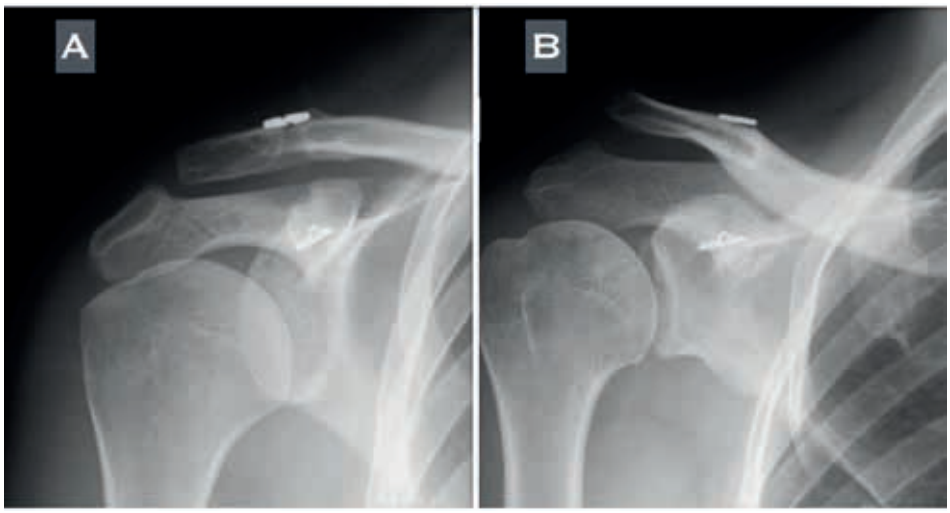


Figura 37:

A.- Radiografía en proyección anteroposterior de hombro derecho con historia de luxación AC de alto grado que se trató mediante un dispositivo de suspensión CC.

B.- Radiografía en proyección anteroposterior de otro hombro derecho con historia de luxación AC de alto grado que se trató mediante un dispositivo de suspensión CC, en la cual se puede apreciar un desplazamiento secundario.

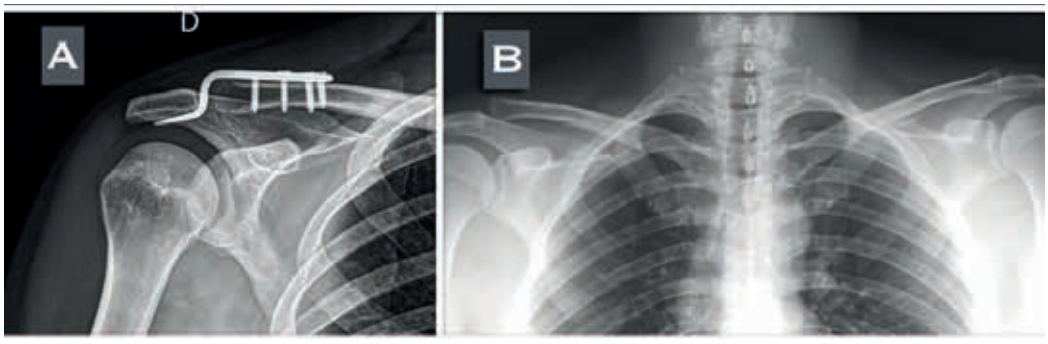


Figura 38:

A.- Radiografía en proyección anteroposterior de un hombro derecho con historia de luxación AC de alto grado, que fue tratada mediante fijación AC con placa gancho.

B.- Radiografía en proyección anteroposterior de ambos hombros del mismo caso de la figura 38A, realizada 15 días después de retirada la placa. Se puede apreciar subluxación vertical de la articulación AC.

En resumen, la proporción de pacientes con evidencia de inestabilidad vertical remanente en la última visita de seguimiento fue del 40% (8/20) en el grupo-ARTRO y del 36.36% (4/11) en el grupo-GANCHO (P=1.000). Estos resultados se presentan en la Tabla 8.

Eventos adversos relacionados con el tratamiento y complicaciones

En uno de los pacientes del grupo-GANCHO se realizó una resonancia magnética, por dolor persistente una vez retirada la placa. La secuencia de "STIR" reveló un foco de edema óseo subacromial (Figura 39A). Se realizó una infiltración de corticoides, y los síntomas remitieron. En el grupo-ARTRO, se registraron 3 complicaciones: 1 fracaso post-traumático del implante (figura 39B) que requirió reintervención y nueva fijación con otro dispositivo de suspensión CC y aloinjerto de semitendinoso, de acuerdo una de las técnicas descritas en el apartado de publicaciones de soporte de esta tesis[29]; y 2 granulomas de herida quirúrgica.

En el grupo-GANCHO hubo 2 complicaciones relacionadas con el procedimiento: 1 infección de la herida que requirió un desbridamiento quirúrgico; y la rotura intraoperatoria de un tornillo clavicular que no pudo ser extraído (ver figura 35, trabajo 1). En la última visita de seguimiento, hubo evidencia clínica de discinesia escapular en 15% (3/20) de los pacientes del grupo-ARTRO y en 18.18% (2/11) de los pacientes del grupo-GANCHO (P=1.000) (Figuras 39C y D). Estos resultados se encuentran reflejados en la tabla 8.

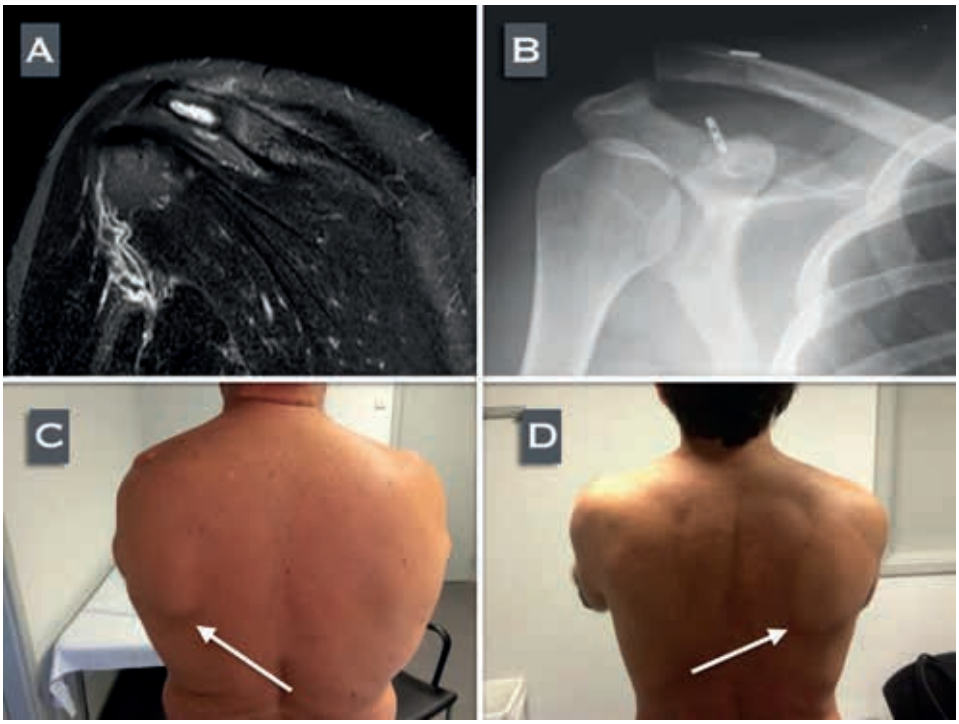


Figura 39:

A.- Reconstrucción coronal de RMN en secuencia STIR realizada a uno de los pacientes del grupo-GANCHO que refería omalgia intensa tras la extracción de la placa. Obsérvese el edema óseo a nivel del acromion.

B.- Radiografía en proyección anteroposterior de hombro derecho con historia de luxación AC de alto grado que fue tratada con un dispositivo de suspensión CC en el que se observó un fracaso postraumático del implante.

C y D.- Fotografía clínica desde perspectiva posterior de dos pacientes que se encuentran realizando aducción activa, lenta y progresiva, tras haber realizado elevación frontal completa. Obsérvese la prominencia del borde inferomedial de la escápula (flechas blancas).

		Total (n=31)	Grupo-ARTRO (n=20)	Grupo-GANCHO (n=11)	*P*
Inestabilidad vertical remanente	n (%)	12 (38.70%)	8 (40%)	4 (36.36%)	1.000
Discinesia escapular	n (%)	5 (16.12%)	3 (15%)	2 (18.18%)	1.000

Tabla 8. Inestabilidad vertical remanente y discinesia escapular registradas en la última visita de seguimiento.

TRABAJO n.3: Abat F, Sarasquete J, Natera LG, Calvo Á, Pérez-España M, Zurita N, Ferrer J, del Real JC, Paz-Jimenez E, Forriol F. Biomechanical analysis of acromioclavicular joint dislocation repair using coracoclavicular suspension devices in two different configurations. J Orthop Traumatol. 2015;16(3):215-9. doi: 10.1007/s10195-015-0346-y.

En el grupo I ó grupo control (n=6), los ligamentos CC se rompieron al alcanzar un máximo de 635.59 Newtons (N) y un mínimo de 245.85 N. En el grupo II (dos túneles en la coracoides y 2 dispositivos de suspensión), dos de las piezas cadavéricas se rompieron a nivel de la fijación escapular, por lo que tuvieron que ser descartadas. En relación a los 4 especímenes restantes, la máxima fuerza alcanzada para hacer fracasar la fijación CC fue de 939.37 N y la mínima de 278.75 N. En el grupo III (1 túnel en la coracoides, 2 túneles en la clavícula y 1 dispositivo de suspensión en disposición de "V"), el valor máximo fue de 533.11 N y el mínimo de 210.30 N. Los resultados obtenidos con la tracción vertical en la prueba biomecánica, en relación a la fuerza necesaria para registrar rotura CC o fracaso de la fijación para cada uno de los especímenes cadavéricos se muestran en la tabla 9.

ESPÉCIMEN	GRUPO I	GRUPO II	GRUPO III
1	534.44	412.43	374.12
2	529.94	351.99	274.10
3	245.85	278.75	533.11
4	253.49	939.37	371.50
5	464.81	*	300.05
6	635.59	*	210.30

Tabla 9. Fuerza registrada (expresada en Newtons) para alcanzar la rotura CC o fracaso del sistema en la prueba biomecánica de tracción vertical, para cada espécimen cadavérico.

En cuanto a los promedios por grupo (tabla 10), de la fuerza registrada para que se evidenciara rotura CC o fracaso del sistema de fijación: grupo I, se registró una fuerza promedio de 444.0 ± 160.16 N; grupo II de 495.6 ± 300.83 N (figura 40); y grupo III de 343.9 ± 111.46 N (figura 41).

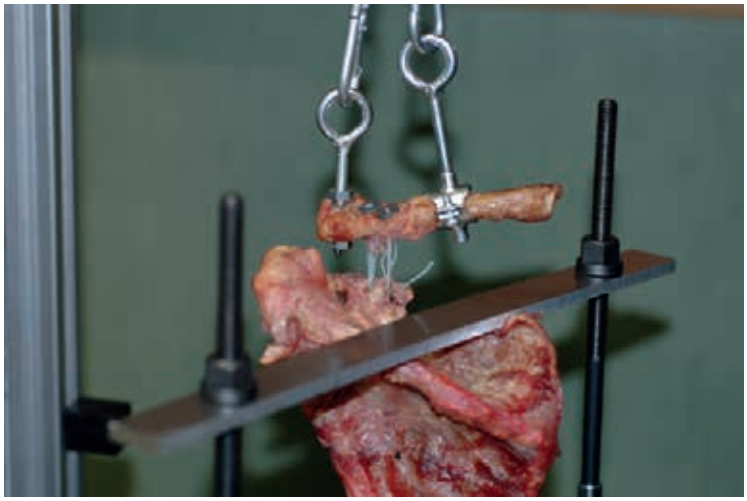


Figura 40. Fotografía en perspectiva posterior de uno de los especímenes del grupo II (hombro izquierdo, 2 túneles tanto en clavícula como en coracoides, y 2 dispositivos de suspensión), en la que se puede apreciar el fracaso del dispositivo de suspensión conoideo.

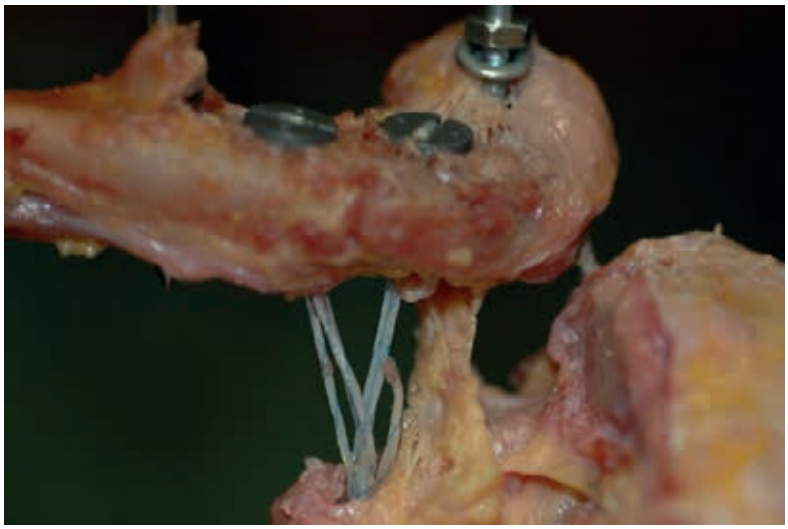


Figura 41. Fotografía en perspectiva posterior de uno de los especímenes del grupo III (hombro derecho, 2 túneles en clavícula y 1 túnel en coracoides, y 1 dispositivo de suspensión), en la que se puede apreciar el fracaso del dispositivo de suspensión a nivel de las suturas laterales, que emulaban el ligamento trapezoide.

Se realizó una comparación entre los 3 grupos, y no se evidenciaron diferencias estadísticamente significativas (ANOVA, p=0.446). En la prueba post hoc de Tukey se realizaron comparaciones entre los tres grupos: grupo I frente a grupo II, p=0.906; grupo I frente a III, p=0.638; y grupo II frente a grupo III, p=0.448.

GRUPO	PROMEDIO	DE	Coeficiente de variación (%)	*n*
I	444.0	160.16	36.1	6
II	495.6	300.83	60.7	4
III	343.9	111.46	32.4	6
Total	419.4	186.73	44.5	16

Tabla 10. Valores promedio de la fuerza necesaria para hacer fracasar el montaje, según los grupos de estudio.

TRABAJO n.4: Natera Cisneros L, Sarasquete Reiriz J. Unstable acromioclavicular joint injuries: Is there really a difference between surgical management in the acute or chronic setting? J Orthop. 2016;14(1):10-18.

Características de los pacientes

Se incluyeron 22 pacientes: 12 grupo-AGUDO (3 Rockwood IIIB, 2 IV y 7V) y 10 grupo-CRÓNICO (1 Rockwood IIIB, 1 IV, y 8V). La edad promedio fue de 31 años (rango 19-45) en el grupo-AGUDO y 41 años (rango 33-55) en el grupo-CRÓNICO (p=0.0001). Todos los pacientes eran hombres. El tiempo medio transcurrido desde que se produjo la lesión hasta que se realizó el procedimiento quirúrgico fue de 8 días (rango 5-15) en el grupo-AGUDO, y 203 días (rango 46-354) en el grupo-CRÓNICO (p=0.0001). El período de seguimiento después de la cirugía fue de 26.50 meses (rango 25-32) en el Grupo-AGUDO y 25.50 meses (rango 24-30) en el grupo-CRÓNICO (p=1.000). El tiempo medio transcurrido desde que se produjo la lesión del hombro hasta la última visita de seguimiento (momento de la recogida prospectiva de datos del estudio) fue de 26.80 meses (rango 25-33) en el grupo-AGUDO y 32.25 meses (rango 30-36) en el grupo-CRÓNICO (p=0.003). La Tabla 11 muestra las características demográficas de los pacientes del estudio.

		Total (n=22)	Grupo-AGUDO (n=12)	grupo-CRÓNICO (n=10)	*P*
Edad (años)	Media [rango]	35 [19-55]	31 [19-45]	41 [33-55]	0.0001
Tiempo desde la lesión hasta la cirugía (días)	Media [rango]	95 [5-354]	8 [5-15]	203 [46-354]	0.0001
Seguimiento después de la cirugía (meses)	Media [rango]	26 [25-32]	26.50 [25-32]	25.50 [24-30]	1.000
Tiempo transcurrido desde la lesión hasta la última visita de seguimiento (meses)	Media [rango]	29.5 [25-36]	26.80 [25-33]	32.25 [30-36]	0.003

Tabla 11. Características demográficas de los pacientes, estratificadas por grupos de tratamiento.

Lesiones glenohumerales asociadas de forma concomitante

Fueron diagnosticadas y tratadas lesiones glenohumerales concomitantes en 16.67% (2/12) de los pacientes del grupo-AGUDO (2 lesiones del labrum superior) y en 20% (2/10) de los pacientes del grupo-CRÓNICO (1 lesión labrum anterior y 1 lesión labrum superior) (p=1.000). Estas lesiones fueron tratadas mediante fijación con anclajes y suturas.

Resultados clínicos y cuestionarios de calidad de vida

Estos resultados se presentan en la Tabla 12.

Cuestionarios	grupo-AGUDO	Grupo-CRÓNICO	*P*
SF36 físico Media ± DE	58.33 ± 1.15	59.58 ± 1.98	0.085
mediana [P_{25} –P_{75}]	58 [56.5-60]	59 [57.5-62]	
SF36 mental Media ± DE	55.25 ± 1.76	56.62 ± 1.89	0.103
mediana [P_{25} –P_{75}]	55 [54-57]	57 [56-58]	
EVA Media ± DE	0.92 ± 0.79	1.44 ± 1.74	0.361
mediana [P_{25} –P_{75}]	1 [0-1.75]	1 [0-2.5]	
DASH Media ± DE	3.80 ± 2.52	2.61 ± 1.79	0.244
mediana [P_{25} –P_{75}]	3.1 [2.05-3.85]	1.70 [1.35-4.6]	
TEST DE CONSTANT Media ± DE	95.50 ±2.58	95.56 ± 3.28	0.966
mediana [P_{25} –P_{75}]	96 [94-98]	96 [93-98]	
SATISFACCIÓN GENERAL Media ± DE	8.5 ± 0.9	9.2 ± 0.67	0.058
mediana [P_{25} –P_{75}]	8 [8-9]	9 [9-10]	

Tabla 12. Resultados clínicos y cuestionarios de calidad de vida.

Seguimiento radiográfico

En la última visita de seguimiento, hubo evidencia de inestabilidad vertical remanente en 8.33% (1/12) de los pacientes del grupo-AGUDO y en ninguno de los pacientes del grupo-CRÓNICO (p=1.000). Hubo evidencia de inestabilidad horizontal remanente en 16.67% (2/12) de los pacientes del grupo-AGUDO y en 20% (2/10) de los pacientes del grupo-CRÓNICO (p=1.000).

Eventos adversos relacionados con el tratamiento y complicaciones

En la última visita de seguimiento, se registró la presencia de discinesia escapular en 8.33% (1/12) de los pacientes del grupo-AGUDO y en 10% (1/10) de los pacientes del grupo-CRÓNICO (p=1.000). No hubo ningún caso de fractura de coracoides, ni de irritación supraclavicular cutánea relacionada con las arandelas del sistema de suspensión, ni de infección; en ninguno de los grupos de tratamiento.

TRABAJO n.5: Cisneros LN, Reiriz JS. Prevalence of remaining horizontal instability in high-grade acromioclavicular joint injuries surgically managed. Eur J Orthop Surg Traumatol. 2017;27(3):323-333. doi: 10.1007/s00590-016-1898-0.)

Características de los pacientes

Un total de 53 pacientes fueron incluidos en el estudio: grupo-1CC, 20 pacientes (3 Rockwood III, 3 IV y 14 V); Grupo-2CC, 12 pacientes (3 Rockwood III, 2 IV y 7 V); grupo-GANCHO, 11 pacientes (5 Rockwood III y 6 V) y grupo-TENDÓN, 10 pacientes (1 Rockwood III, 1IV y 8V). Las características demográficas de los pacientes se muestran en la Tabla 13.

		Total (n=53)	grupo-1CC (n=20)	grupo-2CC (n=12)	grupo-GANCHO (n=11)	grupo-TENDÓN (n=10)
Edad (años)	Media [rango]	37 [19-55]	36 [25-52]	31 [19-45]	41 [19-55]	41 [33-55]
Hombre / Mujer	n(%) / n(%)	50(94.3%) / 3(5.7%)	17(85%) / 3(15%)	12(100%) / 0(0%)	11(100%) / 0(0%)	10(100%) / 0(0%)
Clasificación Rockwood						
Grado III	n(%)	12 (22.6%)	3 (15%)	3 (25%)	5 (45.5%)	1 (10%)
Grado IV	n(%)	6 (11.3%)	3 (15%)	2 (16.7%)	-	1 (10%)
Grado V	n(%)	35 (66%)	14 (70%)	7 (58.3%)	6 (54.5%)	8 (80%)
Tiempo transcurrido desde la lesión hasta la cirugía (días)	Media [rango]	29 [4-354]	9 [4-16]	8 [5-15]	7 [5-14]	203 [46-354]

Tabla 13. Características demográficas de los pacientes por grupos de tratamiento

Evaluaciones radiológicas

La inestabilidad horizontal remanente se evaluó mediante las proyecciones radiográficas de Alexander, y proyecciones axilares en 79.25% (42/53) de los pacientes, y solo mediante proyecciones axilares en 20.75% (11/53) de los pacientes. En las radiografías realizadas en la última visita de seguimiento, del total de los casos, hubo evidencia radiográfica de inestabilidad horizontal remanente en 18.87% (10/53). En cuanto a los casos en los que la inestabilidad horizontal se evaluó tanto por medio de la proyección de Alexander como por medio de la proyección axilar; aquellos en los que se registró evidencia de inestabilidad horizontal, se registró por igual en ambas proyecciones radiográficas. La prevalencia de inestabilidad horizontal posquirúrgica remanente, estratificada por grupos de tratamiento se resume en la tabla 14.

Grupo de tratamiento	Inestabilidad horizontal remanente (n=10)	No inestabilidad horizontal (n=43)
grupo-1CC (n=20)	20% (4/20)	80% (16/20)
grupo-2CC (n=12)	16.67% (2/12)	83.33% (10/12)
grupo-GANCHO (n=11)	18.18% (2/11)	81.82% (9/11)
grupo-TENDÓN (n=10)	20% (2/10)	80% (8/10)
Total (n=53)	18.87% (10/53)	81.13% (43/53)

Tabla 14. Prevalencia de inestabilidad horizontal posquirúrgica remanente, estratificada por grupos de tratamiento.

Resultados clínicos y cuestionarios de calidad de vida

Los resultados clínicos estratificados según la presencia o ausencia de inestabilidad horizontal posquirúrgica remanente se encuentran reflejados en la tabla 15. Solo se detectó una diferencia estadísticamente significativa entre el grupo-INSTAB y el grupo-NO-INSTAB para el cuestionario DASH.

Evaluaciones	Inestabilidad horizontal remanente (n=10)	No inestabilidad horizontal (n=43)	*P*
SF36 físico	57.02 ± 3.17	57.66 ± 3.30	0.583
SF36 mental	53.95 ± 3.98	55.71 ± 3.30	0.150
EVA	1.30 ± 1.49	0.83 ± 1.08	0.260
DASH	5.27 ± 5.42	3.06 ± 2.30	0.049*
TEST DE CONSTANT	93.40 ± 3.50	94.83 ± 4.30	0.333
SATISFACCIÓN GENERAL	8.70 ± 0.95	8.64 ± 1.03	0.874

*diferencia significativa.

Tabla 15. Resultados clínicos y cuestionarios de calidad de vida, estratificados según la presencia o ausencia de inestabilidad horizontal posquirúrgica remanente.

Los resultados clínicos y los cuestionarios de calidad de vida, estratificados según la técnica quirúrgica se encuentran reflejados en la Tabla 16.

Evaluaciones	grupo-1CC (n=20)	grupo-2CC (n=12)	grupo-GANCHO (n=11)	grupo-TENDON (n=10)	Kruskal-Wallis *P*
SF36 físico	58.24 ± 2.16	58.33 ± 1.15	53.70 ± 4.33	59.58 ± 1.98	0.000
SF36 mental	56.15 ± 2.21	55.25 ± 1.76	53.06 ± 6.10	56.62 ± 1.89	0.711
EVA para dolor	0.40 ± 0.50	0.92 ± 0.79	1.45 ± 1.51	1.44 ± 1.74	0.039
DASH	2.98 ± 2.03	3.80 ± 2.52	4.79 ± 5.60	2.61 ± 1.79	0.383
TEST DE CONSTANT	95.30 ± 2.45	95.50 ±2.58	91.36 ± 6.84	95.56 ± 3.28	0.036
SATISFACCIÓN GENERAL	8.85 ± 0.93	8.5 ± 0.9	8.00 ± 1.18	9.2 ± 0.67	0.030

Tabla 16. Resultados clínicos y cuestionarios de calidad de vida, estratificados según técnica quirúrgica.

Relación entre variables evaluada mediante análisis multivariante (ANOVA de dos vías, análisis de varianza)

SF36 físico versus tipo de cirugía, y versus inestabilidad horizontal posquirúrgica remanente

Hubo una diferencia significativa (p=0.002) entre las cuatro técnicas quirúrgicas, y el grupo-GANCHO mostró un valor inferior que el resto de los grupos. No hubo diferencia significativa (p=0.629) entre la presencia y la ausencia de inestabilidad horizontal posquirúrgica remanente, en relación al tipo de tratamiento.

SF36 mental versus tipo de cirugía, y versus inestabilidad horizontal posquirúrgica remanente

Hubo una diferencia significativa (p=0.036) entre las cuatro técnicas quirúrgicas, y el grupo-GANCHO mostró un valor inferior al del resto de los grupos. No hubo diferencia significativa (p=0.134) entre la presencia y la ausencia de inestabilidad horizontal posquirúrgica remanente.

EVA para el dolor versus tipo de cirugía, y versus inestabilidad horizontal posquirúrgica remanente

Hubo una diferencia significativa (p=0.012) entre las cuatro técnicas quirúrgicas, y el grupo-TENDON mostró el valor más alto. No hubo diferencia significativa (p=0.137) entre la presencia y la ausencia de inestabilidad horizontal posquirúrgica remanente.

Cuestionario DASH versus tipo de cirugía, y versus inestabilidad horizontal posquirúrgica remanente

Hubo una diferencia significativa (p=0.043) entre las cuatro técnicas quirúrgicas, y el grupo-GANCHO mostró un valor superior al del resto de los grupos. Hubo una diferencia significativa (p=0.017) entre la presencia y la ausencia de inestabilidad horizontal posquirúrgica remanente. Los valores del cuestionario DASH (a mayor valor, mayor discapacidad) fueron superiores en los pacientes con evidencia de inestabilidad horizontal posquirúrgica remanente.

Test de Constant versus tipo de cirugía, y versus inestabilidad horizontal posquirúrgica remanente

No hubo una diferencia significativa (p=0.151) entre las cuatro técnicas quirúrgicas, ni en relación con la presencia o ausencia de inestabilidad horizontal posquirúrgica remanente (p=0.337).

Satisfacción general versus tipo de cirugía, y versus inestabilidad horizontal posquirúrgica remanente

No hubo diferencia significativa (p=0.206) entre las cuatro técnicas quirúrgicas, ni entre la presencia o ausencia de inestabilidad horizontal posquirúrgica remanente (p=0.896).

En las figuras 41 y 42 se puede apreciar el impacto de la inestabilidad horizontal, según grupo de tratamiento, en cada uno de los cuestionarios clínicos.

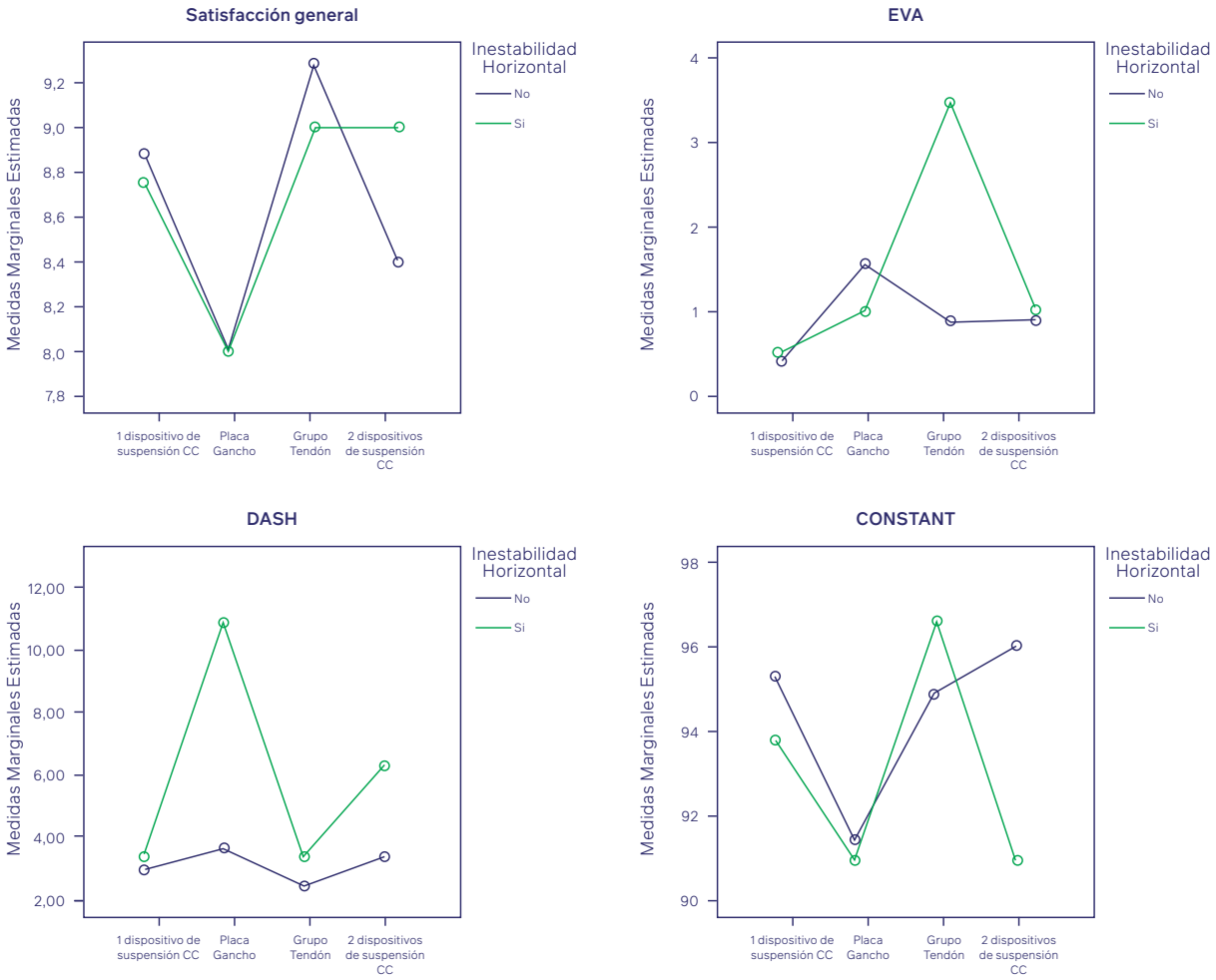


Figura 41. En este gráfico de líneas se puede observar la relación entre la presencia o ausencia de inestabilidad horizontal posquirúrgica remanente y el tipo de tratamiento, respecto a la satisfacción general, el EVA para dolor, el DASH y el test de Constant.

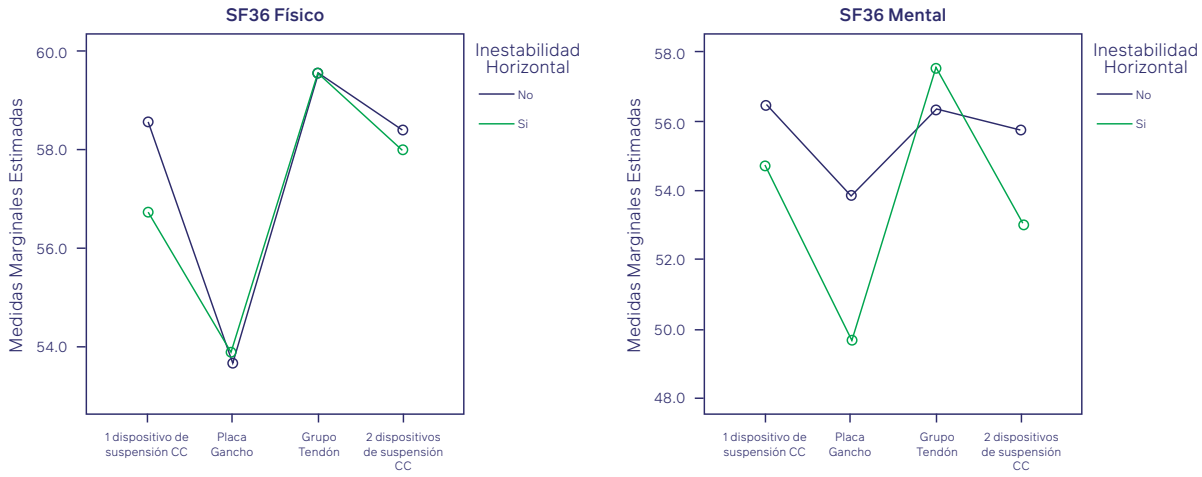
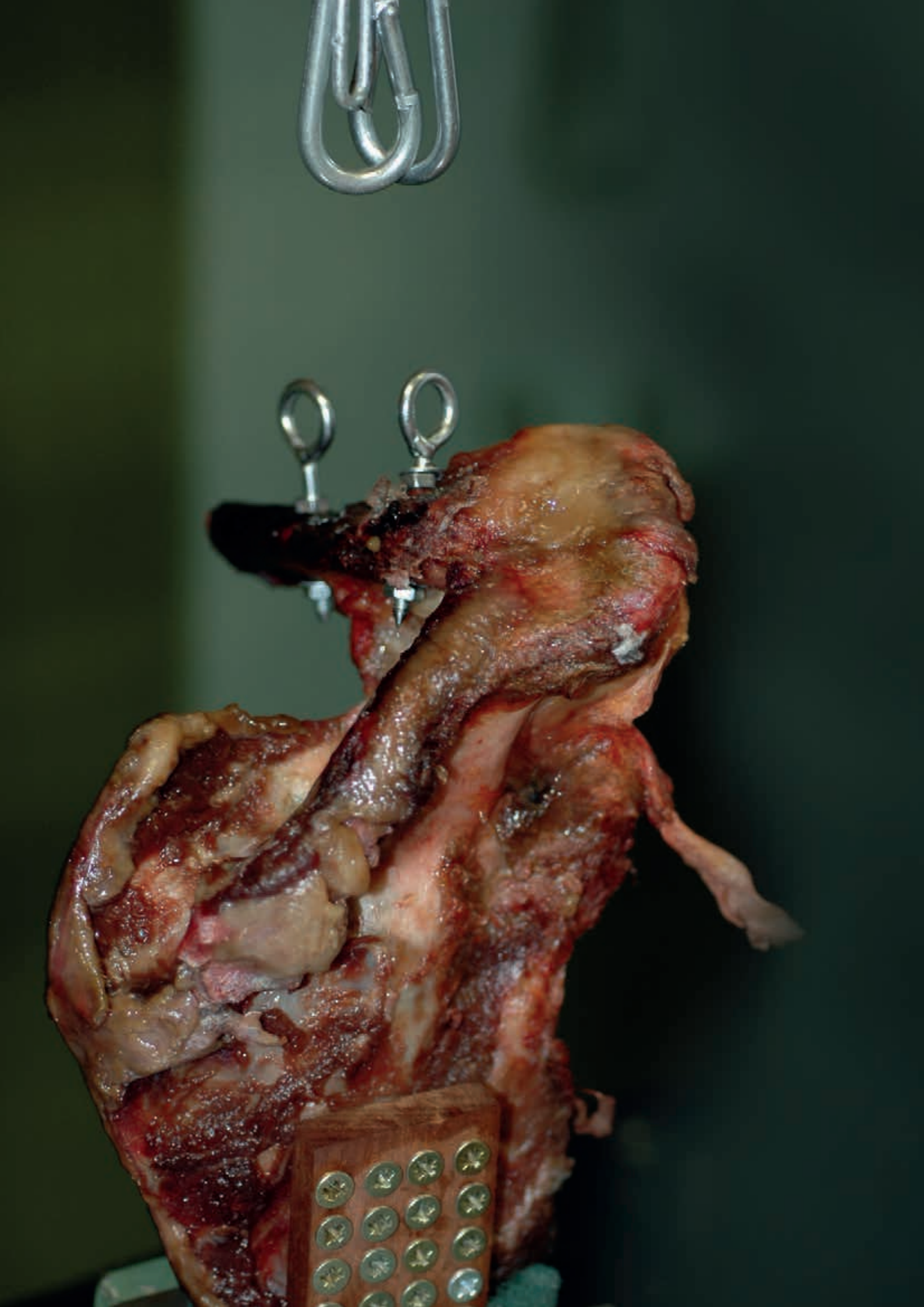


Figura 42. Gráfico de líneas en el que se puede observar la relación entre la presencia o ausencia de inestabilidad horizontal posquirúrgica remanente y el tipo de tratamiento, frente al SF36 (físico y mental).



6

DISCUSIÓN

6 Discusión

Se ha dividido la discusión en tres apartados: el primero de ellos se enfoca en el trabajo n.1, y desarrolla el tema del tratamiento conservador y el tratamiento quirúrgico con técnicas no anatómicas e implantes metálicos rígidos. El segundo apartado agrupa los trabajos n.2 y n.3, y versa sobre el tratamiento artroscópico, las lesiones glenohumerales asociadas y la fijación CC con dispositivos de suspensión no rígidos. El tercer y último apartado agrupa los trabajos n.4 y n.5; y desarrolla el tema de las reconstrucciones CC anatómicas agudas y crónicas, y el rol de inestabilidad horizontal.

6.1 Tratamiento conservador y tratamiento quirúrgico con implantes rígidos

El principal hallazgo del trabajo n.1 fue que, 24 meses o más después de haberse producido la luxación AC de alto grado, los pacientes que habían sido tratados quirúrgicamente mediante fijación AC con placa gancho tenían la misma calidad de vida que los pacientes tratados de forma conservadora, aunque los pacientes tratados de forma conservadora presentaron una mayor incidencia de discinesia escapular en la última visita de seguimiento.

Hasta donde tenemos conocimiento, se han publicado 15 estudios que comparan el tratamiento quirúrgico versus el tratamiento conservador en casos de luxaciones AC de alto grado[6–20]. La mayoría de estos estudios concluye que el tratamiento conservador puede ofrecer un mejor resultado clínico que el tratamiento quirúrgico. Como en el trabajo n.1 de esta tesis doctoral, los pacientes que fueron tratados quirúrgicamente en la mayoría de estudios, fueron tratados mediante técnicas de reducción abierta y fijación interna (RAFI) con implantes metálicos rígidos, que ya se ha demostrado que alteran la biomecánica de la articulación AC[130]. De hecho, en un análisis realizado *in vivo*, que estudiaba el movimiento AC después de la fijación con placa gancho, se demostró que el movimiento de la clavícula y la dinámica AC se alteran de forma significativa[131]. En un estudio previo realizado por nuestro grupo de investigación, en el que se comparó el tratamiento conservador versus la fijación CC no

rígida asistida por artroscopia, se describieron mejores resultados clínicos en el grupo de pacientes tratados quirúrgicamente[12]. El tipo de técnica quirúrgica puede influir sobre los resultados clínicos.

Con respecto a la RAFI con placa gancho, ha de mencionarse que el gancho de este sistema se interpone en la porción posterior de la articulación AC, y esta situación podría comprometer la adecuada cicatrización de las estructuras ligamentarias. Del mismo modo, las placas gancho han de ser extraídas de forma obligatoria, y tal y como se ha descrito previamente, el período durante el cual la placa está implantada podría implicar el desarrollo de complicaciones tales como como fractura del acromion[18,132], osteolisis acromial[133], artrosis AC, síndrome subacromial y rotura del manguito rotador[18,78,132–135]. Alleman *et al*. publicaron un estudio en el que pasaron cuestionarios a 96 traumatólogos y cirujanos ortopédicos que habitualmente trataban la patología AC traumática[136]. El resultado del estudio fue que, el tratamiento de las luxaciones AC Rockwood grado III suele ser conservador en el 41.6% de los casos, y quirúrgico en el 58.4%. Los especialistas encuestados se dividieron en 2 grupos, según si realizaban mayoritariamente cirugía traumatológica o cirugía ortopédica. En los especialistas que realizaban mayoritariamente cirugía traumatológica, hubo 3.4 veces más probabilidades de tratar las luxaciones AC mediante placa gancho que los especialistas que realizaban mayormente cirugía ortopédica[136]. Es evidente que la fijación AC con placa gancho es técnicamente menos demandante que un procedimiento artroscópico de fijación CC con dispositivos de suspensión, motivo por el cual podría representar la estrategia quirúrgica de elección en manos de traumatólogos no especializados en cirugía de hombro.

Gstettner *et al*.[18] compararon pacientes con luxaciones AC grado III tratados mediante fijación AC con placa gancho, versus pacientes tratados de forma conservadora. Estos autores aplicaron el Oxford Shoulder Score (OSS), el simple shoulder test (SST) y el test de Constant. La media del OSS fue de 18.7 en el grupo tratado conservadoramente y de 16.0 en el grupo tratado quirúrgicamente. Esta diferencia no fue estadísticamente significativa. La puntuación media de SST fue de 9.96 en el grupo de tratamiento conservador y de 11.3 en el grupo tratado quirúrgicamente. Esta diferencia no fue estadísticamente significativa. La puntuación promedio del test de Constant fue de 80.7 en el grupo tratado de forma conservadora y de 90.4 en el grupo tratado quirúrgicamente. Esta diferencia fue estadísticamente significativa[18]. Nuestros resultados no difieren demasiado de los publicados por estos autores. En el trabajo n.1 de esta tesis, el puntaje promedio del test de Constant fue de 91.36 para el grupo de pacientes tratados con placa gancho y de 91.05 para el grupo de pacientes tratados de forma conservadora, sin diferencias estadísticamente significativas.

McKee *et al*. demostraron en un ensayo clínico aleatorizado (nivel de evidencia I) en el que compararon la fijación AC mediante placa gancho versus el tratamiento conservador, que aunque la fijación AC con placa gancho resultó en una mejor alineación radiográfica, los pacientes con luxaciones AC de alto grado tratados mediante esta estrategia no tuvieron resultados clínicos superiores que los pacientes tratados de forma conservadora[137]. En este estudio se emplearon el cuestionario de DASH y el test de Constant. En la última visita de seguimiento, la puntuación media en el cuestionario DASH fue de 5 puntos en el grupo de pacientes tratados con placa gancho y de 6 puntos en el grupo de pacientes tratados de forma conservadora. Esta diferencia no fue estadísticamente significativa. El puntaje promedio en el test de Constant fue de 91 en el grupo de pacientes tratados con placa gancho y 95 en el grupo tratado de forma conservadora. Esta diferencia no fue estadísticamente significativa. Teniendo en cuenta estos resultados clínicos, los autores concluyeron que en la actualidad no hay evidencia de que el tratamiento quirúrgico mediante fijación AC con placa gancho pueda mejorar los resultados clínicos en los casos de luxaciones AC agudas de alto grado. Aunque el diseño de nuestro estudio, así como su nivel de evidencia difieren del estudio realizado por McKee *et al*.[137], nuestros resultados refuerzan los resultados presentados por los autores mencionados.

Con respecto a la biomecánica del hombro, se ha demostrado que algunos de los pacientes con luxaciones AC de alto grado podrían desarrollar discinesia escapular[126]. Asimismo, se ha demostrado que la prevalencia de discinesia escapular en aquellos pacientes que han sido tratados quirúrgicamente es menor que en los pacientes tratados de forma conservadora:11,7%[2] versus 70.6%, respectivamente[120]. En el trabajo n.1 de esta tesis, la prevalencia de discinesia escapular fue del 18% en el grupo de pacientes tratados con placa gancho, y del 52,4% en el grupo de pacientes tratados de forma conservadora. A pesar de que se ha demostrado que la presencia de discinesia escapular en pacientes con luxaciones AC puede traducirse en pérdida de fuerza y omalgia debido al desarrollo de conflicto subacromial[12,120,123]; y a pesar de que en nuestro estudio el grupo de pacientes tratados de forma conservadora tuvo una mayor prevalencia de discinesia escapular, no se encontraron diferencias significativas entre ambos grupos de tratamiento con respecto a ninguno de los cuestionarios clínicos y de calidad de vida.

Lin *et al*. describieron los resultados de una serie de 40 pacientes con historia de luxación AC tratados mediante fijación AC con placa gancho[138]. Dichos autores describieron que el 37.5% (15/40) de estos pacientes desarrollaron síndrome subacromial, y el 40% (6/15) presentó rotura del manguito rotador

diagnosticada mediante ecografía[138]. Del mismo modo, se observó erosión acromial a nivel del punto de apoyo del gancho en el 50% (20/40) de los pacientes[138]. A todos los pacientes de esta serie se les retiró la placa gancho en un tiempo medio de 5.78 meses[138]. En nuestra serie, el tiempo transcurrido desde la implantación de la placa hasta la retirada de esta fue de 3.98 meses. Cuando a los pacientes tratados mediante fijación AC con placa gancho se les preguntó acerca de su nivel de satisfacción con respecto a los resultados, muchos de ellos hicieron referencia al dolor que tuvieron en el periodo durante el cual la placa gancho estuvo implantada, información que coincide con publicaciones de otros autores[139]. Boström *et al.* describieron que los pacientes tratados con placa gancho tenían significativamente más dolor que los pacientes tratados mediante una fijación CC no rígida[91]. Dichos autores argumentaron que este hecho puede deberse a la presencia de una irritación crónica en el espacio subacromial, lo cual se puede traducir en dolor persistente[91].

6.2 Tratamiento artroscópico, lesiones asociadas y dispositivos de suspensión no rígidos

El principal hallazgo del trabajo n.2 fue que los pacientes con historia de luxación AC aguda de alto grado que fueron tratados artroscópicamente mediante una fijación CC con un dispositivo de suspensión tienen una mejor calidad de vida en términos del SF36 (físico y mental), del EVA, el test de Constant y la satisfacción general, que los pacientes tratados mediante una fijación AC con placa gancho.

El principal hallazgo del trabajo n.3 fue que la reconstrucción anatómica del complejo CC con 2 dispositivos de suspensión (doble túnel en tanto la clavícula como la coracoides) ofrece una resistencia biomecánica mas similar a la del complejo CC nativo que la reconstrucción CC con un solo sistema de suspensión con una configuración en ''V''.

En el trabajo n.2, los pacientes tratados mediante fijación CC asistida por artroscopia tuvieron una mejor puntuación en el test de Constant registrado en la última visita de seguimiento, que los pa-

cientes que fueron tratados mediante fijación AC con placa gancho. Al desglosar los ítems del test de Constant, no se encontraron diferencias en cuanto al rango de movimiento, la fuerza, ni en la presencia de limitaciones en la vida cotidiana. Sin embargo, se encontraron diferencias estadísticamente significativas con respecto al dolor en general, al dolor nocturno y a las limitaciones deportivas. Los resultados de nuestro estudio coinciden con los publicados por Andreani *et al.*[140], en cuyo grupo de pacientes manejados con el sistema TightRope® se registró un Constant promedio de 90 puntos, en comparación con el Constant del grupo de pacientes tratados con placa gancho, que tuvo un promedio de 75 puntos[140]. Por otro lado, en el estudio publicado por Jensen *et al.*[21], tanto los pacientes tratados con placa gancho, como aquéllos tratados artroscópicamente mediante fijación CC con un dispositivo de suspensión, mostraron resultados clínicos igualmente buenos. A pesar de que no hubo diferencias significativas, en el grupo de pacientes tratados con placa gancho se registró una EVA promedio de 0.8, mientras que el grupo de pacientes manejados mediante fijación CC no rígida se registró una EVA promedio de 0.4[21].

Con respecto al desarrollo de desplazamientos secundarios, Cohen *et al.* describieron una tasa de pérdida parcial de reducción del 19% (3/16) en una serie de pacientes tratados mediante una fijación CC no rígida, y con un seguimiento medio de 12 meses[141]. La tasa de pérdida de reducción observada en el grupo tratado mediante fijación CC con 1 dispositivo de suspensión del trabajo n.2 fue del 40% (8/20), con un seguimiento medio de 32.5 meses. Las diferencias entre estas 2 series de pacientes podrían estar relacionadas con el seguimiento medio (12 meses en la serie de Cohen versus 32.5 meses en el grupo de fijación CC con 1 dispositivo del trabajo n.2). Creemos que cuando se emplea solo un dispositivo de suspensión CC, que ya se ha demostrado que se puede considerar como biomecánicamente insuficiente, podría ser solo cuestión de tiempo hasta que se desarrolle una subluxación AC. Aunque parece que los resultados clínicos no se ven afectados por las subluxaciones verticales secundarias[140], actualmente con nuestro grupo de trabajo estamos haciendo reconstrucciones anatómicas con dos dispositivos de suspensión CC para evitar los desplazamientos verticales secundarios, más un anclaje "todo sutura" fijado en el acromion y cuyos hilos se pasan a través de un túnel en la clavícula para así controlar los desplazamientos horizontales; más una reconstrucción cuidadosa de la fascia deltotrapezoidea, que tiene también un papel determinante en la estabilización vertical y horizontal de la articulación AC[107]. Esta técnica la describimos en uno de los artículos de soporte esta tesis[107], pero incluso actualmente estamos colocando un segundo anclaje todo sutura, pero fijado a la clavícula, para así fijar la fascia deltotrapezoidea al hueso.

El diagnóstico y tratamiento de lesiones glenohumerales concomitantes y el hecho de que no exista la necesidad obligatoria de extraer los implantes en un segundo tiempo, son las principales ventajas de la fijación CC no rígida asistida por artroscopia[21]. Recientemente Boileau *et al.* han descrito en una serie consecutiva de 57 pacientes con historia de inestabilidad AC crónica, una prevalencia de lesiones asociadas en el 48% de los casos[142]. Asimismo, se ha descrito que las posibles lesiones intraarticulares concomitantes no tratadas, podrían representar los motivos de dolor persistente en algunos de los casos tratados mediante cirugía abierta sin acceso a la articulación glenohumeral, o tratados de forma conservadora[21]. Por estos motivos, pensamos que cuando el tratamiento quirúrgico de las luxaciones AC agudas se va a realizar mediante cirugía abierta, y sin acceso a la articulación glenohumeral, se debería considerar la realización de una resonancia magnética preoperatoria, preferiblemente con contraste, para así evitar que pasen inadvertidas posibles lesiones concomitantes, situación que podría condicionar significativamente el resultado final. En un estudio previo de nuestro grupo, se compararon los resultados clínicos de un grupo de pacientes tratados mediante fijación CC no rígida asistida por artroscopia versus un grupo de pacientes tratados mediante medidas conservadoras basadas en fortalecimiento y estabilización de la musculatura periescapular[12]. Los resultados clínicos evaluados en la última visita de seguimiento favorecieron al grupo de pacientes tratados quirúrgicamente[12]. En dicho grupo, se trataron lesiones intraarticulares concomitantes en el 20% (4/20) de los pacientes; mientras que en el grupo de pacientes tratados de forma conservadora (n=20), al no haberse realizado exploración artroscópica ni resonancia magnética, no se pudo determinar si aparte de la luxación AC de alto grado, subyacía simultáneamente una lesión glenohumeral[12].

Autores como Salzmann[23] y Walz[26] argumentan que la colocación de dos dispositivos de suspensión como sustitutos de los ligamentos conoide y trapezoide, es necesaria para conseguir una adecuada estabilidad primaria, tanto en el plano craneo-caudal como en el plano anteroposterior[23,26]. Cabe destacar que estos procedimientos pueden ser considerados como técnicamente demandantes. Algunos autores han descrito altas tasas de complicaciones intraoperatorias relacionadas con las técnicas quirúrgicas que implican la realización de túneles óseos a nivel de la clavícula y de la coracoides[143,144]. En el trabajo n.3 de esta tesis, testamos 2 reconstrucciones que emularon la disposición anatómica de los ligamentos conoide y trapezoide. Una de las configuraciones contempló una reconstrucción en ''V'', en la cual con un solo dispositivo de suspensión, 2 túneles en la clavícula y 1 túnel en la coracoides, se reconstruía anatómicamente el complejo CC. En la otra configuración se emplearon 2 dispositivos de suspensión (1 para el conoide y otro para el trapezoide), con 2 túneles tanto a nivel

de la clavícula como a nivel de la coracoides. Se registraron fuerzas promedio de 444.0 N para producir una disrupción del complejo CC nativo, mientras que el valor promedio registrado para hacer fracasar las reconstrucciones CC anatómicas con 2 dispositivos de suspensión fue de 495.51 N. Walz *et al*. registraron en un estudio biomecánico similar, una fuerza promedio necesaria para conseguir el fracaso de una reconstrucción CC con dos sistemas de suspensión, de 982 N[26]. Wellmann *et al*. registraron una fuerza promedio necesaria de 663 N para hacer fracasar una reconstrucción CC realizada con cerclajes de polidioxanona (PDS)[145], valor similar al descrito por Martetschläger *et al*.[146], que fue de 569.9 N, y que también realizaron reconstrucciones CC con cerclajes de PDS. Aunque en el trabajo n.3 de esta tesis doctoral se registraron valores inferiores a los registrados por Walz *et al*.[26] y Wellmann *et al*.[145] en términos de la fuerza necesaria para hacer fracasar la reconstrucción CC; los resultados que registramos para nuestra reconstrucción CC con 2 dispositivos, fueron muy similares a los registrados para especímenes control con complejos CC nativos.

6.3 Reconstrucción coracoclavicular aguda y crónica, e inestabilidad horizontal

El principal hallazgo del trabajo n.4 fue que los pacientes con historia de instabilidad AC aguda tratados mediante reconstrucción CC anatómica con 2 dispositivos de suspensión, tienen la misma calidad de vida y los mismos resultados radiológicos que los pacientes con historia de inestabilidad AC crónica tratados mediante reconstrucción CC anatómica con aloinjerto tendinoso más un dispositivo de suspensión.

El principal hallazgo del trabajo n.5 fue que la prevalencia de inestabilidad horizontal posquirúrgica remanente fue del 18.87% del total de los pacientes que fueron manejados mediante un procedimiento quirúrgico que no incluyó una estabilización horizontal adicional, y estos pacientes tuvieron una puntuación significativamente inferior en la escala de DASH.

En relación a la inestabilidad vertical remanente, se ha descrito que una pérdida parcial de reducción en el plano vertical puede no influir en el resultado clínico final[28]. Se ha descrito igualmente que una cicatrización del complejo CC con una elongación sutil podría proporcionar estabilidad vertical sufi-

ciente para un correcto funcionamiento del complejo suspensorio del hombro[140]. La tasa de fracaso de fijación tras del manejo quirúrgico en fase crónica, utilizando solo injerto tendinoso, se ha descrito que puede oscilar alrededor del 50% o más[116,118]; mientras que la tasa de fracaso de fijación tras el manejo quirúrgico en fase aguda se ha descrito que oscila alrededor del 26.8%[71,72,116]. Se ha descrito igualmente que este hecho puede obedecer a que los injertos tendinosos tienden a elongarse con el tiempo[119]. En el trabajo n.2 de esta tesis doctoral, en el que un grupo de pacientes fue tratado en fase aguda mediante una fijación CC con un dispositivo de suspensión, se registró una tasa de desplazamientos verticales secundarios del 40% (8/20). Con el trabajo n.4 de esta tesis, quisimos comparar los resultados clínicos y radiológicos de las luxaciones AC de alto grado manejadas mediante reconstrucciones anatómicas individualizadas de los ligamentos conoide y trapezoide, tanto en fase aguda como en fase crónica. La tasa de desplazamientos verticales secundarios del grupo de pacientes manejados en fase aguda con 2 dispositivos de suspensión fue de 8.33% (1/12), y no se registró ningún desplazamiento secundario en ninguno de los 10 pacientes tratados con aporte tendinoso mas dispositivo de suspensión, implantados en fase crónica, tal y como habíamos descrito previamente[147]. Creemos que este hallazgo puede obedecer al hecho de que agregamos un estabilizador mecánico primario a las reconstrucciones realizadas en fase crónica, que protegieron al tendón durante el período de integración al hueso. Carofino y Mazzocca publicaron una serie de 17 pacientes en los cuales los ligamentos CC fueron reconstruidos en fase crónica empleando un aloinjerto de semitendinoso pasado por debajo de la coracoides, y fijado en la clavícula mediante 2 tornillos interferenciales[95]. Dichos autores describieron una tasa de fracaso del 17.65% (3/17)[95]. Uno de esos 3 pacientes tuvo una re-luxación AC completa sin antecedente traumático. Tal y como lo describimos en una de las publicaciones de soporte de esta tesis doctoral[108], creemos que mediante la realización de un túnel a nivel de la coracoides mejoramos las probabilidades de que el injerto tendinoso se integre al hueso. Posteriormente se han descrito variaciones a nuestra técnica, que igualmente contemplan la reconstrucción CC con injerto tendinoso más dispositivo de suspensión, y que además han incorporado la reconstrucción AC con injerto de tendón[148]. En relación al trabajo n.4, los pacientes con luxaciones AC agudas de alto grado habrían de ser informados de que la reconstrucción anatómica de los ligamentos CC realizada de forma tanto temprana como tardía, podría ofrecer resultados comparables. Cabe destacar igualmente que si inicialmente se optase por un tratamiento no quirúrgico y las medidas conservadoras llegasen a fracasar, y finalmente se llegase a realizar un tratamiento quirúrgico en fase crónica; el tiempo transcurrido desde la producción de la lesión hasta la normalización clínica del hombro podría ser significativamente más largo.

6 DISCUSIÓN

Con respecto a las infecciones perioperatorias, se han descrito tasas de infección superiores en el contexto crónico que en el contexto agudo[71,72]. Esto podría obedecer al hecho de que en el contexto crónico se suelen emplear aloinjertos tendinosos. En el contexto agudo, hasta donde tenemos conocimiento, la literatura no contempla descripciones de infecciones profundas[116]. Una revisión sistemática de la literatura describe que la tasa global de infecciones superficiales oscila alrededor del 3.8% para procedimientos artroscópicos[116], en contraste con una tasa de alrededor del 5% para procedimientos realizados mediante cirugía abierta[116]; y hasta un 8% en aquellos procedimientos en los que se usó un injerto tendinoso[105,117]. En la serie de 17 pacientes de Carofino y Mazzocca, uno de los pacientes desarrolló una infección crónica, que requirió la exeresis del aloinjerto, y la realización de un colgajo de cobertura de dorsal ancho[95]. Se han descrito incluso casos de osteomielitis tras reconstrucción de la articulación AC en fase crónica[149]. En la serie de pacientes tratados mediante aloinjerto tendinoso del trabajo n.4 no se registraron infecciones superficiales ni profundas. Al comparar nuestros hallazgos con la tasa de infecciones reportada en la literatura, es probable que el bajo número de pacientes de nuestra serie (n=10) pueda explicar esta diferencia.

Con respecto a la exploración de la estabilidad AC en el plano horizontal, esta puede ser valorada mediante exploración clínica y mediante radiografías en proyección axilar o de Alexander. Se ha descrito también que la valoración de la inestabilidad AC en el plano horizontal se puede realizar mediante exploración ecográfica dinámica[150]. En una revisión sistemática reciente, Aliberti *et al*. describen que actualmente no existe consenso en relación a los métodos de diagnóstico, evaluación y tratamiento de la inestabilidad AC en el plano horizontal[151]. Irlenbusch *et al*.[152] han descrito que para realizar la exploración clínica de la estabilidad AC en el plano horizontal, la clavícula lateral debe ser sujetada por los dedos de una mano del examinador, mientras que la otra mano se encuentra fijando el acromion[152]. La magnitud del desplazamiento anteroposterior de la clavícula lateral en relación al acromion se evalúa, y se cataloga subjetivamente como horizontalmente estable o inestable[152]. En el trabajo n.5 de esta tesis doctoral, la inestabilidad horizontal posquirúrgica remanente se valoró solamente mediante exámenes radiográficos. Con respecto al examen radiológico, hay evidencia de inestabilidad horizontal remanente cuando el acromion está por debajo del tercio distal de la clavícula en la proyección de Alexander[153]; y si el borde anterior del acromion y el borde anterolateral de la clavícula distal no están alineados a nivel de la articulación AC, en la proyección axilar[129]. Del mismo modo, las luxaciones AC Rockwood Grado III se diferencian actualmente en IIIA (horizontalmente estable) y IIIB (horizontalmente inestable) de acuerdo con la diversificación de ISAKOS de la clasificación de Rockwood[69].

Las luxaciones AC IIIB se definen como aquéllas luxaciones en las que existe solapamiento del tercio distal de la clavícula por sobre el acromion en la proyección de Alexander[69]. Aunque la mayoría de los autores utilizan las proyecciones de Alexander[153] para diagnosticar la presencia de inestabilidad horizontal a nivel de la articulación AC[21,34], Lädermann *et al.*[154] describieron el uso de las proyecciones axilares para evaluar la estabilidad horizontal en su serie de pacientes con luxaciones AC agudas de alto grado tratados quirúrgicamente[154]. Estos autores describen excelentes resultados clínicos en el 91.9% de sus pacientes, pero no los estratificaron en función de la presencia o ausencia de inestabilidad horizontal posquirúrgica remanente. En el trabajo n.5 de esta tesis, si que se estratificaron los resultados clínicos en función de la presencia o no de inestabilidad horizontal posquirúrgica remanente.

Con respecto a la repercusión clínica de la inestabilidad AC en el plano horizontal, se ha descrito que los pacientes con luxaciones AC de alto grado tratados de forma quirúrgica, y que presentan inestabilidad horizontal posquirúrgica remanente, pueden tener resultados clínicos significativamente inferiores[34]. Hasta donde tenemos conocimiento, Gerhardt *et al.*[155] fueron los primeros autores que publicaron la importancia de una aumentación horizontal adicional para abordar este problema, pero han sido varias las estrategias de estabilización en el plano horizontal que han sido descritas[107,156,157]. Se ha descrito que la inestabilidad horizontal remanente es el único factor que podría repercutir negativamente en la percepción de los resultados clínicos por parte del paciente[34,114,140]. Esto puede explicarse por el hecho de que cuando hay inestabilidad anteroposterior remanente podría existir más cizallamiento en las superficies articulares AC que cuando hay inestabilidad vertical remanente. En el estudio prospectivo descrito por Scheibel *et al.*[34], en el que se utilizó la técnica de doble TightRope® para el tratamiento de las luxaciones AC agudas de grado V de acuerdo con Rockwood, se evaluaron 28 pacientes después de un seguimiento medio de 26.5 meses. En esta serie, en el 42.9% (12/28) de los pacientes se evidenció inestabilidad AC en el plano horizontal en las proyecciones radiográficas de Alexander. En dicho estudio, los pacientes en los que se registró estabilidad AC en el plano horizontal demostraron resultados clínicos superiores en todos los tests aplicados. Asimismo, estos autores desarrollaron un test para valorar la inestabilidad AC, en el que 100 puntos representan el mejor valor[34]. Los autores destacan la diferencia significativa obtenida en el test de inestabilidad AC descrito por ellos, en el cual se registró una media de 63.3 puntos en el grupo de pacientes con inestabilidad horizontal, en comparación con una media de 92.3 puntos en el grupo de pacientes sin inestabilidad horizontal[34]. Hasta donde tenemos conocimiento, el estudio realizado por Scheibel *et al.*[34] y el trabajo n.5 de esta tesis doctoral, representan las dos únicas publicaciones que relacionan la

presencia de inestabilidad horizontal AC postoperatoria con los resultados clínicos finales. Además, nuestro estudio es el primero en incluir más de una estrategia quirúrgica. Al igual que en el estudio de Scheibel *et al.*[34], en el grupo de pacientes con evidencia de inestabilidad horizontal del trabajo n.5, se registraron resultados clínicos inferiores a los del grupo de pacientes en los que se evidenció una articulación AC estable en el plano horizontal, aunque solo encontramos una diferencia estadísticamente significativa en el cuestionario DASH.

La mayoría de los procedimientos quirúrgicos descritos para el tratamiento de las luxaciones AC de alto grado se centran en la reconstrucción de los ligamentos CC con el fin de restaurar la estabilidad vertical de la articulación AC, y una menor cuantía de los procedimientos quirúrgicos descritos versan sobre la reconstrucción de los ligamentos de AC[123]. Debski *et al.* ya describieron en su estudio biomecánico publicado en 2001, que la estabilidad horizontal de la articulación AC no puede restaurarse completamente reconstruyendo solo los ligamentos CC[61]. De la misma manera, estudios biomecánicos más recientes han reafirmado que la reconstrucción aislada de los ligamentos CC no proporciona suficiente estabilidad horizontal a la clavícula lateral, y por lo tanto recalcan la importancia de una aumentación AC adicional a la reconstrucción CC[32,33,158]. Incluso recientemente se empieza a enfatizar la importancia de la reconstrucción de la fascia deltotrapezoidea para conseguir una estabilidad horizontal de la clavícula distal. En este sentido, Hislop *et al.* desarrollaron un estudio biomecánico en el que emplearon un total de 24 hombros de especímenes cadavéricos, en el cual se asignaron al azar a 3 grupos de tratamiento[159]. Se utilizaron las siguientes técnicas de reconstrucción: un túnel clavicular único para el grupo A, 2 túneles a nivel de la clavícula para el grupo B, y 2 túneles a nivel de clavícula más fijación con sutura de la articulación AC para el grupo C. No se registraron diferencias en estabilidad bidireccional al comparar los 3 grupos. Los autores concluyeron que la adición de una estabilización AC con sutura podría incluso no ser suficiente para garantizar la estabilidad horizontal de la articulación, en ausencia de reparación de la fascia deltotrapezoidea[159]. Recientemente se han descrito procedimientos en los que se emplean anclajes "todo sutura" tanto para la fijación CC como para la fijación AC[160]. A la técnica descrita en uno de los artículos de soporte de esta tesis, en la cual describimos procedimiento que proponemos para estabilizar la articulación AC tanto en el plano vertical como en el plano horizontal[107], actualmente le estamos añadiendo un segundo anclaje "todo sutura" fijado en la clavícula distal, que permite la reconstrucción e imbricación de la fascia deltotrapezoidea sobre el complejo AC. La relevancia clínica del trabajo n.5 de esta tesis, radica en el hecho de que la inestabilidad horizontal remanente puede tener una prevalencia no menospreciable en las

luxaciones AC de alto grado que han sido tratadas quirúrgicamente; y representa un factor que puede influir negativamente en los resultados clínicos finales. Teniendo en cuenta toda la evidencia disponible, en las luxaciones AC de alto grado las estrategias quirúrgicas deben dar la misma importancia a la reconstrucción AC que a la reconstrucción CC[110].

6.4 Limitaciones de los estudios presentados

TRABAJOS n.1, 2, 4 y 5:

La principal limitación de estos 4 estudios radica en su diseño retrospectivo. Los pacientes no fueron aleatorizados antes de someterse a un tratamiento u otro. El número de pacientes es relativamente bajo. El rango de edad es amplio. Las valoraciones clínicas realizadas a través de los cuestionarios de calidad de vida se realizaron una sola vez. No se realizaron comparaciones entre el hombro lesionado y el hombro sano.

Todos los pacientes tratados mediante técnicas quirúrgicas con asistencia artroscópica fueron intervenidos por el mismo cirujano de hombro, mientras que el grupo de pacientes tratado mediante fijación AC con placa gancho fue intervenido por varios cirujanos de traumatología general.

El grupo de pacientes tratado de forma conservadora se conformó por los pacientes que escogieron voluntariamente no ser tratados quirúrgicamente, a pesar de que fueron informados sobre las indicaciones terapéuticas internacionalmente aceptadas para el manejo de estas lesiones. Al momento de realizar la recogida de datos y de conformar los grupos de tratamiento del trabajo n.1, ninguno de los pacientes del grupo de tratamiento conservador había sido intervenido quirúrgicamente. A diferencia de este grupo, los pacientes tratados mediante reconstrucción CC con aloinjerto tendinoso del trabajo n.4 fueron aquéllos que inicialmente rechazaron el tratamiento quirúrgico en el contexto agudo, y que finalmente optaron por el tratamiento quirúrgico al valorar que las medidas conservadoras habían fracasado. La información sobre la presencia o ausencia preoperatoria discinesia escapular en el grupo de pacientes tratados mediante reconstrucción CC con aloinjerto tendinoso no había sido registrada en las historias clínicas.

6 DISCUSIÓN

No se realizaron resonancias magnéticas preoperatorias, con lo que la valoración de la posible presencia de lesiones glenohumerales asociadas solo se pudo realizar en aquéllos pacientes que fueron tratados artroscópicamente. En este sentido, en el grupo de pacientes tratados mediante fijación AC con placa gancho no se pudo valorar la presencia de posibles lesiones glenohumerales concomitantes.

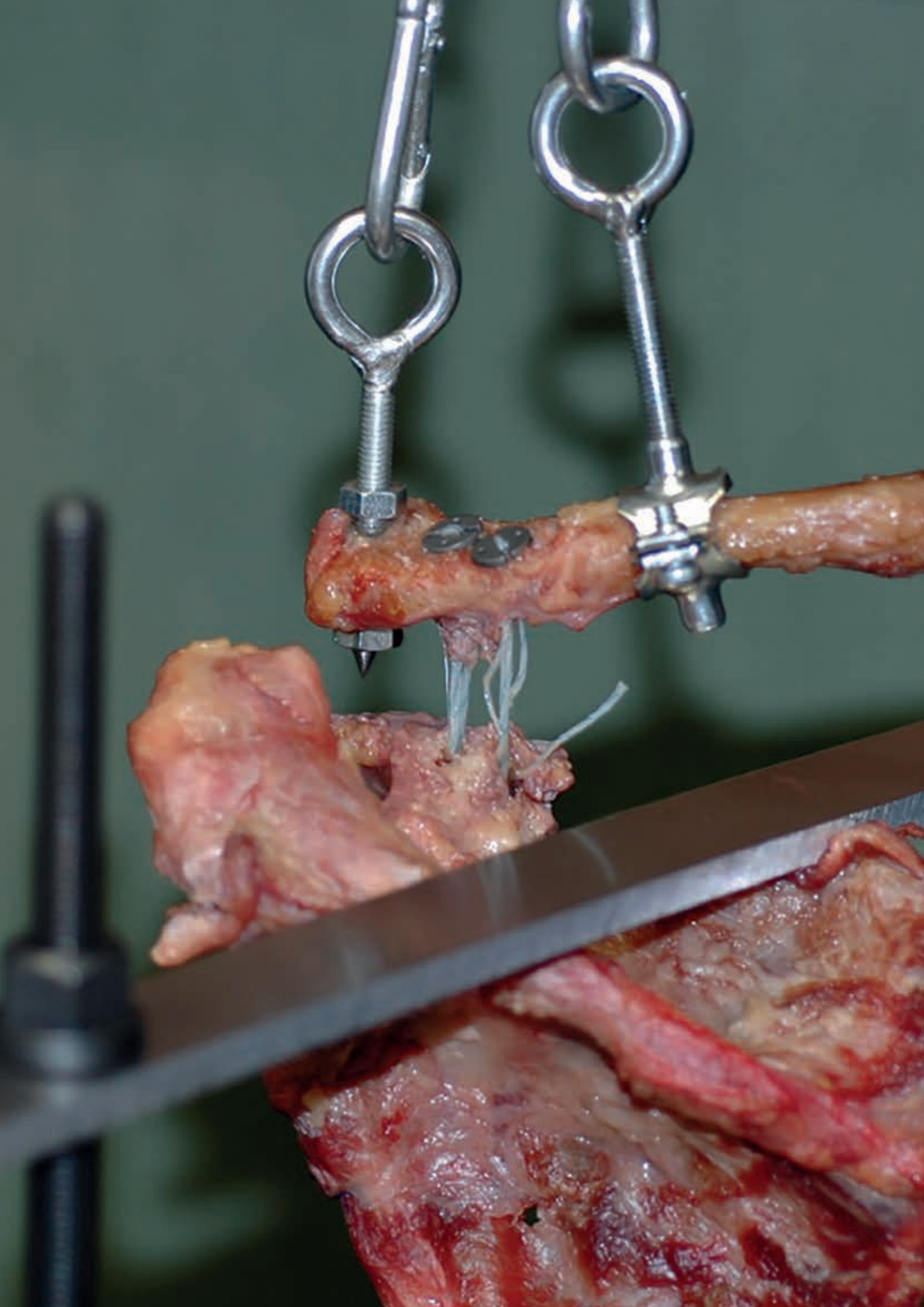
El protocolo radiográfico no fue exactamente el mismo en las tres instituciones. En el grupo de pacientes tratados mediante fijación AC con placa gancho, la inestabilidad horizontal se evaluó solo mediante proyecciones axilares, mientras que en los otros grupos de tratamiento la inestabilidad horizontal se evaluó tanto mediante proyecciones axilares como de Alexander. Los resultados obtenidos no se estratificaron según los diferentes grados de Rockwood. En el trabajo n.5, aunque la distribución de las variables cuantitativas fue "no normal", se realizó un análisis multivariante (ANOVA de dos vías, análisis de varianza). Por otro lado, al estratificar los cuestionarios de calidad de vida según la presencia o ausencia de inestabilidad horizontal remanente, la comparación entre estos dos grupos se realizó mediante la prueba de Mann-Whitney. Los valores de p obtenidos cuando los resultados clínicos de las cuatro técnicas quirúrgicas diferentes se compararon mediante el análisis multivariante fueron similares pero no iguales a los obtenidos mediante la prueba de Kruskal-Wallis.

No se realizaron evaluaciones clínicas para valorar la inestabilidad horizontal remanente. El cuestionario específico para la valoración de las luxaciones AC descrito por Scheibel *et al.*[34] no fue empleado.

La principal fortaleza metodológica de los trabajos n.1, 2, 4 y 5 viene representada por el hecho de que las evaluaciones clínicas y radiológicas se realizaron prospectivamente, una vez que se formularon los objetivos de los estudios.

TRABAJO n.3

La principal limitación de este estudio radica en el hecho de que una valoración biomecánica difiere inherentemente de una situación clínica. Otra debilidad de este estudio es que las reconstrucciones no fueron testadas ni en el plano anteroposterior ni en el plano rotacional. La edad promedio de los especímenes cadavéricos fue de 58 años, la cual es más elevada que el rango etario habitual de presentación de estas lesiones. Dado que es esperable que las características estructurales y biomecánicas de los ligamentos se deterioren con los años, se podrían esperar resultados algo diferentes si se hubiesen empleado especímenes cadavéricos de individuos más jóvenes. Otra debilidad importante a destacar, es que se rompieron dos especímenes del grupo en el que se realizó una reconstrucción CC con 2 dispositivos de suspensión.



7

CONCLUSIONES

7 Conclusiones

TRABAJO n.1: Natera Cisneros LG, Sarasquete Reiriz J. Acute high-grade acromioclavicular joint injuries: quality of life comparison between patients managed operatively with a hook plate versus patients managed non-operatively. Eur J Orthop Surg Traumatol. 2017;27(3):341-350. doi: 10.1007/s00590-016-1862-z

Los pacientes con luxaciones AC agudas de alto grado tratados quirúrgicamente mediante fijación AC con placa gancho podrían presentar los mismos resultados clínicos que los pacientes con luxaciones AC de alto grado tratados de forma conservadora, 24 meses o más tras haberse producido la lesión.

TRABAJO n.2: Natera-Cisneros L, Sarasquete-Reiriz J, Escolà-Benet A, Rodriguez-Miralles J. Acute high-grade acromioclavicular joint injuries treatment: Arthroscopic non-rigid coracoclavicular fixation provides better quality of life outcomes than hook plate ORIF. Orthop Traumatol Surg Res. 2016;102(1):31-9. doi: 10.1016/j.otsr.2015.10.007.

Los pacientes con luxaciones AC agudas de alto grado tratados mediante fijación CC con un dispositivo de suspensión implantado con asistencia artroscópica, podrían tener una mejor calidad de vida que aquellos pacientes tratados quirúrgicamente mediante fijación AC con placa gancho, 24 meses o más después de la intervención.

TRABAJO n.3: Abat F, Sarasquete J, Natera LG, Calvo Á, Pérez-España M, Zurita N, Ferrer J, del Real JC, Paz-Jimenez E, Forriol F. Biomechanical analysis of acromioclavicular joint dislocation repair using coracoclavicular suspension devices in two different configurations. J Orthop Traumatol. 2015;16(3):215-9. doi: 10.1007/s10195-015-0346-y.

La reconstrucción CC con 2 dispositivos de suspensión, con 2 túneles tanto a nivel de la coracoides como a nivel de la clavícula, implantados con orientación anatómica; presenta un comportamiento biomecánico similar al de un complejo CC nativo, en términos de la resistencia ante fuerzas de distracción en el plano vertical.

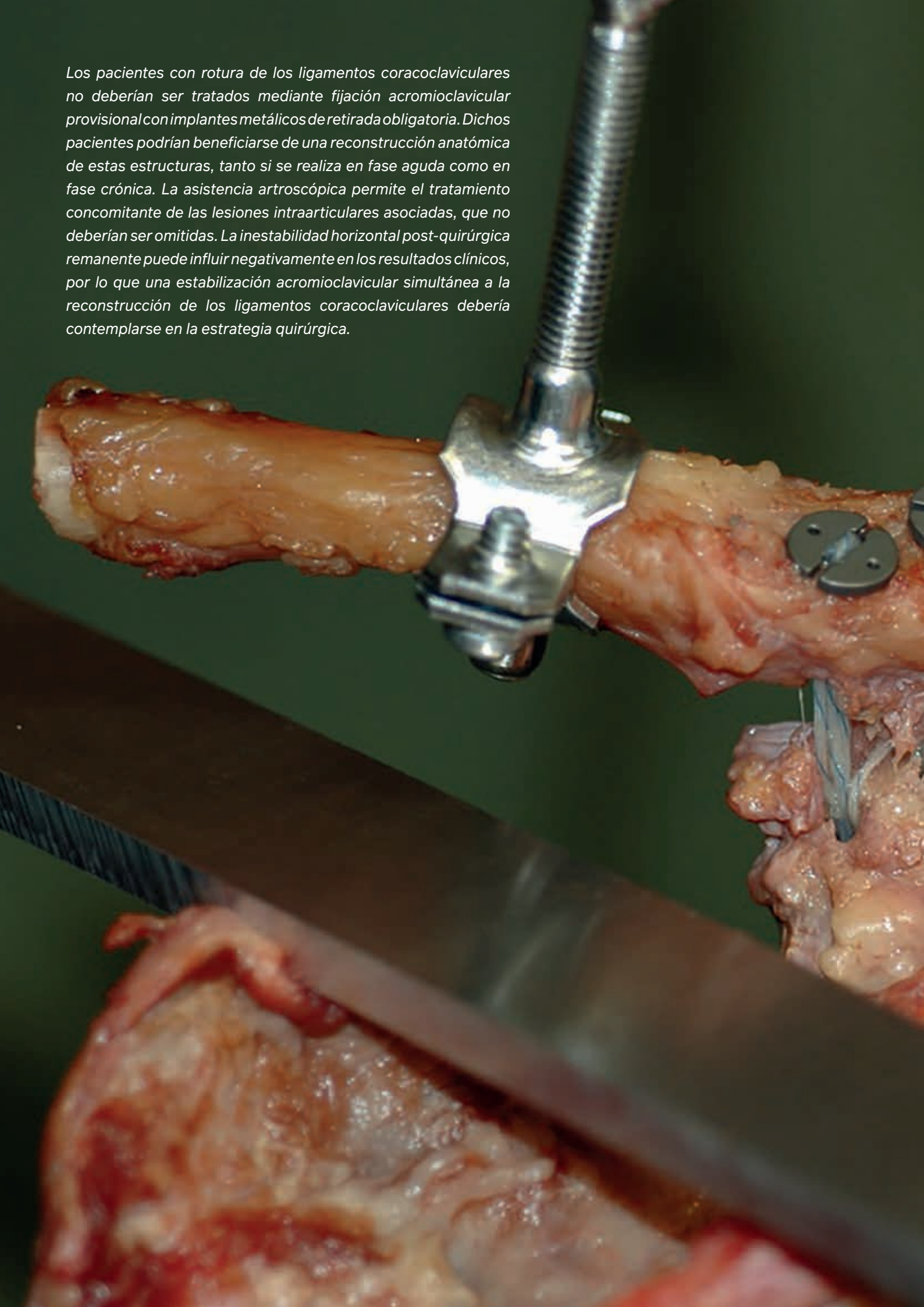
TRABAJO n.4: Natera Cisneros L, Sarasquete Reiriz J. Unstable acromioclavicular joint injuries: Is there really a difference between surgical management in the acute or chronic setting? J Orthop. 2016;14(1):10-18.

Los pacientes con historia de luxación AC de alto grado que han sido tratados mediante reconstrucción anatómica del complejo CC, tanto en fase aguda o en fase crónica; podrían tener resultados clínicos y radiológicos comparables, si se han respetado las premisas biológicas y mecánicas inherentes al momento en el que se ha realizado el procedimiento quirúrgico.

TRABAJO n.5: Cisneros LN, Reiriz JS. Prevalence of remaining horizontal instability in high-grade acromioclavicular joint injuries surgically managed. Eur J Orthop Surg Traumatol. 2017;27(3):323-333. doi: 10.1007/s00590-016-1898-0.

La inestabilidad AC horizontal remanente puede estar presente en casi una quinta parte de los pacientes con historia de luxación AC que han sido tratados quirúrgicamente. Estos pacientes perciben mas limitaciones subjetivas a nivel del desempeño funcional del hombro.

Los pacientes con rotura de los ligamentos coracoclaviculares no deberían ser tratados mediante fijación acromioclavicular provisional con implantes metálicos de retirada obligatoria. Dichos pacientes podrían beneficiarse de una reconstrucción anatómica de estas estructuras, tanto si se realiza en fase aguda como en fase crónica. La asistencia artroscópica permite el tratamiento concomitante de las lesiones intraarticulares asociadas, que no deberían ser omitidas. La inestabilidad horizontal post-quirúrgica remanente puede influir negativamente en los resultados clínicos, por lo que una estabilización acromioclavicular simultánea a la reconstrucción de los ligamentos coracoclaviculares debería contemplarse en la estrategia quirúrgica.



8

COPIAS DE LOS TRABAJOS

8 Copias de los Trabajos

8.1 Publicaciones base de la tesis doctoral

8.1.1

Eur J Orthop Surg Traumatol
DOI 10.1007/s00590-016-1862-z

ORIGINAL ARTICLE • SHOULDER - TRAUMA

Acute high-grade acromioclavicular joint injuries: quality of life comparison between patients managed operatively with a hook plate versus patients managed non-operatively

Luis Gerardo Natera Cisneros[1,2] · **Juan Sarasquete Reiriz**[1,3]

Received: 31 May 2016 / Accepted: 29 September 2016

Abstract
Introduction Surgical indication for acromioclavicular joint (ACJ) injuries still represents a reason for shoulder and trauma debate. In high-grade injuries, surgery is advocated because some of the non-operatively managed patients may have persistent shoulder pain that could make them unable to return to their previous activity. It has been shown that many of the patients with high-grade ACJ injuries that are managed non-operatively involve the development of scapular dyskinesis, situation that may result in loss of strength and weakness. On the other side, it has been widely reported that the period while the hook plate is present involves functional limitations and pain. The purpose of this study was to compare the quality of life (QoL) of patients with acute high-grade ACJ injuries (Rockwood grade III–V), managed operatively with a hook plate versus the QoL of patients managed non-operatively, 24 months or more after shoulder injury.
Patients and methods Patients with acute high-grade ACJ injuries managed operatively (hook plate) or non-operatively, between 2008 and 2012 were included. The QoL was evaluated by means of the Health Survey questionnaire (SF36), the Visual Analogue Scale (VAS) for pain, the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire, the Constant score and the Global Satisfaction (scale from 0 to 10) assessed at the last follow-up visit. The presence of scapular dyskinesis was assessed. Comparison between groups was made.
Results Thirty-two patients were included: 11 hook plate-group (PLATE group) (5 Rockwood III and 6 V) and 21 conservative-group (CONS group) (4 Rockwood III and 17 V). The mean age was 41 [19–55] years old for the PLATE group and 38 [19–55] for the CONS group ($p = 0.513$). The mean follow-up was 32.50 ± 11.64 months for the PLATE group and 34.77 ± 21.98 months for the CONS group ($p = 0.762$). The mean results of the questionnaires assessed at the last follow-up visit were: (1) physical SF36 score (PLATE group 53.70 ± 4.33 and CONS group 52.10 ± 6.11, $p = 0.449$); (2) mental SF36 score (PLATE group 53.06 ± 6.10 and CONS group 56.99 ± 6.47, $p = 0.110$); (3) VAS for pain (PLATE group 1.45 ± 1.51 and CONS group 1.50 ± 1.79, $p = 0.943$); (4) DASH score (PLATE group 4.79 ± 5.60 and CONS group 5.83 ± 6.76, $p = 0.668$); (5) Constant score (PLATE group 91.36 ± 6.84 and CONS group 91.05 ± 7.35, $p = 0.908$); (6) Global Satisfaction (PLATE group 8.00 ± 1.18 and CONS group 8.45 ± 1.73, $p = 0.449$). There was evidence of scapular dyskinesis in 18 % (2/11) of the patients of the PLATE group and in 52.4 % (11/21) of the patients of the CONS group ($p = 0.127$).
Conclusions Patients with acute high-grade ACJ injuries managed operatively with a hook plate may have the same QoL and self-reported questionnaires than patients with high-grade ACJ injuries managed non-operatively, 24 months or more after shoulder injury. If surgery is advocated for this type of injury, the orthopedic population must be aware that the hook-plate system might not represent the most suitable option.
Level of evidence Level IV therapeutic; retrospective comparative study.

✉ Luis Gerardo Natera Cisneros
luisgerardonaterac@gmail.com

[1] Hospital de la Santa Creu i Sant Pau, Universitat Autònoma de Barcelona, Sant Quintí 89, 08026 Barcelona, Spain

[2] Hospital General de Catalunya, Pedro i Pons 1, 08190 Sant Cugat del Vallés, Barcelona, Spain

[3] Hospital Quirón Teknon, Vilana 12, 08022 Barcelona, Spain

Published online: 12 October 2016

Keywords High-grade acromioclavicular joint injuries · Quality of life · Hook plate · Non-operative management · Scapular dyskinesis

Introduction

Surgical indication for acromioclavicular joint (ACJ) injuries still represents a reason for shoulder and trauma debate. In high-grade injuries, surgery is advocated because some of the non-operatively managed patients may have persistent shoulder pain that could make them unable to return to their previous activity [1]. It has been shown that many of the patients with high-grade ACJ injuries that are managed non-operatively involve the development of scapular dyskinesis, situation that may result in loss of strength and weakness [2].

Many different surgical techniques have been described: anatomic and non-anatomic procedures, performed by means of open or arthroscopy-assisted surgery. Most of the studies that compared operative versus non-operative management involved open reduction and internal fixation (ORIF) with metal hardware [3–16]. In most of these studies in which open procedures with metal hardware were used, better outcomes for the non-operative managed were described. On the other side, comparison of the non-operative management versus the operative management by means of a coracoclavicular (CC) suspension device placed with arthroscopic control has resulted in better outcomes for the surgically managed patients [17].

Metal hardware around the ACJ alters its biomechanics, thus involving a second surgical procedure for implant removal once the native structures have healed [18]. Likewise, the hook-plate system has been related to high rates of fixation failures and complications [19]; although patients managed with this system have been described to have good clinical outcomes [20]. On the other side, it has been reported that the period while the plate is implanted involves functional limitations and pain for this group of patients [21]. Pain related to hook plates has been previously attributed to bone edema in the acromion [22], because the disruption of the shoulder suspensory complex makes that the whole upper limb ends hanging from the hook.

The hook plate should be removed before allowing overhead shoulder activities, and motion restriction should be emphasized until removal [23]. Orthopedic surgeons' main concern is that hook of this system may damage the underlying structures [22, 24]. These implant-related adverse effects might influence patient's final functional outcome [25].

Despite the evidence currently available, the hook plate represents a surgical strategy, which is still widely considered. To our knowledge, there is scarce evidence in regards to the management of acute high-grade ACJ injuries comparing the quality of life (QoL) of patients managed with a hook plate versus the QoL of patients managed non-operatively [10].

From previous studies [17], we are aware that the conservative measures in cases of high-grade ACJ injuries may involve some drawbacks, but at the end, clinical outcomes of the majority of patients can be considered at least good [17]. On the other side, and despite the fact that the hook-plate system may allow persistent reduction of the ACJ in 64 % of the patients [22], we believe that the way this system maintains the ACJ reduced while the implant is present represents a biomechanical drawback that might finally result in adverse outcomes.

The aim of this study was to compare the QoL of patients with acute high-grade ACJ injuries managed operatively with a hook plate versus the QoL of patients managed non-operatively, 24 months or more after shoulder injury.

The hypothesis of this study was that patients with high-grade ACJ injuries managed non-operatively have at least comparable clinical outcomes in terms of the QoL and patient self-reported questionnaires when compared to patients managed non-operatively.

Methods

Study design

A retrospective cohort study was performed in three tertiary hospitals. Patients diagnosed of high-grade ACJ injuries (Rockwood grade III–V) and managed operatively (open reduction and internal fixation with a hook plate) and non-operatively by means of functional therapy based on scapular stabilization, were included. All patients gave their written informed consent and accepted that data from their medical files could be used for purposes of this scientific research.

Population

The study population was obtained from records registered in previous studies [17, 22]. The whole population and the study period were the same. The flowchart for enrollment of the patients, and the inclusion and exclusion criteria were quite similar to these previous publications. Differences between these three studies rely on the treatment methods compared.

All records of the shoulder and trauma clinics of these three institutions coded as "ACJ injuries" between January 1, 2008 and January 31, 2012 were revised. Patients were included in the study following these criteria: (a) either sex; (b) radiographic diagnosis at the moment of revision of the radiological records of high-grade ACJ injury (Rockwood grade III–V) observed in the X-rays performed at the initial visit post-injury; (c) physically active and between 18- and 55-year old at the moment of acute injury; (d) managed surgically by means of an open reduction and internal fixation with a hook plate (PLATE group) or conservatively (CONS group); (f) with a clinical history and radiological examination complete and available at the moment of the revision of the records; and (g) with a minimum follow-up of 24 months after treatment decision. The exclusion criteria were: (a) surgical treatment 3 weeks after ACJ injury (because it has been described that after this period the CC ligaments lack of healing potential [17], and this study is about acute ACJ injuries), (b) concomitant previous injuries to the respective shoulder and (c) surgical techniques other than fixation with a hook plate. The flowchart of the enrollment process is shown in Fig. 1. For the purposes of this revision, information regarding patients of the PLATE group was taken from a previous study [22], and information regarding patients of the CONS group from another study [17]. These data previously registered were compared.

Quality of life (QoL) assessments

The QoL was assessed by means of:

(a) The SF36: (1) physical and (2) mental,
(b) The VAS of the injured shoulder: "0" corresponding to "no pain" and "10" corresponding to "the worst pain imaginable,"
(c) The DASH questionnaire,
(d) The Constant score,

and

(e) The "Global Satisfaction" scale (numerical rating scale from 0 to 10; being 0, not satisfied with the treatment, and 10, completely satisfied with the results of the treatment).

Treatment decision making

There was neither preselection nor randomization for each type of treatment. The sample was conformed by all of the patients of the retrospectively reviewed study period, who fulfilled the inclusion criteria. Patients with acute ACJ injuries Rockwood grade IV–V were informed that there were international recommendations regarding the surgical management for this type of lesions [1]; and patients with Rockwood grade III ACJ injuries were informed that there

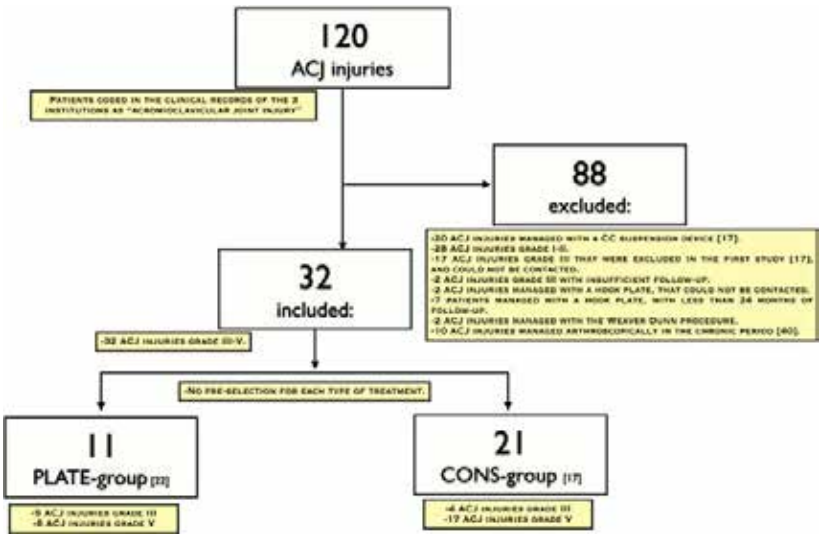


Fig. 1 Flowchart showing the enrollment process of the population

were no evidence-based medical guidelines for decision making and that surgery was recommended in active patients with high demands on the shoulder function [1]. The CONS group was conformed by the patients who preferred not to be managed by means of surgery, despite they were informed about internationally accepted recommendations.

Patients were informed about the different possible treatment options. Specifically, patients were told that non-operative management would consist of initial immobilization of the shoulder by means of wearing a sling and functional therapy based on scapular stabilization. Patients were also told that the deformity of the shoulder would persist that the ACJ could be painful in the future.

Management

Surgical technique PLATE group: This technique has been previously described [22]. Fluoroscopy was positioned at the head of the bed. A standard anterior approach to the clavicle was performed. The ACJ dislocation was exposed and reduced under direct visualization. Hook plates (Synthes, West Chester, USA) were used in all patients. The soft tissue dorsal to the ACJ was dissected in order to allow the insertion of the hook. Detachment of the extracapsular fibers of the trapezius from the medial border of the acromion was performed. The hook was passed below the acromion, and the plate was then applied. Plates were then secured to the clavicle shaft with four or five 3.5-mm cortical screws, approximating the plate to the clavicle. Proper reduction and fixation was checked with fluoroscopy. The deltotrapezial fascia was carefully sutured in order to guarantee an appropriated coverage of the plate. The skin was closed with staples in all cases.

CONS group treatment consisted of immobilization of the respective arm in a sling until the acute pain subsided, as well as anti-inflammatories and physical therapy with a standardized protocol, based on scapular stabilization.

Rehabilitation period

Patients were advised to wear a sling for 3–4 weeks. They were initially allowed to move fully and actively the elbow, wrist and hand. Pendulum exercises begin from the first week post-injury in both groups. Patients of the PLATE group were allowed to passively move the shoulder no more than 90° of elevation in the plane of the scapula after the first week in both groups. The active range of motion was progressively advanced from the sixth week onwards in both groups. Exercises to regain strength were initiated once the patient had full, pain-free passive and active range of motion, and exercises were primarily directed toward scapular stabilization. Return to work without restrictions was allowed after 12–14 weeks, and contact sports or major efforts were avoided for 4 months in the PLATE group (after plate removal) and earlier in the CONS group if patients were asymptomatic.

ACJ injury classification

Grade III and grade V injuries were differentiated according to the traditional Rockwood classification. A grade III if the CC distance of the injured shoulder was increased between 25 and 100 % when compared to the non-injured shoulder; and a grade V if the CC distance of the injured shoulder was increased between 100 and 300 % when compared to the non-injured shoulder [26]. These measurements were taken on standardized Zanca views. Diagnosis of ACJ injuries Rockwood grade IV was made by means of observation in the axillary view of the clavicle posteriorly dislocated in relation to the acromion. For the purposes of this study, the classification of the ACJ injuries registered in the records could not be updated according to the ISAKOS diversification of the Rockwood classification [27] as it was done in a previous study [17], because radiographic assessments of both shoulders with the Alexander projection were not performed at the initial visit post-injury in one of the three institutions (where patients of the PLATE group were managed).

Radiographic follow-up

Radiographic follow-up evaluations were based on the X-rays performed at the last follow-up visit. These assessments consisted on standardized Zanca views. In the PLATE group, the maintenance of ACJ postsurgical reduction and the development of postsurgical secondary vertical displacement were radiologically evaluated according to the modified Rosenørm and Pedersen classification [3]. The ACJ was considered reduced, when there was no displacement in comparison with the non-injured side, subluxed when there was less than 50 % of displacement of the clavicle in relation to the height of the acromion and completely dislocated if the displacement of the clavicle was greater than 50 % of the height of the acromion [3].

In both groups, the development of osteoarthritis, calcification of the CC ligaments and distal third clavicle osteolysis were evaluated.

Complications

Scapular dyskinesis was defined according to Kibler's definition, as the alteration of the normal position or motion of the scapula during coupled scapulohumeral movements [28].

The presence of scapular dyskinesis was assessed at the last follow-up visit, by means of the "yes/no" method described by Kibler's group [29]. This test consists of the evaluation of the scapular motion by the physician when subjects are performing shoulder forward flexion. It is a modification of the Kibler's four-type method and simplifies dyskinesis categories (types I to III) into a single category of "yes" (presence of dyskinesis), and type IV is labeled as "no" (normal scapular motion).

Comparison between these two groups was performed.

Statistical analysis

In this cohort study, no formal sample size was calculated. The sample was conformed by all of the patients of the study period who fulfilled the inclusion criteria. Statistical analysis was carried out according to the complete sample analysis.

Continuous variables are presented as mean and standard deviation (SD) or mean and range. Categorical variables are presented as percentages and frequencies. The relationship between the variables was analyzed with contingency tables for the categorical ones, and the inference was studied with the χ^2 test or Fisher's exact test depending on what corresponded. Comparisons between treatments were made regarding only the injured shoulder. Comparisons between the function of the injured shoulder and the uninjured one were not made. The T test was applied to analyze quantitative variables and the χ^2 for categoric variables. The χ^2 test and the analysis of variance were used to compare preoperative and postoperative results. The level of significance was set at 5 % ($\alpha = 0.05$). Data were analyzed by use of the SPSS 19 (SPSS Inc., Chicago, IL).

Results

Population characteristics

A total of 32 (29 men, 3 female) out of 120-screened patients were included: 11 PLATE group and 21 CONS group. Figure 1 shows the flowchart for enrollment of the patients. Table 1 shows the baseline characteristics of the study population by treatments groups. The mean age was 41 [19–55] years old for the PLATE group and 38 [19–55] for the CONS group ($p = 0.513$). The mean follow-up was 32.50 ± 11.64 months for the PLATE group and 34.77 ± 21.98 months for the CONS group ($p = 0.762$). The mean time elapsed from implantation of the hook plate until its removal was 3.98 ± 1.71 months. In Fig. 2a, the shoulder of a patient of the PLATE group can be observed, and in Fig. 2b, the shoulder of a patient of the CONS group.

Quality of life assessments

The results of SF36 questionnaire for physical and mental domains, VAS for pain of the injured shoulder, DASH questionnaire, Constant score, and "Global Satisfaction" scale are presented in Table 2. No significant differences were found between the two treatment groups.

Table 1 Baseline characteristics of patients by treatment groups

	Total ($n = 32$)	PLATE group ($n = 11$)	CONS group ($n = 21$)	p value
Age (year old) [range]	38 [19–55]	41 [19–55]	38 [19–55]	0.513
Male/female n (%)/n (%)	29 (90.6 %)/3 (9.4 %)	11 (100 %)/0 (0 %)	18 (86 %)/3 (14 %)	0.534

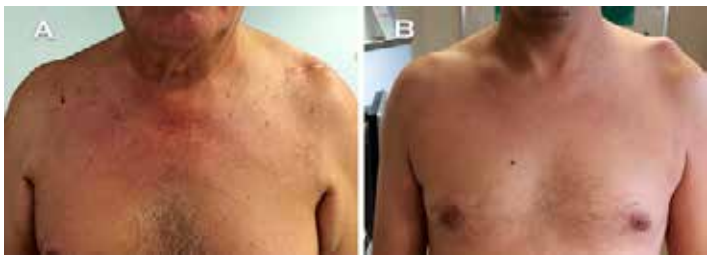


Fig. 2 **a** Clinical picture in which a left shoulder of a patient of the PLATE group can be observed. **b** Clinical picture in which a left shoulder of a patient of the CONS group can be observed

Table 2 Quality of life results

Quality of life evaluations	PLATE group ($n = 11$)	CONS group ($n = 21$)	p value
SF36 for physical domain			
Mean	53.70 ± 4.33	52.10 ± 6.11	0.449
SF36 for mental domain			
Mean	53.06 ± 6.10	56.99 ± 6.47	0.110
VAS for pain			
Mean	1.45 ± 1.51	1.50 ± 1.79	0.944
DASH questionnaire			
Mean	4.79 ± 5.60	5.83 ± 6.76	0.668
Constant score			
Mean	91.36 ± 6.84	91.05 ± 7.35	0.908
Global Satisfaction			
Mean	8.00 ± 1.18	8.45 ± 1.73	0.449

Table 3 Scapular dyskinesis and ACJ dislocations registered at the last follow-up visit

	Total ($n = 32$)	PLATE group ($n = 11$)	CONS group ($n = 21$)	p value
Scapular dyskinesis				
n (%)	13 (40.63 %)	2 (18 %)	11 (52.4 %)	0.127
ACJ dislocations				
n (%)	25 (78.13 %)	4 (36.36 %)	21 (100 %)	0.0001

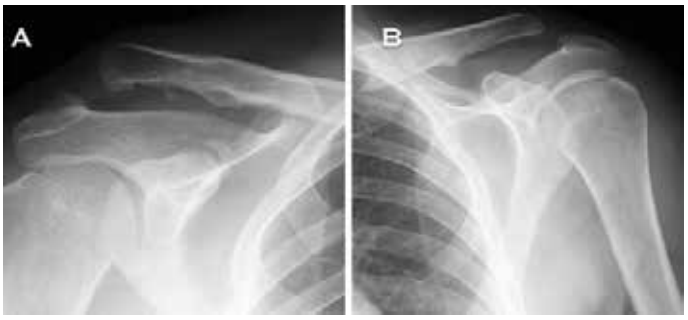


Fig. 3 **a** X-ray in AP view showing a right shoulder of a male patient the sustained a Rockwood grade III ACJ injury that was managed conservatively. Observe the CC calcifications and the osteolysis of the distal third of the clavicle. **b** X-ray in AP view showing a right shoulder of a male patient the sustained a Rockwood grade III ACJ injury that was managed conservatively. Observe the osteolysis of the distal third of the clavicle

Radiographic follow-up

All patients were radiographically examined at the last follow-up visit. In the PLATE group, anatomic reduction of the ACJ was finally achieved in 63.63 % (7/11) of the patients; subluxations were observed in 18.18 % (2/11); and complete dislocations were observed in 18.18 % (2/11). As expected, all patients of the CONS group demonstrated a completely dislocated ACJ. In summary, the proportion of patients with ACJ separations registered at the last follow-up visit was 36.36 % (4/11) in the PLATE group and 100 % (21/21) in the CONS group ($p = 0.0001$). These results are presented in Table 3.

Calcification of the CC ligaments was observed in 27.27 % (3/11) of the shoulders of the PLATE group and in 9.52 % (2/21) of the shoulders of the CONS group ($p = 0.309$) (Fig. 3a).

The lateral end of the clavicle showed osteolysis in 27.27 % (3/11) of the shoulders of the PLATE group and in 14.3 % (3/21) of the shoulders of the CONS group ($p = 0.389$) (Fig. 3a, b).

Fig. 4 **a** X-ray in AP view showing a right shoulder in which ORIF with a hook plate was performed. One of the screws broke intraoperatively, because of the level arm that the weight of the arm was applying over the fixation. **b** X-ray in AP view performed 2 years after plate removal. Observe the CC calcifications

Complications

At the last follow-up visit, there was evidence of scapular dyskinesis in 18 % (2/11) of the patients of the PLATE group and in 52.4 % (11/21) of the patients of the CONS group ($p = 0.127$). These results are presented in Table 3.

In the PLATE group, there were two complications related to surgery: One surgical site infection that required a surgical debridement, and the breakage of a screw that could not be removed from the clavicle (Fig. 4a, b). Likewise, one of the patients of the PLATE group developed a severe pain several months after plate removal, so an MRI was performed. An important subacromial bone edema was revealed. This situation was managed by means of a corticoid injection, and the symptoms subsided.

Discussion

The main finding of this study was that, 24 months or more after shoulder injury, patients with acute high-grade ACJ injuries that have been managed operatively with a hook plate had the same quality of life than patients managed non-operatively, even though patients managed non-operatively showed a higher incidence of scapular dyskinesis at the last follow-up visit.

As far as we have knowledge, 15 studies that compare operative versus non-operative management in cases of high-grade ACJ injuries have been published [3–17]. Most of these studies describe than non-operative management produces a better outcome when compared to operative management. As in the present study, the surgical groups of these studies were managed with ORIF techniques, which have been already shown to alter the biomechanics of the ACJ [30]. In vivo analysis of ACJ motion after hook-plate fixation has shown that the clavicular motion and the ACJ biomechanics vary importantly because of the metal hardware [31]. In a previous study of our group, in which the non-operative management was compared to the arthroscopy-assisted CC non-rigid fixation, we observed better clinical outcomes in the group of patients surgically managed [17]. We believe that the technique chosen do have a strong influence on the clinical outcomes.

Open reduction and ACJ fixation with the hook plate can be an extensive surgical procedure. Part of the hook gets in the posterior aspect of the AC ligaments, and this might represent a reason that compromises the proper healing of these structures. Likewise, hook plates must be mandatory removed, and the period while the plate is implanted might involve the development of serious complications [10, 32–36]. In the PLATE group of our study, one of the patients developed a painful subacromial bone edema [22], which represented the location where the hook was supporting the weight of the whole upper limb, and in other patient, there was intraoperative breakage of a clavicular screw, which we considered was due to an important lever arm of the plate on the acromion, while it was being finally fixed over the clavicle.

Gstettner et al. [10] compared patients with grade III ACJ injuries managed with a hook plate to patients managed non-operatively. These authors applied The Oxford Shoulder Score (OSS), the Simple Shoulder Test (SST) and the Constant score. The mean OSS was 18.7 in the conservatively treated group and 16.0 in the surgically treated group. This difference was not statistically significant. The mean SST score was 9.96 in the conservatively treated group and 11.3 in the surgically treated group. This difference was not statistically significant. The mean Constant score was 80.7 in the conservatively treated group and 90.4 in the group that underwent surgery. This difference was

statistically significant. Among the 28 patients who underwent surgery, these authors described one hematoma (needing revision) and two subcutaneous infections (one needing revision). In one patient, the plate had to be removed after 55 days, because the hook cut upward through the acromion [10]. Our results do not differ too much from those published by these authors. The mean Constant score registered in patients of our study was 91.36 for the PLATE group and 91.05 for the CONS group, without significant differences. Likewise, we registered one surgical site infection that required a surgical debridement, the breakage of a screw that could not be removed from the clavicle, and one patient who developed a subacromial bone edema that required corticoid injection. We believe that taking in consideration that clinical scores of patients managed with the hook plate are comparable to those of patients managed non-operatively, and also taking in consideration the described complications related to the hook plate, surgical management with this system might not represent the best surgical strategy.

On the other side, McKee et al. showed in their randomized clinical trial (therapeutic level I study) in which they compared the hook-plate fixation versus the non-operative management, that, although the hook-plate fixation resulted in superior radiographic alignment, this strategy was not clinically superior to non-operative treatment in cases of acute high-grade ACJ injuries [37]. In this study, authors applied the DASH score and the Constant score. The non-operative group had better early clinical scores, although both groups equally showed a good or excellent clinical result at final follow-up. The mean DASH score was 5 in the hook-plate group and 6 in the non-operative group. This difference was not statistically significant. The mean Constant score was 91 in the hook-plate group and 95 in the non-operative group. This difference was not statistically significant. Considering the obtained results, these authors concluded that, at present, there is no clear evidence that operative treatment with the hook-plate system may improve the clinical outcomes in cases of acute high-grade ACJ injuries. Although the design of our study, as well as its level of evidence, differs from the study performed by McKee et al., our results reinforce the results presented by the mentioned authors: Patients managed by means of the hook-plate fixation do not show superior clinical outcomes than patients managed by means of conservative measures.

In a previous study of our group, we provided evidences about the outcomes of a group of patients managed by means of an arthroscopy-assisted non-rigid CC fixation and a group of patients managed by means of conservative measures based on scapular stabilization [17]. The clinical outcomes assessed at the last follow-up visit favored the group surgically managed, probably because this group was managed with a technique that respects biomechanical and biological principles and allows diagnosis and treatment of concomitant intra-articular injuries [17].

It has been shown that some of the patients with high-grade ACJ injuries might develop scapular dyskinesis, situation that could result in loss of strength, pain and weakness [1]. Likewise, it has been shown that the prevalence of scapular dyskinesis in those patients that have been managed operatively [38] is lesser when compared to patients managed non-operatively [2]. The described prevalence of scapular dyskinesis in patients managed operatively is 11.7 % [38] and non-operatively 70.6 % [2]. In our study, the prevalence of scapular dyskinesis was 18 % in the group of patients of managed with the hook plate and 52.4 % in the group of patients managed conservatively. Despite the fact it has been previously shown that the presence of scapular dyskinesis in ACJ injuries may be related to more probabilities of shoulder pain due to subacromial impingement [2, 17], and despite the fact that the group of patients conservatively managed in this study showed a higher prevalence of scapular dyskinesis, no significant differences between treatment groups were encountered in regards to any of the patient self-reported questionnaires. We believe that maybe the detrimental effect over the subacromial structures of both the decreased CC distance related to scapular dyskinesis and the hook of the hook-plate system may result in comparable subjective symptoms.

The main limitation of our study is its retrospective nature. Patients were not randomized before undergoing one treatment or the other. The number of patients is low. The PLATE group was managed by many trauma surgeons. The age range is wide. For the purposes of this study, clinical assessments through questionnaires were performed only once. The CONS group was conformed by the patients who preferred not to be managed by means of surgery, despite they were informed about internationally accepted recommendations in these cases. No comparisons between the injured and the healthy shoulder were performed.

The main methodological strength of our study is the fact that clinical and radiological evaluations were performed prospectively, once the aim of the study was formulated.

Conclusions

The results of this study show that patients with acute high-grade ACJ injuries managed operatively with a hook plate may have the same quality of life and self-reported questionnaires than patients with high-grade ACJ injuries managed non-operatively, 24 months or more after shoulder

injury. If surgery is advocated for this type of injury, the orthopedic population must be aware that the hook-plate system might not represent the most suitable option.

Compliance with ethical standards

Conflict of interest Dr. Luis Natera Cisneros and Dr. Juan Sarasquete declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

References

1. Beitzel K, Cote MP, Apostolakos J, Solovyova O, Judson CH, Ziegler CG, Edgar CM, Imhoff AB, Arciero RA, Mazzocca AD (2013) Current concepts in the treatment of acromioclavicular joint dislocations. Arthroscopy 29:387–397. doi:10.1016/j.arthro.2012.11.023
2. Gumina S, Carbone S, Postacchini F (2009) Scapular dyskinesis and SICK scapula syndrome in patients with chronic type III acromioclavicular dislocation. Arthroscopy 25:40–45. doi:10.1016/j.arthro.2008.08.019
3. Rosenorn M, Pedersen EB (1974) A comparison between conservative and operative treatment of acute acromioclavicular dislocation. Acta Orthop Scand 45:50–59
4. Cardone D, Brown JN, Roberts SN, Saies AD, Hayes MG (2002) Grade III acromioclavicular joint injury in Australian rules football. J Sci Med Sport 5:143–148
5. Galpin RD, Hawkins RJ, Grainger RW (1985) A comparative analysis of operative versus nonoperative treatment of grade III acromioclavicular separations. Clin Orthop Relat Res 193:150–155
6. Jacobs B, Wade PA (1966) Acromioclavicular-joint injury. An end-result study. J Bone Joint Surg Am 48:475–486
7. Calvo E, Lopez-Franco M, Arribas IM (2006) Clinical and radiologic outcomes of surgical and conservative treatment of type III acromioclavicular joint injury. J Shoulder Elbow Surg 15:300–305
8. MacDonald PB, Alexander MJ, Frejuk J, Johnson GE (1988) Comprehensive functional analysis of shoulders following complete acromioclavicular separation. Am J Sports Med 16:475–480
9. Taft TN, Wilson FC, Oglesby JW (1987) Dislocation of the acromioclavicular joint. An end-result study. J Bone Joint Surg Am 69:1045–1051
10. Gstettner C, Tauber M, Hitzl W, Resch H (2008) Rockwood type III acromioclavicular dislocation: surgical versus conservative treatment. J Shoulder Elbow Surg 17:220–225
11. Walsh WM, Peterson DA, Shelton G, Neumann RD (1985) Shoulder strength following acromioclavicular injury. Am J Sports Med 13:153–158
12. Bakalim G, Wilppula E (1975) Surgical or conservative treatment of total dislocation of the acromioclavicular joint. Acta Chir Scand 141:43–47
13. Larsen E, Hede A (1987) Treatment of acute acromioclavicular dislocation. Three different methods of treatment prospectively studied. Acta Orthop Belg 53:480–484
14. Press J, Zuckerman JD, Gallagher M, Cuomo F (1997) Treatment of grade III acromioclavicular separations. Operative versus nonoperative management. Bull Hosp Joint Dis 56:77–83
15. Larsen E, Bjerg-Nielsen A, Christensen P (1986) Conservative or surgical treatment of acromioclavicular dislocation. A prospective, controlled, randomized study. J Bone Joint Surg Am 68:552–555
16. Bannister GC, Wallace WA, Stableforth PG, Hutson MA (1989) The management of acute acromioclavicular dislocation. A randomised prospective controlled trial. J Bone Joint Surg Br 71:848–850
17. Natera L, Sarasquete J, Abat F, Besalduch M, Monllau JC, Videla S (2015) Acute unstable acromioclavicular joint injuries: quality of life comparison between patients managed operatively with a coracoclavicular suspension device arthroscopically placed versus patients managed non-operatively. Eur Orthop Traumatol 6(4):343–355. doi:10.1007/s12570-015-0326-y
18. Johansen JA, Grutter PW, McFarland EG, Petersen SA (2011) Acromioclavicular joint injuries: indications for treatment and treatment options. J Shoulder Elbow Surg 20:70–82. doi:10.1016/j.jse.2010.10.030
19. Warth RJ, Martetschläger F, Gaskill TR, Millett PJ (2013) Acromioclavicular joint separations. Curr Rev Musculoskelet Med 6:71–78. doi:10.1007/s12178-012-9144-9
20. Jensen G, Katthagen JC, Alvarado LE, Lill H, Voigt C (2014) Has the arthroscopically assisted reduction of acute AC joint separations with the double tight-rope technique advantages over the clavicular hook plate fixation? Knee Surg Sports Traumatol Arthrosc 22:422–430. doi:10.1007/s00167-012-2270-5
21. Kienast B, Thietje R, Queitsch C, Gille J, Schulz AP, Meiners J (2011) Mid-term results after operative treatment of Rockwood grade III–V acromioclavicular joint dislocations with an AC-hook-plate. Eur J Med Res 16:52–56
22. Natera L, Sarasquete J, Escolà A, Rodriguez-Miralles J (2016) Acute high-grade acromioclavicular joint injuries treatment: arthroscopic nonrigid coracoclavicular fixation provides better quality of life outcomes than hook plate ORIF. Orthop Traumatol Surg Res 102(1):31–39. doi:10.1016/j.otsr.2015.10.007
23. Ding M, Ni J, Hu J, Song D (2011) Rare complication of clavicular hook plate: clavicle fracture at the medial end of the plate. J Shoulder Elbow Surg 20:18–20. doi:10.1016/j.jse.2011.06.005
24. Hackenberger J, Schmidt J, Altmann T (2004) The effects of hook plates on the subacromial space—a clinical and MRT study. Z Orthop Ihre Grenzgeb 142:603–610
25. Lin HY, Wong PK, Ho WP, Chuang TY, Liao YS, Wong CC (2014) Clavicular hook plate may induce subacromial shoulder impingement and rotator cuff lesion-dynamic sonographic evaluation. J Orthop Surg Res 6(9):6. doi:10.1186/1749-799X-9-6
26. Rockwood CA Jr, Williams GR Jr, Young DC (1998) Disorders of the acromioclavicular joint. In: Rockwood CA Jr, Matsen FA 3rd (eds) The shoulder. WB Saunders, Philadelphia, pp 483–553
27. Beitzel K, Mazzocca AD, Bak K, Itoi E, Kibler WB, Mirzayan R, Imhoff AB, Calvo E, Arce G, Shea K (2014) ISAKOS upper extremity committee consensus statement on the need for diversification of the Rockwood classification for acromioclavicular joint injuries. Arthroscopy 30:271–278. doi:10.1016/j.arthro.2013.11.005
28. Kibler WB, McMullen J (2003) Scapular dyskinesis and its relation to shoulder pain. J Am Acad Orthop Surg 11:142–151
29. Uhl TL, Kibler WB, Gecewich B, Tripp BL (2009) Evaluation of clinical assessment methods for scapular dyskinesis. Arthroscopy 25:1240–1248. doi:10.1016/j.arthro.2009.06.007
30. Jari R, Costic RS, Rodosky MW, Debski RE (2004) Biomechanical function of surgical procedures for acromioclavicular joint dislocations. Arthroscopy 20:237–245

31. Kim YS, Yoo YS, Jang SW, Nair AV, Jin H, Song HS (2015) In vivo analysis of acromioclavicular joint motion after hook plate fixation using three-dimensional computed tomography. J Shoulder Elbow Surg 24(7):1106–1111. doi:10.1016/j.jse.2014.12.012
32. Chiang CL, Yang SW, Tsai MY, Kuen-Huang Chen C (2010) Acromion osteolysis and fracture after hook plate fixation for acromioclavicular joint dislocation: a case report. J Shoulder Elbow Surg 19:13–15. doi:10.1016/j.jse.2009.12.005
33. Hoffler CE, Karas SG (2010) Transacromial erosion of a locked subacromial hook plate: case report and review of literature. J Shoulder Elbow Surg 19:e12–e15. doi:10.1016/j.jse.2009.10.019
34. Bahk MS, Kuhn JE, Galatz LM, Connor PM, Williams GR Jr (2010) Acromioclavicular and sternoclavicular injuries and clavicular, glenoid, and scapular fractures. Instr Course Lect. J Bone Joint Surg Am 59:209–226
35. Sim E, Schwarz N, Hocker K, Berzlanovich A (1995) Repair of complete acromioclavicular separations using the acromioclavicular-hook plate. Clin Orthop Relat Res 314:134–142. doi:10.1097/00003086-199505000-00017
36. Nadarajah R, Mahaluxmivala J, Amin A, Goodier DW (2005) Clavicular hook-plate: complications of retaining the implant. Injury 36:681–683. doi:10.1016/j.injury.2004.08.010
37. McKee M, Pelet S, McCormack RG, Harvey E, Papp S, Rouleau D et al (2015) Multicenter randomized clinical trial of nonoperative versus operative treatment of acute acromio-clavicular joint dislocation. J Orthop Trauma 29(11):479–487. doi:10.1097/BOT.0000000000000437
38. Murena L, Canton G, Vulcano E, Cherubino P (2013) Scapular dyskinesis and SICK scapula syndrome following surgical treatment of type III acute acromioclavicular dislocations. Knee Surg Sports Traumatol Arthrosc 21:1146–1150

8.1.2

Orthopaedics & Traumatology: Surgery & Research 102 (2016) 31–39

Available online at ScienceDirect www.sciencedirect.com

Elsevier Masson France EM|consulte www.em-consulte.com/en

Original article

Acute high-grade acromioclavicular joint injuries treatment: Arthroscopic non-rigid coracoclavicular fixation provides better quality of life outcomes than hook plate ORIF

L. Natera-Cisneros [a,b,*], J. Sarasquete-Reiriz [a,c], A. Escolà-Benet [b], J. Rodriguez-Miralles [b,d]

[a] Hospital de la Santa Creu i Sant Pau, Universitat Autònoma de Barcelona, street Sant Quintí 89, 08026 Barcelona, Spain
[b] Hospital General de Catalunya, Street Pedro i Pons 1, 08190 Sant Cugat del Vallés, Barcelona, Spain
[c] Hospital Quirón Teknon, Street Vilana 12, 08022 Barcelona, Spain
[d] Consorci Hospitalari de Vic, Street Francesc Pla 'El Vigatà' 1, 8500 Vic Barcelona, Spain

ARTICLE INFO

Article history:
Received 18 June 2015
Accepted 19 October 2015

Keywords:
Unstable acromioclavicular joint injuries
Arthroscopy-assisted management
Hook plate
Concomitant intraarticular injuries
Scapular dyskinesis
Quality of life

ABSTRACT

Introduction: Treatment of acute high-grade acromioclavicular joint (ACJ) injuries with metal hardware alters the biomechanics of the ACJ, implying a second surgery for hardware removal. The period during which the plate is present involves functional limitations, pain and a risk factor for the development of hardware-related-injuries. Arthroscopy-assisted procedures compared to open-metal hardware techniques offer: less morbidity, the possibility to treat associated lesions and no need for a second operation. The aim was to compare the Quality of life (QoL) of patients with acute high-grade ACJ injuries (Rockwood grade III–V), managed arthroscopically with a non-rigid coracoclavicular (CC) fixation versus the QoL of patients managed with a hook plate, 24 months or more after their shoulder injury.
Patients and methods: A retrospective revision of high-grade ACJ injuries managed in three institutions was performed. Patients treated by means of an arthroscopy-assisted CC fixation or by means of a hook plate were included. The inclusion period was between 2008 and 2012. The QoL was evaluated at the last follow-up visit by means of the SF36, the visual analog scale (VAS), the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire, the Constant score and the global satisfaction (scale from 0 to 10). The presence of scapular dyskinesis and remaining vertical instability were evaluated. Comparison between groups was performed.
Results: Thirty-one patients were included: 20 arthroscopy-group (ARTH group: 3 Rockwood III, 3 IV and 14 V) and 11 hook plate-group (HOOK group: 5 Rockwood III and 6 V). The mean age was 36 [25–52] year-old for the ARTH group and 41 [19–55] for the HOOK group ($P = 0.185$). The mean results of the questionnaires were: (1) physical SF36 score (ARTH group 58.24 ± 2.16 and HOOK group 53.70 ± 4.33, $P < 0.001$); (2) mental SF36 score (ARTH group 56.15 ± 2.21 and HOOK group 53.06 ± 6.10, $P = 0.049$); (3) VAS (ARTH group 0.40 ± 0.50 and HOOK group 1.45 ± 1.51, $P = 0.007$); (4) DASH (ARTH group 2.98 ± 2.03 and HOOK group 4.79 ± 5.60, $P = 0.200$); (5) Constant score (ARTH group 95.30 ± 2.45 and HOOK group 91.36 ± 6.84, $P = 0.026$); (6) global satisfaction (ARTH group 8.85 ± 0.93 and HOOK group 8.00 ± 1.18, $P = 0.035$). There was evidence of scapular dyskinesis in 15% (3/20) of the patients of the ARTH group and in 18% (2/11) of the patients of the HOOK group ($P = 1.000$). Remaining vertical ACJ instability was observed in 40% (8/20) of the patients of the ARTH group and in 36.36% (4/11) of the patients of the HOOK group ($P = 1.000$).
Conclusion: Patients with acute high-grade ACJ injuries managed arthroscopically with a non-rigid CC fixation seem to have a better QoL than patients managed with a hook plate.
Level of evidence: Level IV therapeutic; retrospective comparative study.

* Corresponding author. Hospital de la Santa Creu i Sant Pau, Universitat Autònoma de Barcelona, street Sant Quintí 89, 08026 Barcelona, Spain. Tel.: +34 600 39 38 26; office: +34 93 553 7031.
E-mail address: luisgerardonaterac@gmail.com (L. Natera-Cisneros).

http://dx.doi.org/10.1016/j.otsr.2015.10.007
1877-0568/

1. Introduction

Surgical management of acute high-grade acromioclavicular joint (ACJ) injuries should be focused on facing the torn ends of the ligaments, because it is accepted that in the acute phase they still have healing potential [1].

Most methods of treatment incorporate the use of metal hardware, which could alter the biomechanics of the ACJ, thus implying a second surgical procedure for hardware removal once the ligaments have healed [2]. The hook plate, the ACJ transfixion with K-wires (Phemister technique) and the coracoclavicular (CC) fixation with a screw (Bosworth technique) are recognized as non-anatomic procedures related to high rates of fixation failures and complications [3]. Likewise, clinical outcomes depend on the technique performed [4].

Patients with unstable ACJ injuries managed with the hook plate system have shown good and excellent clinical outcomes [5]. On the other side, hook plates must be removed 8 to 12 weeks after surgery, situation that supposes the need of a second surgery. Likewise, it has been widely reported that the period while the plate is implanted involves important functional limitations and great pain for the patients [6]. This implant should be removed before allowing overhead shoulder activities, and motion restriction should be emphasized until removal [7]. Orthopaedic surgeon's main concern is that hook plates may cause subacromial impingement and even rotator cuff tears [8]. These implant-related adverse effects might influence patient's final functional outcome [9].

Patients with unstable ACJ injuries managed with arthroscopy-assisted procedures have shown good and excellent clinical outcomes, without the need for a second operation [5]. These procedures incorporate a CC suspension device aimed to narrow the CC space thus allowing the facing of the torn CC ligaments. The advantages that arthroscopy can offer among open techniques are: less morbidity, the possibility of diagnose and treat associated lesions [10]; and the possibility of having a straight visualization of the inferior aspect of the base of the coracoid, convenient when placing CC fixation systems.

It has been postulated that persistent shoulder pain after ACJ surgery could be related to untreated overlooked intraarticular concomitant injuries [11]. Although, this idea seems to be logical, the relation between variables has not been yet studied. The main aim of this study was to compare the QoL of patients with acute high-grade ACJ injuries managed arthroscopically with an early non-rigid CC fixation versus the QoL of patients managed with a hook plate, 24 months or more after shoulder injury. The secondary aim was to arthroscopically assess the prevalence of concomitant intraarticular injuries in the ARTH group.

We hypothesized that patients with acute high-grade ACJ injuries managed arthroscopically with an early non-rigid CC fixation have a better QoL than patients managed with a hook plate.

2. Patients and methods

2.1. Study design

A retrospective cohort study was performed in three tertiary hospitals. Patients, diagnosed of high-grade ACJ injuries (grade III–V according to the Rockwood classification) and managed operatively by means of an arthroscopy-assisted non-rigid CC fixation or by means of open reduction and internal fixation with a hook plate, were included.

All patients gave their written informed consent and accepted that data from their electronic medical files could be used for purposes of this scientific research.

2.2. Study population

Most of the study population was obtained from records registered for a previous study [12] in which the electronic medical files of two institutions were reviewed. For the purposes of this study, authors invited to participate the trauma unit of a third institution, in order to increase the number of cases and to provide comparative evidences between different treatment methods and surgical strategies.

All the records of the shoulder and trauma clinics of these three institutions coded as "ACJ injuries" between January 1st 2008 and January 31st 2012 were revised. Patients were included in the study following these inclusion criteria:

- either sex;
- radiographic diagnose of high-grade ACJ injury;
- physically active and between 18 and 55 year-old at the moment of acute injury;
- managed operatively by means of an arthroscopy-assisted non-rigid CC fixation (ARTH group) or by means of open reduction and internal fixation with a hook plate (HOOK group);
- with a clinical history and radiological examination complete and available at the moment of the revision of the records;
- with a minimum follow-up of 24 months after surgery;
- operated within the first three weeks after shoulder injury.

The exclusion criteria were:

- radiographic diagnose of an ACJ injury Rockwood grade I–II;
- surgical treatment performed three weeks after ACJ injury (because it has been described that after this period the CC ligaments lack of healing potential [13]);
- previous injuries to the respective shoulder;
- surgical techniques other than acute arthroscopically assisted CC non-rigid fixation, or fixation with a hook plate.

The patients who fulfilled these eligibility criteria were contacted and proposed to be included in the study.

Once patients were contacted and accepted to participate in the study, they signed an informed consent ("last follow-up visit"), and radiographic and clinical examinations of the injured shoulder were collected.

2.3. Quality of Life (QoL) evaluations

The QoL was assessed by means of:

- the SF36: (1) physical and (2) mental;
- the VAS of the injured shoulder: "0" corresponding to "no pain" and "10" corresponding to "the worst pain imaginable"
- the DASH questionnaire;
- the Constant score;
- the "Global Satisfaction" scale (numerical rating scale from 0 to 10; being 0, not satisfied with the treatment, and 10, completely satisfied with the results of the treatment).

Items of the Constant score (range of motion, strength and activity limitations) are also presented separately. In order to be able to make dichotomous differences between groups; when drawing back items about limitations, "severe" and "moderate" limitations were grouped into only one category ("yes"). However, for the purposes of calculating the Constant score itself, these items were considered as described by the authors [14] (for example, sport limitation: severe, moderate, no).

2.4. ACJ injury classification

Classification was made by means of observing the X-rays performed at the initial visit post-injury. Clinical examination in the acute setting was not considered for classification. Radiographic examinations of both shoulders were performed to all patients at the initial visit post-injury. The X-rays protocol of these three institutions included: strict anteroposterior (AP) view (both shoulders), Zanca view (both shoulders) and axillary view (only injured shoulder). The cross-body adduction view (Alexander view) was performed at the initial visit post-injury in two of the three institutions, so in accordance to the diversification of the Rockwood classification proposed by ISAKOS [15], the classification could not be updated as it was done in a previous study [12]. In the three institutions, axillary views were performed with the patient in the prone position, and necessary abduction of the shoulder was passively achieved through manipulation by the examiner.

Grade III and grade V injuries were differentiated according to the traditional Rockwood classification [16]. A grade III if the CC distance of the injured shoulder was increased between 25–100% when compared to the non-injured shoulder; and a grade V if the CC distance of the injured shoulder was increased between 100–300% when compared to the non-injured shoulder [16]. These assessments were made on Zanca views. Diagnosis of ACJ injuries Rockwood grade IV was made by means of observation in the axillary view of the clavicle posteriorly dislocated in relation to the acromion [16].

2.5. Treatment decision-making

The consultant in charge at each of the three institutions leaded the decision-making. There was not randomization before decision-making.

In regards to the severity of the injuries, decision-making was based on the radiologic magnitude of displacement between the clavicle and the acromion, which at the end is the indicator of a tear or not in the CC ligaments with affection or not of the deltotrapezial fascia [2,17], which also plays a determinant role in the stability of the ACJ [18].

Patients with acute high-grade ACJ injuries Rockwood grade IV–V were told that there were international recommendations regarding the surgical management for this type of injuries [2]; and patients with Rockwood grade III ACJ injuries were told that there were no evidence-based medical guidelines for decision-making and that surgery was recommended in active patients with high demands on the shoulder function.

Once the diagnosis high-grade ACJ injury was established, patients were informed about the different treatment options. Specifically, patients of the HOOK group were told that the plate had to be removed 12 to 16 weeks after implantation.

Likewise, patients of the ARTH group were told about the risks of a surgical intervention and about the possibility of diagnose and treat concomitant glenohumeral injuries.

2.6. Management: arthroscopically assisted non-rigid CC fixation and hook plate

2.6.1. ARTH group

This technique has been previously described [12]. Patients were placed in the beach chair position under general anesthesia and interscalene block. The arm was fixed to a mechanical arm holder with the shoulder elevated up to 45–50° and with 2–3 kg of traction. Three standard arthroscopic portals were used: posterior, anterolateral and lateral. Diagnostic arthroscopic examination of the shoulder was performed in order to detect glenohumeral concomitant injuries. With the arthroscope placed in the lateral portal, subacromial bursa debridement was performed through the anterolateral portal in order to visualize the coracoacromial (CA) ligament. This structure was then followed to the coracoid base. The base of the coracoid undersurface was debrided. A 3-cm incision perpendicular to the clavicle was made, then the tip of the acromioclavicular guide was placed at the bottom of the base of the coracoid under arthroscopic visualization, near the wall of the scapula; and the sliding tube of the guide was located on top of the clavicle with an angle of 80–90° at the middle of what it should be the native origins of the CC ligaments (isometric reconstruction), placing the suspension device 3-cm medial to the lateral edge of the clavicle [12,19]. A 2.4-mm K-wire was passed from the clavicle to the coracoid and the isometric tunnel was made over the K-wire with a 4.5-mm cannulated drill. A shuttle-suture was then retrieved from the coracoid tunnel and then the CC suspension device (TightRope, Arthrex, Inc, Naples, Florida, USA) was introduced from the coracoid to the clavicle, guided by the suture. The titanium flip was placed at the base of the coracoid process and the button at the top of the clavicle. The ACJ was manually reduced by pushing the elbow upwards and the clavicle downwards at the same time. The traction sutures of the system were alternatively pulled until the clavicle washer of the system locked. Anatomic reduction was confirmed by means of direct visualization and palpation. Closure of the deltotrapezoidal fascia was then performed to secure the reduction. The skin was sutured and the arm was placed in a sling.

2.6.2. HOOK group

Fluoroscopy was positioned at the head of the bed. A standard anterior approach to the clavicle was performed. The ACJ injury was exposed and reduced under direct visualization. Hook plates (Synthes, West Chester, USA) were used in all patients. The soft tissue dorsal to the ACJ was dissected and prepared for the insertion of the hook. Detachment of the extracapsular fibers of the trapezius from the medial border of the acromion was performed. The hook was passed below the acromion and the plate was applied. Plates were then secured to the clavicle shaft with four or five 3.5 mm cortical screws, approximating the plate to the clavicle. Proper reduction and fixation was checked with fluoroscopy. The deltotrapezial fascia was carefully sutured in order to guarantee an appropriated coverage of the plate. The skin was closed with staples in all cases.

2.7. Rehabilitation protocol

The rehabilitation period involved wearing a sling for 3–4 weeks. Patients were initially allowed to move fully and actively the elbow, wrist, and hand. Patients of the HOOK group were allowed to passively move the shoulder no more than 90° of elevation in the plane of the scapula after the first week, and patients of the ARTH group three weeks after surgery. Pendulum exercises begin from the first week post-injury in both groups.

The active range of motion was progressively advanced from the sixth week onwards in both groups. Exercises to regain strength were initiated once the patient had full, pain-free passive and active range of motion, and exercises were primarily directed toward scapular stabilization.

Return to work without restrictions was allowed after 12–14 weeks and contact sports or major efforts were avoided for 4–6 months in both groups.

2.8. Radiographic follow-up

Radiographic follow-up evaluations were made by one of the investigators, based on the X-rays performed at the last follow-up visit. Remaining vertical ACJ instability was evaluated. For the purposes of this study, in the HOOK group these assessments were performed once the implant was removed. Remaining vertical ACJ

instability was assessed on bilateral Zanca views. In both groups, the maintenance of ACJ post-surgical reduction and the development of post-surgical secondary displacement were radiologically evaluated according to the modified Rosenørm and Pedersen classification [20]. The ACJ was considered reduced when there was no displacement in comparison to the non-injured side, subluxed when there was less than 50% of displacement of the clavicle in relation to the height of the acromion and completely dislocated if the displacement of the clavicle was greater than 50% of the height of the acromion. We did not measure the CC distance.

2.9. Registration of adverse events related to treatment and complications

Scapular dyskinesis was diagnosed according to Kibler's definition, as the alteration of the normal position or motion of the scapula during coupled scapulohumeral movements [21].

The presence of scapular dyskinesis was assessed at the last follow-up visit by one of the investigators, by means of the "yes/no" method described by Kibler's group [22]. This test consists on the evaluation of the scapular motion by the physician when the patient is performing shoulder forward flexion with both shoulders. It is a simplification of the Kibler's 4-type method, and groups dyskinesis categories (types I to III) into a single category of "yes" (presence of dyskinesis), and type IV is labeled as "no" (normal scapular motion).

Comparison between groups was performed.

3. Statistical analysis

The sample was conformed by all of the patients of the study period who fulfilled the inclusion criteria. Statistical analysis was carried out according to the complete sample analysis.

Continuous variables are presented as mean and standard deviation (SD) or mean and range. Categorical variables are presented as percentages and frequencies. The relationship between variables was analyzed with contingency tables for the categorical ones, and the inference was studied with the Chi^2 test or Fisher's exact test depending on what corresponded. The *t*-test was applied to analyze quantitative variables. Comparison between treatments was performed regarding only the injured shoulder. Comparisons between the function of the injured shoulder and the uninjured one were not performed. The level of significance was set at 5% ($\alpha = 0.05$). Data were analyzed by use of the SPSS 19 (SPSS Inc., Chicago, Illinois).

4. Results

4.1. Population characteristics

A total of 31 out of 120 screened patients were included: 20 ARTH group (3 Rockwood III, 3 IV and 14 V) and 11 HOOK group (5 Rockwood III and 6 V). The proportion of cases with injury of the deltotrapezial fascia was 85% [(17/20), 3 grade IV and 14 grade V] in the ARTH group and 54.55% [(5/11), 6 grade V] in the HOOK group ($P = 0.038$). Fig. 1 shows the flowchart for enrollment of the patients. Table 1 shows the baseline characteristics of the study population by treatments groups. The mean age was 36 [range 25–52] year-old for the ARTH group and 41 [19–55] for the HOOK group ($P = 0.185$). There were 17 men in the ARTH group and 11 in the HOOK group. The mean follow-up was 38.40 ± 4.34 months for the ARTH group and 32.50 ± 11.64 months for the HOOK group ($P = 0.052$). The mean [range] time from acute ACJ injury until the last follow-up visit for both groups was 36 [24–78] months. The mean time elapsed from

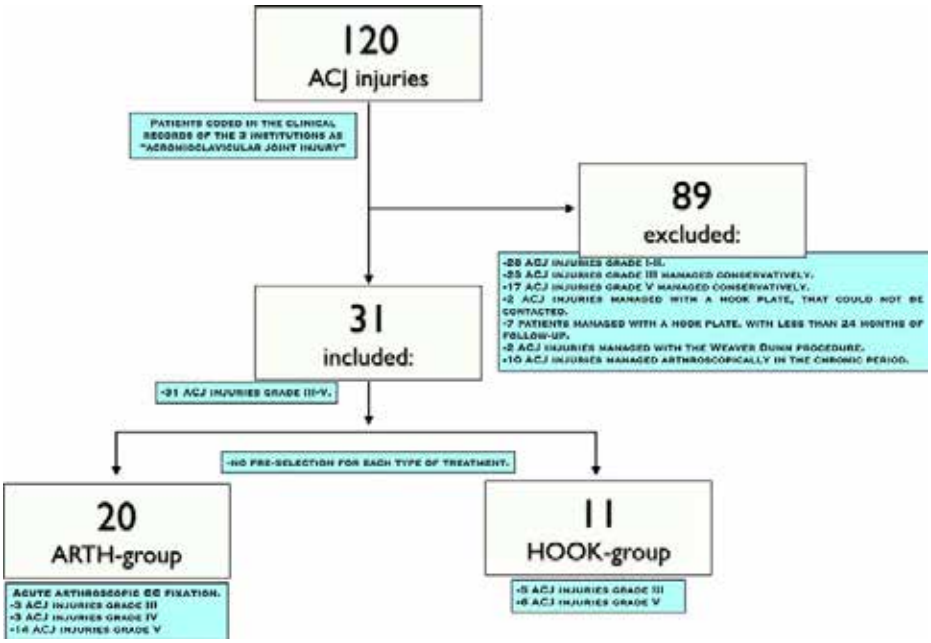


Fig. 1. Flowchart for enrollment of the cases according to the criteria established in the study protocol.

Table 1
Baseline characteristics of patients by treatment groups.

	Total (n = 31)	ARTH group (n = 20)	HOOK group (n = 11)	P value
Age (year-old) [range]	38 [19–55]	36 [25–52]	41 [19–55]	0.185
Male/female n (%)/n (%)	28 (90%)/3 (10%)	17 (85%)/3 (15%)	11 (100%)/0 (0%)	0.535

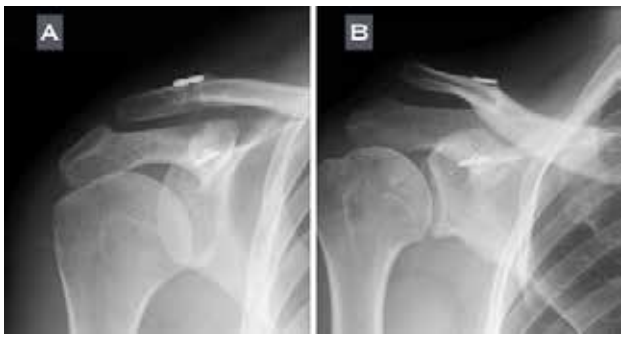


Fig. 2. A. X-ray in AP view of a right shoulder showing a high-grade ACJ injury that was managed by means of a CC suspension device. B. X-ray in AP view of a right shoulder performed at the last follow-up visit, showing a remaining vertical instability (secondary displacement) in a patient who had a high-grade ACJ injury that was managed by means of a CC suspension device.

Table 2
Quality of life results.

Quality of life evaluations	ARTH group (n = 20) Mean ± SD	HOOK group (n = 11) Mean ± SD	P value
SF36 for physical domain	58.24 ± 2.16	53.70 ± 4.33	< 0.001
SF36 for mental domain	56.15 ± 2.21	53.06 ± 6.10	0.049
VAS for pain	0.40 ± 0.50	1.45 ± 1.51	0.007
DASH questionnaire	2.98 ± 2.03	4.79 ± 5.60	0.200
Constant score	95.30 ± 2.45	91.36 ± 6.84	0.026
Global satisfaction	8.85 ± 0.93	8.00 ± 1.18	0.035

implantation of the hook plate until its removal was 3.98 ± 1.71 months.

In the ARTH group (Fig. 2A), concomitant glenohumeral injuries were detected and treated in 20% (4/20) of the patients: 1 posterior Bankart, 2 slap lesions type II and 1 rotator cuff tear. These injuries were catalogued to be acute, thus were managed by means of fixation with suture-anchors. In the HOOK group, it was not possible to assess the glenohumeral joint in order to diagnose concomitant injuries.

4.2. Quality of life evaluations

These results are presented in Table 2.

Constant score items were broken down, and separated results are presented in Table 3 (range of motion and strength) and Table 4 (sleep, daily living and sports limitations).

4.3. Radiographic follow-up

Remaining vertical instability was registered in 38.70% (12/31) of the patients (Fig. 2B). In the ARTH group, anatomic reduction of the ACJ was finally achieved in 60% (12/20) of the patients; subluxations were observed in 20% (4/20); and complete dislocations were observed in 20% (4/20).

In the HOOK group (Fig. 3A), anatomic reduction of the ACJ was finally achieved in 63.63% (7/11) of the patients; subluxations were observed in 18.18% (2/11) (Fig. 3B); and complete dislocations were observed in 18.18% (2/11).

In summary, the proportion of patients with remaining vertical instability at the last follow-up visit was 40% (8/20) in the ARTH group and 36.36% (4/11) in the HOOK group (P = 1.000). These results are presented in Table 5.

4.4. Adverse events related to treatment and complications

One of the patients of the HOOK group had a persistent severe pain several months after plate removal, so a MRI was performed. The short inversion time inversion recovery (STIR)

Table 3
Range of motion and strength of the injured shoulder, assessed at the last follow-up visit.

	Total (n = 31) Mean ± SD	ARTH group (n = 20) Mean ± SD	HOOK group (n = 11) Mean ± SD	P value
Forward flexion (°)	176.2 ± 2.5	176.4 ± 3.2	175.7 ± 2.1	0.478
Lateral elevation (°)	160.1 ± 3.6	162.4 ± 4.3	158.9 ± 2.9	0.496
External rotation in adduction (°)	46.3 ± 3.4	47.2 ± 2.8	45.1 ± 3.2	0.199
Internal rotation in abduction (°)	72 ± 1.8	72.2 ± 2.1	71.9 ± 1.3	0.903
Strength of abduction (pounds)	25.1 ± 3.4	24.5 ± 2.7	25.7 ± 3.8	0.365

Table 4
Sleep, daily living and sports limitations.

	Total (n = 31) n (%)	ARTH group (n = 20) n (%)	HOOK group (n = 11) n (%)	P value
Sleep affected (yes)	6 (19.35)	1 (5)	5 (45.45)	0.013
Daily living limitation (yes)	7 (22.58)	3 (15)	4 (36.36)	0.209
Sports limitation (yes)	8 (25.80)	2 (10)	6 (54.55)	0.012

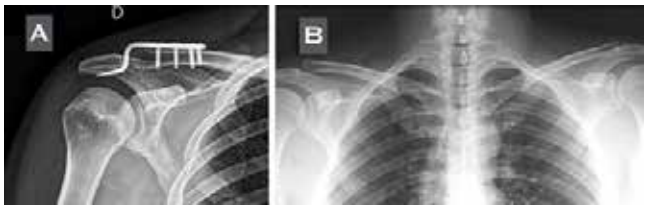


Fig. 3. A. X-ray in AP view of a right shoulder, showing the fixation of a high-grade ACJ injury by means of a hook plate. B. X-ray in AP view of a both shoulders performed 15 days after plate removal. Vertical subluxation of the ACJ can be observed.

Table 5
Scapular dyskinesis and remaining vertical instability assessed at the last follow-up visit.

	Total (n = 31) n (%)	ARTH group (n = 20) n (%)	HOOK group (n = 11) n (%)	P value
Scapular dyskinesis	5 (16.12)	3 (15)	2 (18.18)	1.000
Remaining vertical instability	12 (38.70)	8 (40)	4 (36.36)	1.000

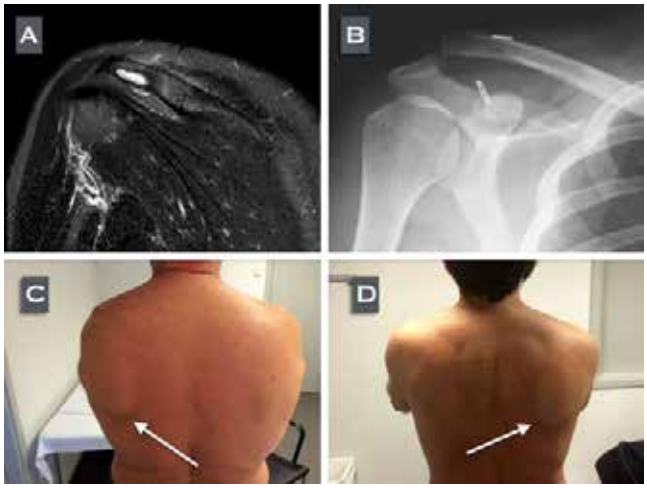


Fig. 4. A. Coronal reconstruction of a MRI in STIR sequence performed to one of the patients of the HOOK group that was having persistent severe pain several months after plate removal. Observe the important acromial bone edema caused by the persistent pressure of the hook. B. X-ray in AP showing a right shoulder with a high-grade ACJ injury that was managed with a CC suspension device in which implant failure was observed. The subcoracoid flip lost its fixation. C and D. Posterior perspective of patients while performing shoulders forward flexion. Observe the prominence of the inferomedial border of the scapula (white arrows).

sequence revealed an important subacromial bone edema (Fig. 4A). This situation was managed by means of a corticoid injection, and the symptoms subsided.

In the ARTH group, there were 3 complications related to surgery: 1 implant failure (Fig. 4B) that required a re-intervention managed with another CC suspension device and a semitendinous allograft, according to our previosly described technique [17]; and 2 surgical wound granulomas.

In the HOOK group there were 2 complications related to surgery: 1 surgical site infection that required a surgical debridment and the breakage of a screw that could not be removed from the clavicle.

At the last follow-up visit, there was evidence of scapular dyskinesis in 15% (3/20) of the patients of the ARTH group and in 18.18% (2/11) of the patients of the HOOK group ($P = 1.000$) (Fig. 4C and D). These results are presented in Table 5.

5. Discussion

The main finding of this study was that patients with acute high-grade ACJ injuries managed arthroscopically with a non-rigid CC fixation have a better quality of life in terms of the SF36 (physical and mental), the VAS, the Constant score and the global satisfaction, than patients managed with a hook plate.

In regards to the surgical approach of high-grade ACJ injuries, the literature is plenty of surgical procedures. It has been reported that the CA ligament transfer, the hook plate fixation, the AC K-wire fixation and the CC screw fixation could be considered as biomechanically insufficient [23]. In vivo analysis of ACJ motion after hook plate fixation has shown that the clavicular motion and the ACJ biomechanics changed significantly [24]. The technique chosen may have a strong influence on the result, especially if open procedures and fixation with metal hardware are performed.

In our study, patients of the HOOK group rated their questionnaires worst than those of the ARTH group. When patients of the HOOK group were asked about their global satisfaction in regards to the outcomes, many of them referred to the discomfort they felt during the time the hook plate was implanted, information that coincide with previous publications [6]. We believe that the functional limitation and pain patients perceive while the hook plate is implanted has a determinant influence over the self-perception of the result. Boström et al. described that patients managed with a hook plate had significantly more pain than patients managed by means of a CC non-rigid fixation [25]. They argue that it may be due to the presence of a chronic irritation in the subacromial space, which leads to a persistent pain syndrome [25].

In this study, patients of the ARTH group had a better Constant score at the last follow-up visit than patients of the HOOK group. Likewise, Items of the Constant score were broken down. No differences were encountered in regards to the range of motion, the strength nor the daily living limitations. However, statistically significant differences were encountered regarding the sleep, the sports limitations and the pain. Differences in these items were determinants to "make a difference" when summarizing the whole Constant score. On the other side, no statistically significant differences were found in regards to the DASH score. We believe that this issue may be due to the fact that the DASH score involves more subjective items to assess than the Constant score, situation that may lead to dissolution of the possible differences. Items of the Constant score are more objective and focused on the physical examination, while all thirty items of the DASH score are merely subjective. Taking in consideration that in both groups of our series the objective items were "comparable", and taking in consideration that the Constant score involves only two subjective items (pain and activity level: sleep, daily living and sports), differences between groups in regards to these subjective items made the overall Constant score of the ARTH group higher enough to reach a significant difference.

The results of our study coincide with those published by Andreani et al., in which their group of patients managed with the Tightrope® system had a mean Constant score of 90, and the group of patients managed with a hook plate had 75 [26]. On the other side, in the study published by Jensen et al., patients managed with the hook plate system or arthroscopically with a CC suspension device showed equally good and excellent clinical results [5]. Despite there were not significant differences, their group of patients managed by means of the hook plate showed a mean VAS of 0.8, while the group of patients managed by means of the Tightrope® showed a mean VAS of 0.4 [5].

In regards to the hook plate, open reduction and ACJ fixation with this system can be an extensive surgical procedure. Part of the hook gets in the posterior aspect of the AC ligaments, and this might represent a reason that compromises the proper healing of these structures. Likewise, hook plates must be mandatory removed, and the period while the plate is implanted might involve the development of serious complications, such as cutting upward of the hook through the acromion [27], acromial osteolysis [28] and fracture [29], ACJ osteoarthritis, subacromial impingement, rotator cuff tears [30] and plate bending [31]. Despite timely removal of the plate, there could be also an increased risk of fracture of the distal clavicle after low energy trauma [32].

Lin et al. described that in a group of patients with ACJ injuries and distal third clavicle fractures managed by means of the hook plate, 37.5% (15/40) developed subacromial impingement syndrome, and their functional scores were poorer than the non-impinged patients [9]. Among these patients, 40% (6/15) had a rotator cuff tear diagnosed by means of a sonographic evaluation. Likewise, acromial erosion caused by hook pressure was observed in 50% (20/40) of the patients. All patients of this series had their plates removed at a mean time of 5.78 months [9]. In our series, the mean time elapsed from plate implantation to removal was 3.98 months. We did not perform sonographic evaluation of our patients, but we consider that the lower scores registered in the questionnaires could rely on possible underlying injuries related to the plate.

In regards to remaining vertical instability, biomechanical studies have shown that the hook plate involves a biomechanical disadvantage when compared to CC non-rigid fixations. The CC displacement during cyclic loading has been shown to be higher for hook plate fixations [33]. Despite these biomechanical premises, clinical studies comparing patients managed with the hook plate versus patients managed with CC non-rigid fixations have shown no differences in regards to the remaining vertical instability [5]. It has been also shown that partial loss of vertical reduction do not influence the overall result [13]. A possible explanation for this finding could be the fact that the healed CC elongated ligaments provide enough stability to relieve symptoms [26].

In regards to the shoulder biomechanics, it has been shown that some of the patients with high-grade ACJ injuries might develop scapular dyskinesis, situation that could result in loss of strength, pain and weakness [2]. Likewise, it has been shown that the prevalence of scapular dyskinesis in those patients that have been managed operatively [34] is lesser when compared to patients managed non-operatively [35]. The described prevalence of scapular dyskinesis in patients managed operatively is 11.7% [34]. In our study, there were no differences between groups in regards to the prevalence of scapular dyskinesis. Our results partially coincide with those previously published. Our overall prevalence of scapular dyskinesis was 16.1% (5/31): 15% (3/20) in the ARTH group and 18.8% (2/11) in the HOOK group.

Diagnosis and treatment of concomitant glenohumeral injuries and no mandatory implant removal are the advantages of a CC non-rigid fixation arthroscopy-assisted [5]. Likewise, it has been postulated that possible remaining concomitant intraarticular injuries may represent the reasons for failure of some of the cases managed by means of open surgery without access to the glenohumeral joint or by means of non-operative management [5]. We are now defending the idea that, if orthopaedic surgeons decide to manage acute unstable ACJ injuries by means of an open procedure that does not involve access to the glenohumeral joint, it should be considered to perform a preoperative MRI arthrography to avoid "leaving behind" important simultaneous acute injuries that, in case they go unnoticed, may significantly condition the final outcome.

In regards to synthetic ligament reconstructions in acute ACJ injuries, the synthetic graft most commonly known is the Ligastic®

[36]. Mares et al. described a rate of clavicular osteolysis around the tunnels for the Ligastic® of 22% (6 of 27 patients) [36]. These authors have also described unsatisfactory clinical outcomes with this implant [36]. In fact, they reported in their study that they are currently rejecting the use of this type of implant, and advising against its use.

Cohen et al. described a 19% (3/16) rate of partial loss of reduction in a series of patients managed by means of a synthetic ligament placed arthroscopically between the clavicle and the coracoid, and with a mean follow-up of 12 months [37]. The rate of loss of reduction observed in the ARTH group of our series was 40% (8/20), with a mean follow-up of 32.5 months. In regards to the development of secondary displacements, differences between these series of patients might be in relation to the mean follow-up (12 months in the series of Cohen versus 32.5 months in the ARTH group of our series). We believe that, when using only one CC suspension device, it is matter of time until an ACJ subluxation may be developed. Although it seems that clinical outcomes are not affected by this issue [26], we are actually making anatomic synthetic reconstructions with two CC suspension devices plus an AC augmentation with an all suture anchor plus a careful reconstruction of the deltotrapezial fascia, which plays a determinant role in the vertical and horizontal stabilization of the ACJ [18].

Despite all the evidence today available about the biomechanical and biological disadvantages that might arise from the fixation with a hook plate, in both groups of our series high scores were registered at the questionnaires performed at the last follow-up visit. Although significant differences were found when final outcomes were compared, we assume that the clinical relevance of these statistical differences may be questioned by trauma-surgeons that are used to this "easy to place" implant.

The main limitation of our study is its retrospective design. Patients were not randomized before undergoing one treatment or the other. The number of patients is low. The ARTH group was managed by only one shoulder surgeon, and the HOOK group was managed by many trauma-surgeons. The age range is wide, and the mean age of the HOOK group patients is higher, although this difference was not significant. The proportion of cases with injury of the deltotrapezial fascia was significantly higher in the ARTH group; but nevertheless, better clinical outcomes were obtained at the last follow-up assessment of this group.

Taking in account that MRIs were not performed preoperatively, we were only able to assess the prevalence of simultaneous intraarticular injuries in the group managed by means of the arthroscopy-assisted procedure. Likewise, MRI study was not performed postoperatively to all patients of the HOOK group.

For the purposes of this study, clinical assessments through questionnaires were performed only once.

It must be mentioned that there is scarce information regarding surgical outcomes of ACJ injuries if the lesions are broken down into types III through V according to the classification of Rockwood [38]. Most reports include type III ACJ injuries [20,27,39,40]. This study adds evidence to the few studies actually available [5].

6. Conclusion

In this study, patients with acute high-grade ACJ injuries managed arthroscopically with a non-rigid CC fixation had a better quality of life in terms of the SF36 (physical and mental), the VAS, the Constant score and the global satisfaction, than patients managed with a hook plate, 24 months or more after shoulder injury. Lower scores registered in the questionnaires of the HOOK group could rely on possible underlying injuries related to the plate, and higher scores of the ARTH group might be in relation to the management of concomitant intraarticular injuries.

Disclosure of interest

Dr. Juan Sarasquete Reiriz receives royalties from Biomet® Sports Medicine.

The other authors declare that they have no competing interest.

Acknowledgements

Authors would like to thank Carolina Cisneros and Renan Zelada for their help in the language management of this manuscript.

References

[1] Rolf O, Hann von Weyhern A, Ewers A, Boehm TD, Gohlke F. Acromioclavicular dislocation Rockwood III–V: results of early versus delayed surgical treatment. Arch Orthop Trauma Surg 2008;128:1153–7.
[2] Johansen JA, Grutter PW, McFarland EG, Petersen SA. Acromioclavicular joint injuries: indications for treatment and treatment options. J Shoulder Elbow Surg 2011;20:70–82, http://dx.doi.org/10.1016/j.jse.2010.10.030.
[3] Warth RJ, Martetschläger F, Gaskill TR, Millett PJ. Acromioclavicular joint separations. Curr Rev Musculoskelet Med 2013;6:71–8, http://dx.doi.org/10.1007/s12178-012-9144-9.
[4] Beitzel K, Cote MP, Apostolakos J, Solovyova O, Judson CH, Ziegler CG, et al. Current concepts in the treatment of acromioclavicular joint dislocations. Arthroscopy 2013;29:387–97, http://dx.doi.org/10.1016/j.arthro.2012.11.023.
[5] Jensen G, Katthagen JC, Alvarado LE, Lill H, Voigt C. Has the arthroscopically assisted reduction of acute AC joint separations with the double tight-rope technique advantages over the clavicular hook plate fixation? Knee Surg Sports Traumatol Arthrosc 2014;22:422–30, http://dx.doi.org/10.1007/s00167-012-2270-5.
[6] Kienast B, Thietje R, Queitsch C, Gille J, Schulz AP, Meiners J. Mid-term results after operative treatment of rockwood grade III–V acromioclavicular joint dislocations with an AC- hook-plate. Eur J Med Res 2011;16:52–6.
[7] Ding M, Ni J, Hu J, Song D. Rare complication of clavicular hook plate: clavicle fracture at the medial end of the plate. J Shoulder Elbow Surg 2011;20:18–20, http://dx.doi.org/10.1016/j.jse.2011.06.005.
[8] Hackenberger J, Schmidt J, Altmann T. The effects of hook plates on the subacromial space – a clinical and MRT study. Z Orthop Ihre Grenzgeb 2004;142:603–10.
[9] Lin HY, Wong PK, Ho WP, Chuang TY, Liao YS, Wong CC. Clavicular hook plate may induce subacromial shoulder impingement and rotator cuff lesion – dynamic sonographic evaluation. J Orthop Surg Res 2014;6(9):6, http://dx.doi.org/10.1186/1749-799X-9-6.
[10] Arrigoni P, Brady PC, Zottarelli L, Barth J, Narbona P, Huberty D, et al. Associated lesions requiring additional surgical treatment in grade 3 acromioclavicular joint dislocations. Arthroscopy 2014;30:6–10, http://dx.doi.org/10.1016/j.arthro.2013.10.006.
[11] Pauly S, Gerhardt C, Haas NP, Scheibel M. Prevalence of concomitant intraarticular lesions in patients treated operatively for high-grade acromioclavicular joint separations. Knee Surg Sports Traumatol Arthrosc 2009;17:513–7, http://dx.doi.org/10.1007/s00167-008-0666-z.
[12] Natera L, Sarasquete J, Abat F, Besalduch M, Monllau JC, Videla S. Acute unstable acromioclavicular joint injuries: quality of life comparison between patients managed operatively with a coracoclavicular suspension device arthroscopically placed versus patients managed non-operatively. Eur Orthop Traumatol 2015, http://dx.doi.org/10.1007/s12570-015-0326-y [Epub ahead of print].
[13] Weinstein DM, McCann PD, McIlveen SJ, Flatow EL, Bigliani LU. Surgical treatment of complete acromioclavicular dislocations. Am J Sports Med 1995;23:324–31.
[14] Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. Clin Orthop Relat Res 1987:160–4.
[15] Beitzel K, Mazzocca AD, Bak K, Itoi E, Kibler WB, Mirzayan R, et al. ISAKOS upper extremity committee consensus statement on the need for diversification of the Rockwood classification for acromioclavicular joint injuries. Arthroscopy 2014;30:271–8, http://dx.doi.org/10.1016/j.arthro.2013.11.005.
[16] Rockwood Jr CA, Williams Jr GR, Young DC. Disorders of the acromioclavicular joint. In: Rockwood Jr CA, Matsen 3rd FA, editors. The shoulder. Philadelphia: WB Saunders; 1998. p. 483–553.
[17] Natera L, Sarasquete Reiriz J, Abat F. Anatomic reconstruction of chronic coracoclavicular ligament tears: arthroscopic-assisted approach with nonrigid mechanical fixation and graft augmentation. Arthrosc Tech 2014;15(5):e583–8, http://dx.doi.org/10.1016/j.eats.2014.06.014 [eCollection 2014 Oct].
[18] Natera L, Sarasquete J, Besalduch M, Petrica A, Escolà A, Rodriguez J. Horizontal and vertical stabilization of acute unstable acromioclavicular joint injuries arthroscopy-assisted. Arthrosc Tech 2015, http://dx.doi.org/10.1016/j.eats.2015.07.014 [In press].
[19] Abat F, Sarasquete J, Natera LG, Calvo Á, Pérez-España M, Zurita N, et al. Biomechanical analysis of acromioclavicular joint dislocation repair using

coracoclavicular suspension devices in two different configurations. J Orthop Traumatol 2015;16(3):215–9, http://dx.doi.org/10.1007/s10195-015-0346-y.
[20] Rosenorn M, Pedersen EB. A comparison between conservative and operative treatment of acute acromioclavicular dislocation. Acta Orthop Scand 1974;45:50–9.
[21] Kibler WB, McMullen J. Scapular dyskinesis and its relation to shoulder pain. J Am Acad Orthop Surg 2003;11:142–51.
[22] Uhl TL, Kibler WB, Gecewich B, Tripp BL. Evaluation of clinical assessment methods for scapular dyskinesis. Arthroscopy 2009;25:1240–8, http://dx.doi.org/10.1016/j.arthro.2009.06.007.
[23] Jari R, Costic RS, Rodosky MW, Debski RE. Biomechanical function of surgical procedures for acromioclavicular joint dislocations. Arthroscopy 2004;20:2372–445.
[24] Kim YS, Yoo YS, Jang SW, Nair AV, Jin H, Song HS. In vivo analysis of acromioclavicular joint motion after hook plate fixation using three-dimensional computed tomography. J Shoulder Elbow Surg 2015:21, http://dx.doi.org/10.1016/j.jse.2014.12.012 [pii: S1058-2746(14)00679-X. Epub ahead of print].
[25] Boström Windhamre HA, von Heideken JP, Une-Larsson VE, Ekelund AL. Surgical treatment of chronic acromioclavicular dislocations: a comparative study of Weaver-Dunn augmented with PDS-braid or hook plate. J Shoulder Elbow Surg 2010;19:1040–8, http://dx.doi.org/10.1016/j.jse.2010.02.006.
[26] Andreani L, Bonicoli E, Parchi P, Piolanti N, Michele L. Acromio-clavicular repair using two different techniques. Eur J Orthop Surg Traumatol 2014;24:237–42, http://dx.doi.org/10.1007/s00590-013-1186-1.
[27] Gstettner C, Tauber M, Hitzl W, Resch H. Rockwood type III acromioclavicular dislocation: surgical versus conservative treatment. J Shoulder Elbow Surg 2008;17:220–5, http://dx.doi.org/10.1016/j.jse.2007.07.017.
[28] Chiang CL, Yang SW, Tsai MY, Kuen-Huang Chen C. Acromion osteolysis and fracture after hook plate fixation for acromioclavicular joint dislocation: a case report. J Shoulder Elbow Surg 2010;19:13–5, http://dx.doi.org/10.1016/j.jse.2009.12.005.
[29] Hoffler CE, Karas SG. Transacromial erosion of a locked subacromial hook plate: case report and review of literature. J Shoulder Elbow Surg 2010;19:e12–5, http://dx.doi.org/10.1016/j.jse.2009.10.019.
[30] Bahk MS, Kuhn JE, Galatz LM, Connor PM, Williams Jr GR. Acromioclavicular and sternoclavicular injur ies and clavicular, glenoid, and scapular fractures. Instr Course Lect. J Bone Joint Surg Am 2010;59:209–26.
[31] Sim E, Schwarz N, Hocker K, Berzlanovich A. Repair of complete acromioclavicular separations using the acromioclavicular-hook plate. Clin Orthop Relat Res 1995;314:134–42, http://dx.doi.org/10.1097/00003086-199505000-00017.
[32] Nadarajah R, Mahaluxmivala J, Amin A, Goodier DW. Clavicular hook-plate: complications of retaining the implant. Injury 2005;36:681–3, http://dx.doi.org/10.1016/j.injury.2004.08.010.
[33] Lädermann A, Gueorguiev B, Stimec B, Fasel J, Rothstock S, Hoffmeyer P. Acromioclavicular joint reconstruction: a comparative biomechanical study of three techniques. J Shoulder Elbow Surg 2013;22:171–8, http://dx.doi.org/10.1016/j.jse.2012.01.020.
[34] Murena L, Canton G, Vulcano E, Cherubino P. Scapular dyskinesis and SICK scapula syndrome following surgical treatment of type III acute acromioclavicular dislocations. Knee Surg Sports Traumatol Arthrosc 2013;21:1146–50.
[35] Gumina S, Carbone S, Postacchini F. Scapular dyskinesis and SICK scapula syndrome in patients with chronic type III acromioclavicular dislocation. Arthroscopy 2009;25:40–5, http://dx.doi.org/10.1016/j.arthro.2008.08.019.
[36] Mares O, Luneau S, Staquet V, et al. Acute grade III and IV acromioclavicular dislocations: outcomes and pitfalls of reconstruction procedures using a synthetic ligament. Orthop Traumatol Surg Res 2010;96:721–6.
[37] Cohen G, Boyer P, Pujol N, Hamida Ferjani B, Massin P, Hardy P. Endoscopically assisted reconstruction of acute acromioclavicular joint dislocation using a synthetic ligament. Outcomes at 12 months. Orthop Traumatol Surg Res 2011;97:145–51, http://dx.doi.org/10.1016/j.otsr.2010.10.004.
[38] Tauber M, Koller H, Hitzl W, Resch H. Dynamic radiologic evaluation of horizontal instability in acute acromioclavicular joint dislocations. Am J Sports Med 2010;38(6):1188–95, http://dx.doi.org/10.1177/0363546510361951.
[39] Calvo E, Lopez-Franco M, Arribas IM. Clinical and radiologic outcomes of surgical and conservative treatment of type III acromioclavicular joint injury. J Shoulder Elbow Surg 2006;15:300–5.
[40] Cardone D, Brown JN, Roberts SN, Saies AD, Hayes MG. Grade III acromioclavicular joint injury in Australian Rules Football. J Sci Med Sport 2002;5:143–8.

8.1.3

J Orthopaed Traumatol
DOI 10.1007/s10195-015-0346-y

ORIGINAL ARTICLE

Biomechanical analysis of acromioclavicular joint dislocation repair using coracoclavicular suspension devices in two different configurations

Ferran Abat · Juan Sarasquete · Luis Gerardo Natera · Ángel Calvo · Manuel Pérez-España · Néstor Zurita · Jesús Ferrer · Juan Carlos del Real · Eva Paz-Jimenez · Francisco Forriol

Received: 27 August 2014 / Accepted: 13 February 2015

Abstract
Background The best treatment option for some acromioclavicular (AC) joint dislocations is controversial. For this reason, the aim of this study was to evaluate the vertical biomechanical behavior of two techniques for the anatomic repair of coracoclavicular (CC) ligaments after an AC injury.
Materials and methods Eighteen human cadaveric shoulders in which repair using a coracoclavicular suspension device was initiated after injury to the acromioclavicular joint were included in the study. Three groups were formed; group I ($n = 6$): control; group II ($n = 6$): repair with a double tunnel in the clavicle and in the coracoid (with two CC suspension devices); group III ($n = 6$): repair in a "V" configuration with two tunnels in the clavicle and one in the coracoid (with one CC suspension device). The biomechanical study was performed with a universal testing machine (Electro Puls 3000, Instron, Boulder, MA, USA), with the clamping jaws set in a vertical position. The force required for acromioclavicular reconstruction system failure was analyzed for each cadaveric piece.
Results Group I reached a maximum force to failure of 635.59 N (mean 444.0 N). The corresponding force was 939.37 N (mean 495.6 N) for group II and 533.11 N (mean 343.9 N) for group III. A comparison of the three groups did not find any significant difference despite the loss of resistance presented by group III.
Conclusion Anatomic repair of coracoclavicular ligaments with a double system (double tunnel in the clavicle and in the coracoid) permits vertical translation that is more like that of the acromioclavicular joint. Acromioclavicular repair in a "V" configuration does not seem to be biomechanically sufficient.

Keywords Acromioclavicular dislocation · Joint · Anatomic repair · Biomechanics

F. Abat (✉)
Department of Sports Orthopaedics, ReSport Clinic, Barcelona, Spain
e-mail: ferranabat@gmail.com

F. Abat · J. Sarasquete · L. G. Natera
Department of Traumatology and Orthopaedic Surgery, Hospital de la Santa Creu i Sant Pau, Universitat Autónoma de Barcelona, Sant Quintí, 89, Barcelona 08026, Spain

Á. Calvo · N. Zurita
Hospital IMED Elche, Alicante, Spain

M. Pérez-España · J. Ferrer
Shoulder and Elbow Pathology Unit Shoulder of Madrid, Madrid, Spain

J. C. del Real · E. Paz-Jimenez
Engineering School (ICAI), University of Comillas, Madrid, Spain

F. Forriol
Universidad San Pablo CEU, Madrid, Spain

Introduction

Acromioclavicular (AC) dislocations usually present as the result of a fall that produces trauma to the lateral aspect of the shoulder. It brings about a variable separation of the acromioclavicular joint depending on the degree of damage to the capsule, the acromioclavicular ligaments, as well as the coracoclavicular (CC) ligaments. Rockwood classified them into grades I–VI depending on the severity of the injury and the degree of displacement [1]. Grade I–II injuries are treated conservatively, without surgery, leading

Published online: 05 March 2015

to satisfactory results and a return to sporting activity in most cases [2]. The treatment of grade III injuries is controversial. However, surgical treatment is recommended for high-grade lesions IV–VI [3]. Despite their clinical impact, there is still no consensus for the surgical treatment of Rockwood high-grade lesions [4, 5].

From a biomechanical point of view, the importance of the acromioclavicular and coracoclavicular ligaments for maintaining the vertical and horizontal stability of the acromioclavicular joint has been shown [6]. There are many techniques that can be applied to the repair of the AC and CC ligaments in the literature [7, 8]. It is currently popular to perform these repairs in an anatomic way [5, 9].

To replace CC ligaments, some authors advocate using tendons (autograft or allograft) [10], while others perform repairs with synthetic devices [11, 12] which allow for the reduction of the AC joint, with the expectation that these devices might act as scaffolding while the injured ligaments heal.

Synthetic CC suspension devices placed arthroscopically permit the reduction of AC dislocations during the biological healing of the CC ligaments. Among the options for repairs with synthetic devices is anatomic reconstruction with a double tunnel in the clavicle as well as in the coracoid [5]. This technique allows the conoid and trapezoid ligaments to be emulated, and has shown biomechanical advantages [12], but there is also an increased risk of fracture of the clavicle during the construction of two tunnels and an increase in technical difficulty [5]. On the other hand, the isometric approach seeks to restore the anatomy of the conoid and trapezoid ligaments by using a single anchoring stitch in the coracoid at the midway point of the insertion of both ligaments.

The aim of the study reported in this paper was to evaluate the vertical biomechanical behavior of two techniques for the anatomic repair of coracoclavicular ligaments that can be used for the surgical treatment of acromioclavicular dislocations using synthetic CC suspension devices. The hypothesis was that anatomic CC repair with a double tunnel in both the coracoid and clavicle is the repair that comes closest to restoring the natural stability of the AC joint.

Materials and methods

Eighteen human cadaveric shoulders (9 men, 9 women) from individuals aged 41–63 years (mean 58) were used. All specimens studied were free of systemic diseases or previous acromioclavicular injury. The pieces were stored at −20 °C and subsequently prepared prior to study. Shoulders were sectioned and soft tissue was removed, leaving the bone and ligament structure. The scapula bound to the clavicle with the intact coracoclavicular ligaments and acromioclavicular joint were obtained. In all cases, the ZipTight-type synthetic coracoclavicular suspension device was used (Biomet, Warsaw, IN, USA).

Three groups were formed: group I ($n = 6$), the control group; group II ($n = 6$), repair with a double tunnel in both the clavicle and coracoid (with two CC suspension devices); group III ($n = 6$), repair in a "V" configuration with two tunnels in the clavicle and one in the coracoid (with one CC suspension device).

Reconstruction techniques

For reconstruction with double tunnels in the coracoid (group II), anatomic repair of the CC, conoid, and trapezoid ligaments was performed (Fig. 1). This was done with two tunnels in the clavicle and another two tunnels at the base of the coracoid at the anatomic positions of the ligaments (4.5 cm from the acromial end of the clavicle for the conoid ligament tunnel and 2.5 cm for the trapezoid) [1, 5, 9, 12]. An individualized anatomic ligament repair of each ligament was performed.

In the reconstruction with a single tunnel in the coracoid (group III) for isometric repair of the CC ligaments in a "V" configuration (Fig. 2), two tunnels were created in the clavicle at the usual insertion of the conoid and trapezoid ligaments and one was made at the base of the coracoid (at the midpoint of the insertion of both ligaments). The CC suspension device was put in place with the titanium component locked into the base of the coracoid, passing

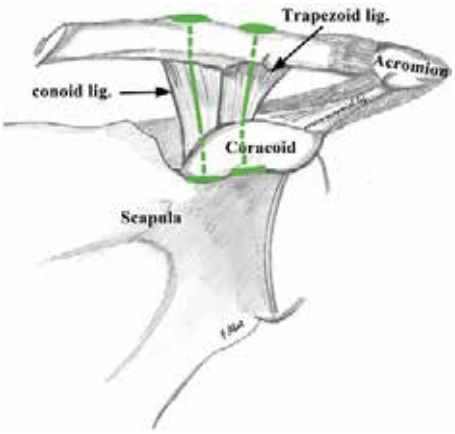


Fig. 1 Scheme for anatomic repair of the conoid and trapezoid ligaments with two CC suspension devices. Layout with a double tunnel in both the clavicle and coracoid

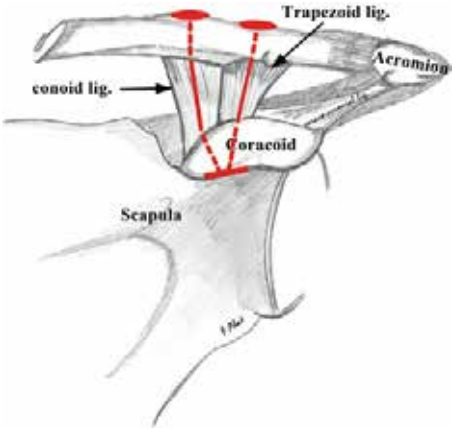


Fig. 2 Scheme for anatomic repair of the coracoclavicular ligaments in a "V" configuration. Note the arrangement of a single CC suspension device with two tunnels in the clavicle and one in the coracoid

through the tunnel inversely. Each loop of the device was then passed through the corresponding tunnel in the clavicle so as to obtain a repair of the CC ligaments with a single implant in a "V" configuration.

Biomechanical study protocol

The studied cadaveric pieces were placed in a universal testing machine (Electro Puls 3000, Instron, Boulder, MA, USA) with the clamping jaws vertical. The base of the scapula was fixed to the clamp by a compression system using two plates with screw tips to ensure proper fixation. By means of brackets, a bar contacting the upper edge of the scapula was fitted to prevent vertical movement.

To analyze the vertical behavior of the CC suspension systems, two rings were placed in the clavicle (one outside and one inside the fixations), which were connected by two chains to the vertical movement clamp. The chains allowed the traction system to be placed at the same distance. The traction test was performed at a speed of 15 mm/min. Pretensioning was performed at 15 N before the displacement of the bar of the testing machine was initiated. The test was stopped when the tensile force dropped by 60 % of the maximum applied force (Fmax 60 %) or when mobility of the part or implant failure was observed. In each test, the maximum breaking force (in N) was obtained. Group I (control) was tested first, thereby obtaining the reference values for a healthy shoulder. Groups II and III were tested later.

Statistical analysis

Mean values were calculated along with their standard deviations. Comparison was performed with an analysis of variance using the Tukey post-hoc test. SPSS (v.21.0) software was used. The level of significance was the usual 5 % ($\alpha = 0.05$, bilateral).

Results

The results obtained with the vertical traction biomechanical test to evaluate the maximum breaking force are shown in Table 1.

In group I and the control group ($n = 6$), the CC ligaments tore in all specimens upon reaching a maximum of 635.59 N and a minimum of 245.85 N. In group II (two tunnels and two fixations), two of the pieces were torn by the scapular fixation, so they were discarded. In the remaining four, the maximum force achieved was 939.37 N and the minimum was 278.75 N. In group III (two fixations and a single coracoid tunnel), the maximum value was 533.11 N and the minimum value was 210.30 N.

Upon performing a cluster analysis (Table 2), group I showed an average peak force of 444.0 N (SD 160.16) and group II averaged 495.6 N (SD 300.83). Group III had an average of 343.9 N (SD 111.46). A comparison of the three groups did not show any significant differences (ANOVA, $p = 0.446$), although the clear decline in resistance in group III is worth noting. Furthermore, no subsequent peer comparison indicated a significant difference from the overall value (Tukey post-hoc test, group I vs II, $p = 0.906$, group I vs III, $p = 0.638$, and group II vs III, $p = 0.448$).

Discussion

The main finding of this study was that the anatomic repair of the CC ligament with a double system (double tunnel in both the clavicle and coracoid) is biomechanically more

Table 1 Maximum breaking force in the vertical traction biomechanical test for each cadaveric piece

	Group I Control	Group II	Group III
1	534.44	412.43	374.12
2	529.94	351.99	274.10
3	245.85	278.75	533.11
4	253.49	939.37	371.50
5	464.81	*	300.05
6	635.59	*	210.30

Values expressed in Newtons (N)

Table 2 Mean values of maximum force according to study groups

Group	Average	SD	CV (%)	*n*
I	444.0	160.16	36.1	6
II	495.6	300.83	60.7	4
III	343.9	111.46	32.4	6
Total	419.4	186.73	44.5	16

Values expressed in Newtons (N)

like the AC joint than the AC repair with a single CC system in a "V" configuration is. Moreover, AC repair with a single CC system in a "V" configuration does not appear to be biomechanically sufficient, as it shows a clear tendency to offer less resistance. These findings confirm the hypothesis of the present study. We believe that compliance with these anatomical and biomechanical objectives allows for fewer recurrent subluxations and less residual pain, leading to a better clinical outcome.

A large number of AC dislocation repair techniques have been described, but there is still controversy over what the standard technique should be. Generally, repair focuses on reinforcing the CC ligaments with non-absorbable sutures, screws, pins, plates, or other methods of internal fixation [13–15]. Repairs with tendon grafts or fixation devices are based on the Weaver–Dunn technique and its variations [16, 17]. Initially, these coracoclavicular suspension devices were described for tibiofibular syndesmosis repair, but they have since been used in AC joint reconstruction too [18, 19]. Authors such as Salzmann [5] and Walz [12] argue that the placement of two CC suspension systems as replacements for the conoid and trapezoid ligaments is required to achieve proper primary stability. The precise anatomy of these two CC ligaments has already been described: the length of each ligament should be about 10 mm, giving a distance of 10–15 mm between the clavicle and coracoid [1, 5, 9, 12]. In agreement with a study by Breslow [20], the AC capsule and its ligaments work together to maintain horizontal stability, while the CC ligaments limit vertical displacement. Dimakopoulos et al. [21] were the first to provide clinical data on double-bundle repair for acute AC dislocations. The Mazzoca group [3, 7] described the open clamp technique with a semitendinosus tendon which, despite using an anatomic collarbone implementation, only uses a single point of traction on the coracoid. Lafosse et al. [22] reported a modified Weaver–Dunn technique performed arthroscopically, while Choi et al. [23] described procedures that use suture fixations to repair acute dislocations of the AC complex, with two sutures placed in the anatomic position to provide primary stability of the AC and CC ligaments. Recently, Tomlinson [24] and Baumgarten [25] described the anatomic repair of the CC complex using tendon grafts in the form of a cerclage around the coracoid with anatomic fixation under the clavicle. Rehbein et al. [26] reported a transosseous suture technique with a cerclage in the AC and CC in an anatomic position.

Morrison et al. [15] suggest that a simple loop around the coracoid to repair the CC ligaments can cause the final position of the left clavicle to be displaced anteriorly. In the present study, we proposed that the best reconstruction is performed in the anatomical arrangement emulating the conoid and trapezoid ligaments. To achieve this, we tested two configurations, one of which was a "V" that emulated the fixation in the collarbone but with one tunnel placed at the isometric point of the coracoid, and the other a configuration with a double tunnel in the clavicle and a double tunnel in the coracoid that used two coracoclavicular suspension devices.

Chernchujit et al. [4] reported CC ligament tension results of 578 N, whereas they reached a value of 767 N with a double FiberWire® suture. Furthermore, Walz et al. [12] achieved a tension of 982 N using two coracoclavicular suspension systems (TightRope®). Wellmann et al. [27] reported a value of 663 N for a repair performed with polydioxanone (PDS), similar to the value recently reported by Martetschläger et al. [28]. Our study showed mean values for intact ligaments of 444.0 N (maximum 635.59 N), while the mean value for anatomic repairs involving double tunnels in the coracoid was 495.51 N (maximum 939.37 N). Although our study yielded lower values in terms of the average tension obtained with the repair compared to other reference works such as Motamedi et al. [29] and Wellmann et al. [27], the results reported here are very similar to those obtained in specimens with an intact acromioclavicular joint.

The main limitation of this study is that it is a cadaveric biomechanical study, so it inherently differed from the normal clinical situation. Nonetheless, this is a rigorous, well-controlled, and reproducible work. Another weakness is that we did not test the failure of the repair in combined craniocaudal, anterior–posterior, and rotational traction. The average age (58 years) of the donors of the cadaveric parts used is, however, comparable to those presented in previous studies, and is substantially higher than the normal average age at presentation of acromioclavicular dislocations (20 years). Since it has been shown that the mechanical qualities of the ligaments and bones deteriorate over the years, better results would be expected in younger individuals. One other weakness is that two specimens were lost from group II.

The results obtained in this study indicate that repair with a synthetic double CC suspension device with double tunneling in the coracoid as well as the clavicle gives vertical traction biomechanical results that resemble those of the native AC joint.

Acknowledgments We are grateful to E. Goode for his help in editing the manuscript.

Conflict of interest The authors declare that they have no conflict of interest related to the publication of this manuscript.

Ethical standards This is a cadaver study for which all ethical considerations and the international guidelines for cadaveric studies were followed.

References

1. Rockwood CJ, Williams G, Young D (1998) Disorders of the acromioclavicular joint. In: Rockwood CJ, Matsen FA III (eds) The shoulder, 2nd edn. WB Saunders, Philadelphia, pp 483–553
2. Jari R, Costic RS, Rodosky MW, Debski RE (2004) Biomechanical function of surgical procedures for acromioclavicular joint dislocations. Arthroscopy 20(3):237–245
3. Mazzocca AD, Santangelo SA, Johnson ST, Rios CG, Dumonski ML, Arciero RA (2006) A biomechanical evaluation of an anatomical coracoclavicular ligament reconstruction. Am J Sports Med 34(2):236–246
4. Chernchujit B, Tischer T, Imhoff AB (2006) Arthroscopic reconstruction of the acromioclavicular joint disruption: surgical technique and preliminary results. Arch Orthop Trauma Surg 126(9):575–581
5. Salzmann GM, Walz L, Buchmann S, Glabgly P, Venjakob A, Imhoff AB (2010) Arthroscopically assisted 2-bundle anatomical reduction of acute acromioclavicular joint separations. Am J Sports Med 38(6):1179–1187
6. Fukuda K, Craig EV, An KN, Cofield RH, Chao EY (1986) Biomechanical study of the ligamentous system of the acromioclavicular joint. J Bone Joint Surg Am 68(3):434–440
7. Mazzocca AD, Arciero RA, Bicos J (2007) Evaluation and treatment of acromioclavicular joint injuries. Am J Sports Med 35(2):316–329
8. Smith TO, Chester R, Pearse EO, Hing CB (2011) Operative versus non-operative management following Rockwood grade III acromioclavicular separation: a meta-analysis of the current evidence base. J Orthop Traumatol 12(1):19–27
9. Costic RS, Labriola JE, Rodosky MW, Debski RE (2004) Biomechanical rationale for development of anatomical reconstructions of coracoclavicular ligaments after complete acromioclavicular joint dislocations. Am J Sports Med 32(8):1929–1936
10. Lee SJ, Nicholas SJ, Akizuki KH, McHugh MP, Kremenic IJ, Ben-Avi S (2003) Reconstruction of the coracoclavicular ligaments with tendon grafts: a comparative biomechanical study. Am J Sports Med 31(5):648–655
11. Tischer T, Imhoff AB (2009) Minimally invasive coracoclavicular stabilization with suture anchors for acute acromioclavicular dislocation. Am J Sports Med 37(3):e5
12. Walz L, Salzmann GM, Fabbro T, Eichhorn S, Imhoff AB (2008) The anatomic reconstruction of acromioclavicular joint dislocations using 2 TightRope devices: a biomechanical study. Am J Sports Med 36(12):2398–2406
13. DeBerardino TM, Pensak MJ, Ferreira J, Mazzocca AD (2010) Arthroscopic stabilization of acromioclavicular joint dislocation using the AC graftrope system. J Shoulder Elbow Surg 19(2 Suppl):47–52
14. Mlasowsky B, Brenner P, Düben W, Heymann H (1988) Repair of complete acromioclavicular dislocation (Tossy stage III) using Balser's hook plate combined with ligament sutures. Injury 19(4):227–232
15. Morrison DS, Lemos MJ (1995) Acromioclavicular separation. Reconstruction using synthetic loop augmentation. Am J Sports Med 23(1):105–110
16. Liu HH, Chou YJ, Chen CH, Chia WT, Wong CY (2010) Surgical treatment of acute acromioclavicular joint injuries using a modified Weaver–Dunn procedure and clavicular hook plate. Orthopedics 33:8
17. Weaver JK, Dunn HK (1972) Treatment of acromioclavicular injuries, especially complete acromioclavicular separation. J Bone Joint Surg Am 54(6):1187–1194
18. Cottom JM, Hyer CF, Philbin TM, Berlet GC (2008) Treatment of syndesmotic disruptions with the Arthrex Tightrope: a report of 25 cases. Foot Ankle Int 29(8):773–780
19. Scheibel M, Ifesanya A, Pauly S, Haas NP (2008) Arthroscopically assisted coracoclavicular ligament reconstruction for chronic acromioclavicular joint instability. Arch Orthop Trauma Surg 128(11):1327–1333
20. Breslow MJ, Jazrawi LM, Bernstein AD, Kummer FJ, Rokito AS (2002) Treatment of acromioclavicular joint separation: suture or suture anchors? J Shoulder Elbow Surg 11(3):225–229
21. Dimakopoulos P, Panagopoulos A, Syggelos SA, Panagiotopoulos E, Lambiris E (2006) Double-loop suture repair for acute acromioclavicular joint disruption. Am J Sports Med 34(7):1112–1119
22. Lafosse L, Baier GP, Leuzinger (2005) Arthroscopic treatment of acute and chronic acromioclavicular joint dislocation. Arthroscopy 21(8):1017
23. Choi SW, Lee TJ, Moon KH, Cho KJ, Lee SY (2008) Minimally invasive coracoclavicular stabilization with suture anchors for acute acromioclavicular dislocation. Am J Sports Med 36(5):961–965
24. Tomlinson DP, Altchek DW, Davila J, Cordasco FA (2008) A modified technique of arthroscopically assisted AC joint reconstruction and preliminary results. Clin Orthop Relat Res 466(3):639–645
25. Baumgarten KM, Altchek DW, Cordasco FA (2006) Arthroscopically assisted acromioclavicular joint reconstruction. Arthroscopy 22(2):228.e1–228.e6
26. Rehbein K, Jung C, Becker U, Bauer G (2008) Treatment of acute AC joint dislocation by transosseal acromioclavicular and coracoclavicular fiberwire cerclage. Z Orthop Unfall 146(3):339–343
27. Wellmann M, Zantop T, Weimann A, Raschke MJ, Petersen W (2007) Biomechanical evaluation of minimally invasive repairs for complete acromioclavicular joint dislocation. Am J Sports Med 35(6):955–961
28. Martetschläger F, Buchholz A, Sandmann G, Siebenlist S, Döbele S, Hapfelmeier A, Stöckle U, Millett PJ, Elser F, Lenich A (2013) Acromioclavicular and coracoclavicular PDS augmentation for complete AC joint dislocation showed insufficient properties in a cadaver model. Knee Surg Sports Traumatol Arthrosc 21(2):438–444
29. Motamedi AR, Blevins FT, Willis MC, McNally TP, Shahinpoor M (2000) Biomechanics of the coracoclavicular ligament complex and augmentations used in its repair and reconstruction. Am J Sports Med 28(3):380–384

8.1.4

Journal of Orthopaedics 14 (2017) 10–18

Contents lists available at ScienceDirect

Journal of Orthopaedics

journal homepage: www.elsevier.com/locate/jor

Original Article

Unstable acromioclavicular joint injuries: Is there really a difference between surgical management in the acute or chronic setting?

Luis Natera Cisneros [a,b,*], Juan Sarasquete Reiriz [a,c]

[a] Hospital de la Santa Creu i Sant Pau, Universitat Autònoma de Barcelona, Street Sant Quintí 89, Postcode: 08026 Barcelona, Spain
[b] Hospital General de Catalunya, Street Pedro i Pons 1, Postcode: 08190, Sant Cugat del Vallés, Barcelona, Spain
[c] Hospital Quirón Teknon, Street Vilana 12, Postcode: 08022 Barcelona, Spain

ARTICLE INFO

Article history:
Received 6 July 2016
Received in revised form 8 September 2016
Accepted 13 October 2016
Available online

Keywords:
Unstable acromioclavicular joint injuries
Anatomic reconstruction
Timeline
Acute and chronic setting
Arthroscopy-assisted

ABSTRACT

Aim: To compare the outcomes of unstable ACJ injuries managed with an arthroscopy-assisted anatomic reconstruction of the coracoclavicular (CC) ligaments in the acute and chronic setting.
Methods: A retrospective revision was performed. The SF36, visual analog scale for pain, DASH questionnaire, constant score and the global satisfaction were assessed at the last follow-up visit.
Results: 22 patients were included. Results of the questionnaires assessed at the last follow-up visit showed no significant differences between the study groups.
Conclusion: Management of ACJ injuries in the acute or chronic setting may involve comparable outcomes if biological and mechanical aspects are considered.
Level of evidence: Level III, retrospective cohort study.

1. Introduction

Surgical management of acute unstable acromioclavicular joint (ACJ) injuries should be focused on realigning the torn ends of the ligaments, because it is accepted that in the acute phase they still have healing potential.[1] On the other side, surgical management of chronic ACJ injuries should incorporate a biological augmentation, because it is accepted that after 3 weeks from shoulder injury the AC and the CC ligaments have lost their property to heal.[2]

Previous studies that compared the surgical management in the acute setting versus surgical management in the chronic setting suggest that better outcomes may be obtained from early management.[1,3] Surgical techniques performed in these studies were non-anatomic procedures, which incorporated temporary metal hardware, both for patients managed in the acute and chronic setting.[1,3]

It has been reported that non-anatomic procedures may involve worst clinical and radiological outcomes than anatomic ligaments reconstructions.[4] It has been also reported that reconstructions with tendon allograft for chronic injuries tend to involve partial lost of reduction with follow-up because elongation of the graft.[5] It is actually clear that outcomes depend on the technique performed.[6]

As far as we have knowledge, there are not studies that provide comparative evidences regarding the outcomes of unstable ACJ injuries managed with an anatomic reconstruction of the CC ligaments in the acute setting versus those injuries managed in the chronic setting.

The aim was to provide evidences about the clinical and radiological outcomes of unstable ACJ injuries managed with an arthroscopy-assisted anatomic reconstruction of the coracoclavicular (CC) ligaments in the acute and chronic setting.

We hypothesized that patients with unstable ACJ injuries managed with an anatomic reconstruction of the CC ligaments performed in the acute setting by means of two CC suspension devices anatomically placed, would have similar outcomes than patients with unstable ACJ injuries managed with an anatomic reconstruction of the CC ligaments performed in the chronic setting by means of a CC ligaments reconstruction with a tendon allograft, protected by a primary mechanical stabilizer during the integration process of the graft to the bone tunnels.

* Corresponding author at: Hospital de la Santa Creu i Sant Pau, Universitat Autònoma de Barcelona, Street Sant Quintí 89, Postcode: 08026 Barcelona, Spain.
E-mail address: luisgerardonaterac@gmail.com (L. Natera Cisneros).

http://dx.doi.org/10.1016/j.jor.2016.10.011
0972-978X/

2. Patients and methods

2.1. Study design

A retrospective cohort study was performed in two tertiary hospitals. Patients with unstable ACJ injuries (grade IIIB-V according to the modified Rockwood classification) managed by means of an anatomic reconstruction of the CC ligaments arthroscopy-assisted, performed in the acute and chronic setting were included. The inclusion period ran from January 2011 to January 2013.

2.2. Study population

Patients were included in the study following these inclusion criteria: (a) either sex; (b) radiographic diagnosis of unstable ACJ injury (Rockwood IIIB-IV-V); (c) physically active and between 18 and 55 year-old at the moment of shoulder surgery; (d) managed operatively by means of an arthroscopy-assisted CC reconstruction with two suspension devices (ACUTE-group) or by means of an arthroscopy-assisted CC reconstruction with a tendon allograft plus a suspension device (CHRONIC-group); (e) with a clinical history and radiological examination complete and available at the moment of the revision of the records; (f) with a minimum follow-up of 24 months after surgery and (g) operated by the same shoulder surgeon. The exclusion criteria were: (a) radiographic diagnosis of an ACJ injury Rockwood grade I-II-IIIA; (b) previous injuries to the respective shoulder and (c) surgical techniques other than acute or chronic arthroscopically assisted anatomic CC reconstruction. The patients who fulfilled these eligibility criteria were contacted and proposed to be included in the study. Once patients accepted to participate in the study, they signed an informed consent, and radiographic and clinical examinations of the injured shoulder were collected.

2.3. ACJ injury classification

Classification was made by means of observing the X-rays performed at the initial visit post injury. Radiographic examinations of both shoulders were performed to all patients at the initial visit post injury. The X-rays protocol of these two institutions included: strict anteroposterior (AP) view (both shoulders), Zanca view (both shoulders) and axillary view (only injured shoulder). Axillary views were performed with the patient in the prone position. The cross-body adduction view (Alexander view) was performed at the initial visit post injury in all patients, so in accordance to the diversification of the Rockwood classification proposed by ISAKOS,[7] the classification could be updated as it was done previously.[8] Rockwood IIIB injuries were those in which there was evidence of the clavicle overriding the acromion in the Alexander X-rays[7].

Grade III and grade V injuries were differentiated according to the traditional Rockwood classification.[9] A grade III if the CC distance of the injured shoulder was increased between 25 and 100% when compared to the non-injured shoulder; and a grade V if the CC distance of the injured shoulder was increased between 100 and 300% when compared to the non-injured shoulder.[9] These assessments were made on Zanca views. Diagnosis of ACJ injuries Rockwood grade IV was made by means of observation in the axillary view of the clavicle posteriorly dislocated in relation to the acromion.[9]

2.4. Clinical assessments and quality of life (QoL) evaluations

The clinical outcomes and the QoL were evaluated by means of the Health Survey questionnaire (SF36), the visual analog scale (VAS) for pain, the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire, the constant score and the global satisfaction (scale from 0 to 10), assessed at the last follow-up visit.

2.5. Management decision-making

There was no randomization before decision-making. Patients with acute unstable ACJ injuries Rockwood grade IV–V (Fig. 1A) were told that there were international recommendations regarding the surgical management for this type of injuries[11]; and patients with Rockwood grade III ACJ injuries were told that there were no evidence-based medical guidelines for decision-making and that surgery was recommended in active patients with high demands on the shoulder function. In summary, indications were based on the radiological magnitude of displacement between the clavicle and the acromion, which at the end is the indicator of a tear or not in the CC ligaments with affection or not of the deltotrapezial fascia,[10,11] which also plays a determinant role in the vertical and horizontal stability of the ACJ.[12]

Once the diagnosis unstable ACJ injury was established, patients were informed about the different treatment options. The timeline between acute and chronic injuries, as well as the surgical technique, were established according to current international consensus.[6] Acute injuries were managed with two CC suspension devices anatomically placed within the first three weeks after injury (Fig. 1B), and chronic injuries were managed with tendon graft augmentation after three weeks from shoulder injury (Fig. 1C and D). Patients who at the initial visit post injury at the shoulder clinic, agreed to undergo for surgical management were included in the ACUTE-group. Patients of the CHRONIC-group were those who initially rejected surgery in the acute setting, thus were initially managed conservatively. After a period of conservative measures with no remission of the symptoms these patients were proposed to have surgery in the chronic setting. Patients of both groups were told about the risks of a surgical intervention.

2.6. Surgical technique

2.6.1. ACUTE-group

The performed technique involves the placement of two CC suspension devices by means of an arthroscopy-assisted procedure. This technique has been previously described adding an ACJ horizontal augmentation.[12] In the series of patients of this study, no horizontal augmentation was performed.

The coracoacromial (CA) ligament is followed until its insertion at the coracoid. The base of the coracoid is cleaned with a vaporizer. The suspension devices are passed through the tunnels in a retrograde direction. The retrograde direction (from coracoid to clavicle) implies making CC tunnels with a diameter of 3.5 mm, thus minimizing the probability of coracoid fracture. A transverse incision with a length of 3 cm is made 2 cm medial to the lateral edge of the clavicle. This incision is made between the locations where the native origins of the conoid and trapezoid ligaments should be in the inferior aspect of the clavicle. The native origin of the conoid is 4.5 cm medial to the lateral edge of the clavicle, and the trapezoid is 2.5 cm and slightly anterior when compared with the conoid.[13] A cross section of the deltotrapezial fascia is performed. The traction is released, and a Biomet AC drilling guide (reference 909511) with a calibrated angulation of 80 to 90 is placed at the base of the coracoid, adjacent to the wall of the scapula, and 5 mm lateral to the medial border of the coracoid, with the sliding tube of the guide located in the superior aspect of the clavicle, 4.5 cm medial to the ACJ (conoid native origin) (Fig. 2A). A 2.4-mm K-wire is passed through the AC guide. The location of the AC guide is then changed. In the inferior aspect of the coracoid, the AC guide is placed 5 mm medial to the lateral

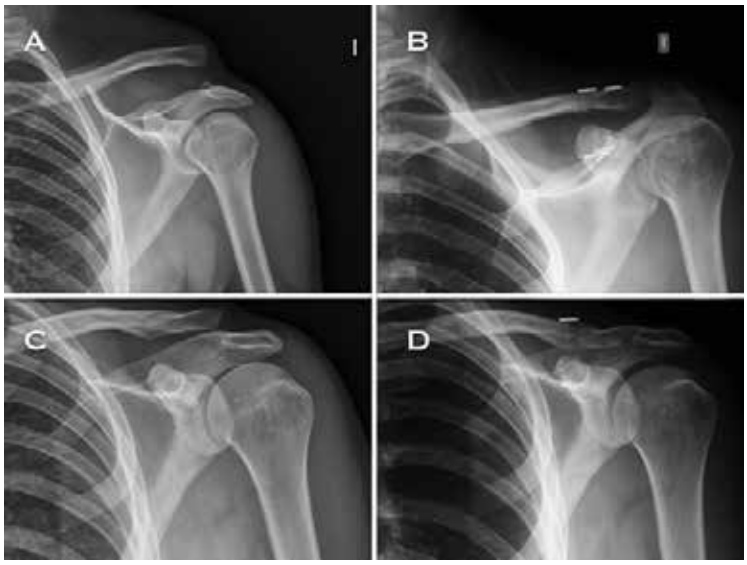


Fig. 1. (A) Anteroposterior X-ray of a left shoulder in which an ACJ injury Rockwood grade V can be observed. (B) Anteroposterior X-ray of a left shoulder in which an anatomic CC fixation with two suspension devices was performed in the acute setting. (C) Anteroposterior X-ray of a left shoulder in which an ACJ injury Rockwood grade V can be observed. (D) Anteroposterior X-ray of a left shoulder in which an anatomic reconstruction of the CC ligaments with tendon allograft was performed in the chronic setting. Observe the trapezoid tunnel in clavicle, lateral to the conoid tunnel in clavicle, through which also passes the suspension device.

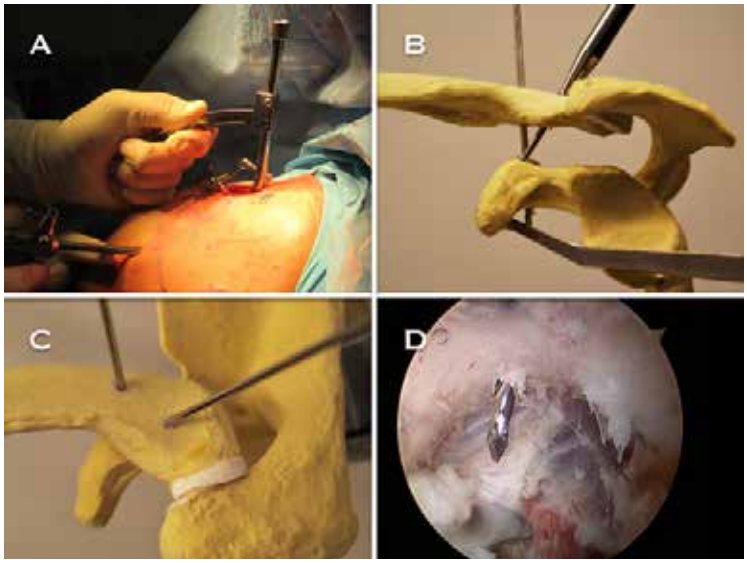


Fig. 2. (A) Posterior perspective of a left shoulder in which the AC guide is being introduced through the anterior portal with the sliding tube supported in the superior aspect of the clavicle. The arthroscope is introduced through the anterolateral portal. (B) AC sawbone in which the conoid K-wire has been already passed, and the AC guide is supported in order to allow the placement of the trapezoid K-wire. (C) Superior perspective of an AC sawbone in which the two K-wires placed in the anatomic locations of the CC ligaments can be observed. (D) Subcoracoid vision of a right shoulder through the anterolateral portal. Observe the two CC K-wires coming out from the coracoid. The conoid K-wire (red arrow) is more posterior and medial than the trapezoid K-wire (blue arrow). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

border of the coracoid and slightly anterior when compared with the location of the conoid K-wire. In the superior aspect of the clavicle, the sliding tube should be located in the trapezoid native origin, which is 2.5 cm medial to the ACJ and slightly anterior when compared with the location of the previous K-wire.

A 2.4-mm K-wire is passed from the clavicle to the coracoid, following the anatomic orientation of the trapezoid ligament (Fig. 2B). From the superior aspect of the clavicle, convergence of the two K-wires can be observed (Fig. 2C). The distance between K-wires in the inferior aspect of the coracoid should be about 1.5 cm (Fig. 2D). Afterward, a 3.5-mm cannulated drill is passed over the conoid K-wire until it comes out from the inferior aspect of the coracoid, where the AC guide catches it. The conoid K-wire is removed, and the cannulated drill is kept in position. A shuttle suture (1-mm PDS; Ethicon, Somerville, NJ) is passed from the clavicle to the coracoid through the cannulated drill and is then recovered with a grasper from the anterior portal. A No. 2 MaxBraid suture (Arthrotek [Biomet]) is tied to the distal limb of the PDS that passes through the conoid tunnel, and the PDS is then pulled out cranially to make the shuttle MaxBraid pass through the tunnel. Next, the 3.5-mm cannulated drill is passed over the trapezoid K-wire. The trapezoid K-wire is removed, and the cannulated drill is kept in position. Another 1-mm PDS shuttle suture is passed from the clavicle to the coracoid through the cannulated drill and is recovered with a grasper from the anterior portal. A No. 2 MaxBraid suture is tied to the distal limb of the PDS that passes through the trapezoid tunnel, and the PDS is then pulled out cranially to make the shuttle MaxBraid pass through the tunnel. The conoid suspension device (ZipTight, reference 904834; Biomet) is first passed through the tunnel. The distal limb of the conoid shuttle MaxBraid is provisionally tied to the sliding sutures of the suspension device. This shuttle MaxBraid, which is coming out from the conoid tunnel in the clavicle, should be pulled out cranially to make the suspension device pass through the tunnel (Fig. 3A). The same procedure is repeated in the trapezoid tunnel. Once both suspension devices have been passed through each tunnel, the titanium flip devices of both are properly placed in the inferior aspect of the coracoid (Fig. 3B). Before tensioning of the ZipTights is performed (Fig. 3C), the sliding sutures of the system should be threaded in the washers to make them descend until they touch the clavicle. Afterward, the surgical assistants should reduce the ACJ by pushing the elbow upward and the clavicle downward at the same time. Once the flip device of the conoid ZipTight has been properly supported in the inferior aspect of the coracoid, it is tied and fixed by pulling alternatively on both limbs of the sliding sutures in a cranial direction to make the washer go down until it touches the clavicle and self-locks. Now fixation and locking of the trapezoid ZipTight can be performed. Both ZipTights are completely fixed by pulling alternatively on both limbs of the sliding sutures in a cranial direction. Once the 2 ZipTights have been locked (Fig. 3D), the final CC interval reduction can be checked with intraoperative radiographs. The ACJ reduction is checked by direct palpation, direct arthroscopic visualization, or intraoperative radiographs. The remnants of the sliding sutures are now cut. The deltotrapezial fascia is carefully closed and reconstructed with No. 1.0 Vicryl (Ethicon).

2.6.2. CHRONIC-group

This arthroscopy-assisted technique has been previously described.[10]

Anatomic reconstruction of the CC ligaments using a semi-tendinosus tendon allograft was performed in all patients. The technique involves one tunnel at the coracoid, and two tunnels at the clavicle. These tunnels are aimed to emulate the anatomical locations of the CC ligaments. We also add a CC suspension device in order to guarantee the primary stability of the reconstruction.

Fig. 3. (A) AC sawbone in which the conoid CC suspension device is being passed in a retrograde direction. This suspension device is being pulled out from the superior aspect of the clavicle. (B) Subcoracoid vision of a right shoulder through the anterolateral portal. Observe the two subcoracoid flips of the two suspension devices. (C) Superior perspective of a left shoulder in which the sliding sutures of both suspension devices can be observed after have being passed in a retrograde direction. (D) Superior perspective of a left shoulder in which the washers of both suspension devices can be observed.

We perform an arthroscopy-assisted reconstruction in order to be able to diagnose and treat possible associated glenohumeral injuries, and in order to have a proper view of the inferior aspect of the base of the coracoid at the moment of drilling the tunnel.

A subacromial approach to the base of the coracoid is performed. A Mumford procedure is associated. A transverse skin incision over the clavicle is performed. The conoid native insertion is 4.5-cm medial to the distal end of the clavicle and the trapezoid native insertion 2.5-cm and subtly anterior when compared to the conoid.[13] A cross section of the deltotrapezial fascia is performed, and the AC drilling guide is placed at the base of the coracoid with the sliding tube at the superior aspect of the clavicle, 4.5-cm medial to its distal end (conoid native origin). A K-wire is passed through the cannulated drill. The K-wire is removed and the cannulated drill is maintained in the same position. A shuttle suture is passed through the cannulated drill. Two metal-core sutures (No. 2 MaxBraids) are tied to the distal end of the PDS that passes through the coracoid. Subsequently, the same procedure should be performed, this time for the clavicular tunnel of the trapezoid ligament. One of the metal-core sutures that pass through the conoid tunnel is temporarily tied to one of the ends of the tendon graft. The other end of the graft is temporarily tied to the PDS, which is coming out from the trapezoid clavicle and exits through the anterior portal.

The graft is passed by means of pulling cranially of the metal-core suture that comes out from the conoid tunnel. Subsequently, the PDS which is coming out from the trapezoid clavicle tunnel is pulled in a superior direction; so the graft is directed laterally and superiorly, conforming the anatomic "V" configuration of the reconstruction (Fig. 4A). One of the ends of the shuttle metal-core suture is still free in the conoid tunnel. This suture is now tied to the CC suspension device, and pulled out in a cranial direction so the device passes in a retrograde direction (Fig. 4B). The washer should be threaded with the sliding sutures, in order to be able to bring it down until it is applied over the clavicle. In the inferior aspect of the coracoid the subcoracoid flip of the suspension device should be properly supported (Fig. 4C). The assistants must reduce the ACJ, by means of pushing the elbow upwards and the clavicle downwards at the same time. Posteriorly, the graft is fixed in the clavicular portion of the tunnels with biotenodesis interferential screws. The CC suspension device is now locked (Fig. 4D). The deltotrapezial fascia is carefully reconstructed.

The described technique provides the advantages of a minimally invasive surgery, avoids the biomechanical disadvantages related to rigid metal hardware procedures, offers a greater biomechanical resistance thus minimizing the risk of secondary displacements related to non-anatomical techniques, and combines a primary mechanical stabilization and a definitive biological stabilization represented by the graft, once integrated to bone. In Fig. 1D, the radiological aspect of a left shoulder in which the described technique was performed can be appreciated.

2.7. Rehabilitation period

The rehabilitation period involved wearing a sling for 3–4 weeks. Patients were initially allowed to move fully and actively the elbow, wrist, and hand. In both groups, pendulum exercises begin from the first week post-injury, and patients were allowed to passively move the shoulder no more than 90° of elevation in the plane of the scapula after the first week. The active range of motion was progressively advanced from the sixth week onwards in both groups. Exercises to regain strength were initiated once the patient

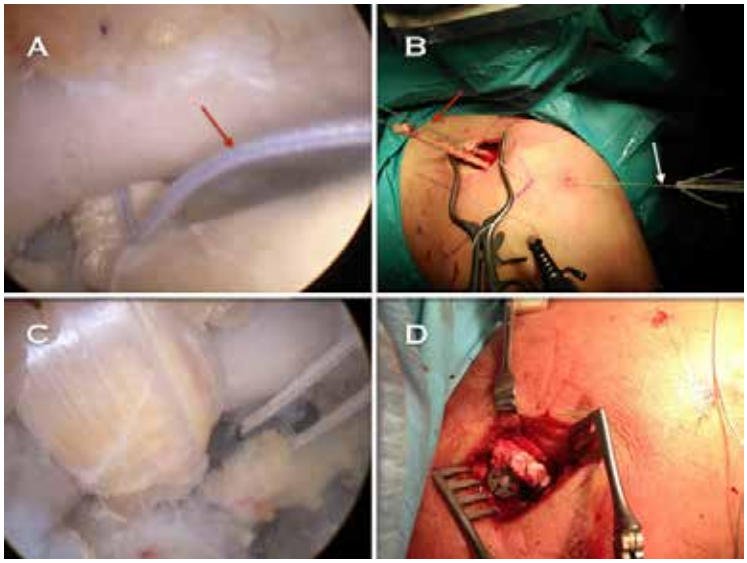


Fig. 4. (A) Subcoracoid vision of a right shoulder through the anterolateral portal. Observe the tendon allograft coming from the conoid tunnel in the coracoid. This tendon is being pulled from the trapezoid tunnel in clavicle. The red arrow is pointing the shuttle suture, which is going to be used to pass the suspension device. (B) Superior perspective of a right shoulder in which the two limbs of the tendon allograft are being pulled cranially (red arrow). The suspension device is tied to the shuttle suture (white arrow), which is also being pulled cranially from the superior aspect of the conoid tunnel in clavicle. (C) Subcoracoid vision of a right shoulder through the anterolateral portal. Observe the tendon allograft coming out from the conoid tunnel and surrounding the coracoid before ascending to the trapezoid tunnel in clavicle. The subcoracoid flip of the suspension device is properly supported. (D) Superior perspective of a right shoulder in which the final aspect of the construction can be observed.

had full, pain-free passive and active range of motion, and exercises were primarily directed toward scapular stabilization. Return to work without restrictions was allowed after 12–14 weeks and contact sports or major efforts were avoided for 4–6 months in both groups.

2.8. Radiographic follow-up

Radiographic follow-up evaluations were made based on the X-rays performed at the last follow-up visit. Radiographic examinations of both shoulders were performed. The X-rays included the same protocol performed at the initial visit post injury: strict AP view (both shoulders), Zanca view (both shoulders), axillary view (only injured shoulder) and cross-body adduction view (Alexander view).

Remaining vertical ACJ instability was assessed on bilateral Zanca views, according to the modified Rosenørm and Pedersen classification.[14] The ACJ was considered reduced when there was no displacement in comparison to the non-injured side, subluxed when there was less than 50% of displacement of the clavicle in relation to the height of the acromion and completely dislocated if the displacement of the clavicle was greater than 50% of the height of the acromion. We did not measure the CC distance. Remaining horizontal instability was assessed by means of observation of the clavicle overriding the acromion in the Alexander X-rays performed at the last follow-up visit.

2.9. Assessment of scapular motion and complications

Scapular dyskinesis was diagnosed according to Kibler's definition, as the alteration of the normal position or motion of the scapula during coupled scapulohumeral movements.[15] The presence of scapular dyskinesis was assessed at the last-follow up visit, by means of the "yes/no" method described by Kibler's group.[16] This test consists on the evaluation of the scapular motion by the physician when the patient is performing shoulder forward flexion with both shoulders. It is a simplification of the Kibler's 4-type method, and groups dyskinesis categories (types I to III) into a single category of "yes" (presence of dyskinesis), and type IV is labeled as "no" (normal scapular motion). Comparison between groups was performed.

Coracoid fracture, development of hardware irritation and infections were registered.

3. Statistical analysis

The sample was conformed by all of the patients of the study period who fulfilled the inclusion criteria. There was not a previous estimation of the population. Statistical analysis was carried out according to the complete sample analysis.

Continuous variables are presented as mean and standard deviation (SD) or mean and range. Categorical variables are presented as percentages and frequencies. The relationship between variables was analyzed with contingency tables for the categorical ones, and the inference was studied with the X^2 test or Fisher's exact test depending on what corresponded. The Mann–Whitney *U* test was applied to analyze quantitative variables. Descriptive statistics, such as percentage and median with interquartile range (IQR, 25th to 75th percentile) were used to analyze data on subjective and objective shoulder function.

Comparison between treatments was performed regarding only the injured shoulder. Comparisons between the function of the injured shoulder and the uninjured one were not performed. The level of significance was set at 5% ($\alpha = 0.05$). Data were analyzed by use of the SPSS 19 (SPSS Inc., Chicago, IL).

4. Results

4.1. Population characteristics

22 patients were included: 12 ACUTE-group (3 Rockwood IIIB, 2 IV and 7V) and 10 CHRONIC-group (1 Rockwood IIIB, 1 IV, and 8V). The mean age was 31 (range 19–45) year-old in the ACUTE-group and 41 (range 33–55) in the CHRONIC-group ($p = 0.0001$). All patients were men. The mean time elapsed from shoulder injury to surgery was 8 days (range 5–15) in the ACUTE-group, and 203 days (range 46–354) in the CHRONIC-group ($p = 0.0001$). The mean follow-up after surgery was 26.50 months (range 25–32) in the ACUTE-group and 25.50 months (range 24–30) in the CHRONIC-group ($p = 1.000$). The mean time elapsed from shoulder injury to the last follow-up visit (moment of study assessments) was 26.80 months (range 25–33) in the ACUTE-group and 32.25 months (range 30–36) in the CHRONIC-group ($p = 0.003$). Table 1 shows the baseline characteristics of the study population by treatments groups.

4.2. Associated concomitant glenohumeral injuries

Concomitant glenohumeral injuries were detected and treated in 16.67% (2/12) of the patients of the ACUTE-group (2 slap lesions type II) and in 20% (2/10) of the patients of the CHRONIC-group (1 Bankart and 1 slap lesion type II) ($p = 1.000$). These injuries were managed by means of fixation with suture-anchors.

4.3. Quality of life evaluations

These results are presented in Table 2.

4.4. Radiographic follow-up

At the last follow-up visit, there was evidence of remaining vertical instability in 8.33% (1/12) patients of the ACUTE-group and in none of the patients of the CHRONIC-group ($p = 1.000$). There was evidence of remaining horizontal instability in 16.67% (2/12) of the patients of the ACUTE-group and in 20% (2/10) of the patients of the CHRONIC-group ($p = 1.000$).

4.5. Scapular dyskinesis

At the last follow-up visit, there was evidence of scapular dyskinesis in 8.33% (1/12) of the patients of the ACUTE-group and in 10% (1/10) of the patients of the CHRONIC-group ($p = 1.000$).

Table 1
Baseline characteristics of patients by treatment groups.

		Total ($n = 22$)	ACUTE-group ($n = 12$)	CHRONIC-group ($n = 10$)	*P value*
Age (year-old)	Mean [range]	35 [19–55]	31 [19–45]	41 [33–55]	0.0001
Time from injury to surgery (days)	Mean [range]	95 [5–354]	8 [5–15]	203 [46–354]	0.0001
Mean follow-up after surgery (months)	Mean [range]	26 [25–32]	26.50 [25–32]	25.50 [24–30]	1.000
Time elapsed from shoulder injury to last follow-up visit (months)	Mean [range]	29.5 [25–36]	26.80 [25–33]	32.25 [30–36]	0.003

Table 2
Quality of life results.

Quality of life evaluations.	ACUTE-group	CHRONIC-group	*P value*
SF36 physical	58.33 ± 1.15	59.58 ± 1.98	0.085
Mean ± SD			
Median [P_{25}–P_{75}]	58 [56.5–60]	59 [57.5–62]	
SF36 mental	55.25 ± 1.76	56.62 ± 1.89	0.103
Mean ± SD			
Median [P_{25}–P_{75}]	55 [54–57]	57 [56–58]	
VAS	0.92 ± 0.79	1.44 ± 1.74	0.361
Mean ± SD			
Median [P_{25}–P_{75}]	1 [0–1.75]	1 [0–2.5]	
DASH	3.80 ± 2.52	2.61 ± 1.79	0.244
Mean ± SD			
Median [P_{25}–P_{75}]	3.1 [2.05–3.85]	1.70 [1.35–4.6]	
Constant score	95.50 ± 2.58	95.56 ± 3.28	0.966
Mean ± SD			
Median [P_{25}–P_{75}]	96 [94–98]	96 [93–98]	
Global satisfaction	8.5 ± 0.9	9.2 ± 0.67	0.058
Mean ± SD			
Median [P_{25}–P_{75}]	8 [8–9]	9 [9–10]	

4.6. Complications

There was no any case of coracoid fracture, hardware irritation or infection or in any of the treatment groups.

5. Discussion

The main finding of this study was that patients with unstable ACJ injuries managed with an anatomic reconstruction of the CC ligaments in the acute setting have the same quality of life and radiological outcomes than patients managed with an anatomic reconstruction of the CC ligaments with tendon allograft plus a primary mechanical stabilizer in the chronic setting.

Unstable ACJ injuries managed with arthroscopy-assisted procedures have shown good and excellent clinical outcomes.[17] Diagnosis and treatment of concomitant glenohumeral injuries and no mandatory implant removal are the main advantages of arthroscopy-assisted techniques among open procedures.[17,18] As far as we have knowledge, this is the first comparative report in regards to associated intraarticular injuries in the acute and chronic setting.

Warren-Smith and Ward analyzed 32 patients with Allman grade 3 ACJ injuries managed with the Weaver–Dunn procedure.[19] There were no differences between the 10 early and the 22 late patients; but authors concluded that surgery was technically easier when performed in the acute setting. Their study showed excellent functional results in 67% (6/9) of the patients treated in the acute setting and in 55% (11/20) of the patients treated in the chronic setting.[19] We agree with authors in the technical aspects. In the chronic setting reduction of the ACJ is more difficult, and it often involves the need of associate a Mumford procedure.

Weinstein et al. described the time point distinguishing acute versus delayed surgery, as 3 weeks from the date of injury.[2] In their comparative study the surgical procedure used was the modified Weaver–Dunn technique in 55.56% (15/27) of the cases managed in the acute setting and in 82.35% (14/17) of the cases managed in chronic setting. The rest of the repairs were performed by means of AC non-reabsorvable sutures. Satisfactory results were obtained in 96% of the cases treated in the acute phase and in 76% of the cases treated in chronic phase. The differences were statistically significant in favor of the treatment in the acute phase.[2] 44.44% (12/27) of the patients of the acute group and 17.67% (3/17) of the patients of the chronic group were managed by means of an AC fixation with sutures (horizontal stabilization). We believe that differences between outcomes of these groups could rely on the differences in the number of patients that received a horizontal stabilization, taking in consideration that horizontal instability is a risk factor for a poor clinical outcome.[20]

Rolf et al. compared a group of patients treated immediately after occurrence of shoulder injury (29 patients, using the modified Phemister technique, adding a CC fixation with sutures) versus a group of patients that had surgery after failure of conservative treatment (20 patients using the modified Weaver–Dunn procedure).[1] Clinical results were significantly superior in the group of patients managed in the acute phase.[1] Biomechanical studies have shown the inferior resistance to vertical loads of the Weaver Dunn procedure when compared to CC fixation with sutures.[21] We believe that differences encountered in the study performed by Wolf et al. might be in relation to the currently known biomechanical disadvantages of the Weaver Dunn procedure.[21]

Mignani et al. compared 25 patients treated in the acute setting versus 15 patients in treated in the chronic setting.[22] In both groups the management consisted on AC and CC temporary fixations with Kirschner wires and concomitant excision of the distal third of the clavicle. Authors reported satisfactory results in 100% of the patients of the acute group and 93% in the patients of the chronic group, with no statistically significant differences.[22] In this study, no biological augmentation was added in the group of patients managed in the chronic setting, so we believe this condition could influence the worst outcomes registered in the chronic group, even though the differences did not reach statistical significance. If a biological augmentation is not incorporated in chronic ACJ injuries, it may be perfectly expected that patients managed in the acute setting have better outcomes.

Dumontier et al. compared 32 patients treated in the acute setting (first 3 weeks) versus 24 patients treated in the chronic setting (over 3 weeks).[23] All patients were managed by means of the Weaver–Dunn procedure. The results were satisfactory in 81% of the patients treated in the acute setting and in 79% of the patients treated in the chronic setting.[23] The study reported no significant differences between groups. We believe that registered outcomes were quite similar between groups, because in the group managed in the chronic setting a biological augmentation was incorporated (CA ligament), and in the group managed in the acute setting the transposition of the CA ligament could have been useful to narrow the CC space, thus favoring the healing of the native structures.

Von Heideken et al. compared 22 patients managed in the acute setting (within the first 4 weeks after injury) versus 15 patients managed in the chronic setting (after a minimum of 4 months of conservative measures).[3] The technique used was the ACJ fixation with a hook plate. In the acute group, the remnants of the ligaments were brought in vicinity by the reduction of the clavicle with the hook plate. In the chronic group, a modified Weaver Dunn procedure augmented with a hook plate was used. The results favored significantly both in the clinical and radiological aspects, to the group of patients who were managed in the acute setting.[3] We believe that these differences might be the reflection of the biomechanical superiority of the native CC ligaments over the translocated CA ligament.[24] In our study, it can be said that the registered outcomes involve a comparison between the healed native CC ligaments and the tendon-reconstructed CC ligaments. In fact, it has been shown that the biomechanical behavior of a CC ligaments reconstruction with tendon allograft is superior to the native CC ligaments.[24]

Millet et al. compared the outcomes of patients who underwent delayed CC reconstruction (more than 30 days) when compared with those who underwent early reconstruction CC (less than 30 days).[25] In their study the whole population consisted on 31 patients with Rockwood grade III and grade V ACJ injuries, but they do not specify the number of patients included in each group. Authors performed the same technique in all shoulders. The

technique consisted on an anatomic CC reconstruction with a tibialis anterior or peroneus longus tendon allograft implanted by either an open or arthroscopically assisted procedure. Patients who underwent early reconstruction showed no significant differences in postoperative clinical or radiographic results when compared with those who underwent delayed reconstruction. We believe that in this study the registered outcomes were similar between groups because in the group managed in the chronic setting a biological augmentation was incorporated. Considering that it is accepted that in the acute setting the native structures have healing potential, a biological augmentation with a tendon allograft might be saved; but this study shows that if an anatomic reconstruction with a biological augmentation is performed, the expected outcomes may be the same independently of the timing for surgery.

It has been shown that radiographic results (maintenance of the reduction of the ACJ and the CC interval) obtained by means of the management in the acute phase may be better than those obtained in the chronic phase.[1,3] It has been reported that tendon grafts tends to lengthen over time; and besides, they may emulate a "windshield" effect at the level of the clavicular tunnels, situation that eventually ends with widening of the tunnels.[26] In a previous study in which patients treated in the acute phase were managed by means of one CC suspension device[8] we noticed a high incidence of secondary displacements. With our current study we wanted to compare the clinical and radiological outcomes of unstable ACJ injuries managed with an acute anatomic synthetic reconstruction of the CC ligaments versus unstable ACJ injuries managed by means of a chronic CC ligaments reconstructions with tendon allograft plus a CC suspension device. We consider it is fundamental to guarantee the primary mechanical stabilization of the chronic reconstruction, which at the end represents the protection of the integration-to-bone period of the reconstructed structures.

It has been also shown that partial loss of vertical reduction do not influence the overall result.[2] A possible explanation for this finding could be the fact that the healed CC elongated ligaments provide enough stability to relieve symptoms.[27] The failure rate after fixation in the chronic setting using only tendon graft has been described to be around 50% or more[28,29]; while the failure rate after management in the acute setting has been described to be around 26.8%.[28] In our study, there were no significant differences between groups. We believe that this issue relies on the fact that we added a primary mechanical stabilizer to the reconstructions performed in the chronic setting.

In the series of 17 patients described by Carofino and Mazzocca, in which the CC ligaments were reconstructed using a semitendinosus allograft passed beneath the coracoid and through bone tunnels in the clavicle, there was a failure rate of 17.65% (3/17).[30] One of those patients had a failure due to loss of reduction. We believe that making a tunnel in the coracoid and thus promoting integration-to-bone of the tendon allograft, and incorporating a suspension device; minimizes the probabilities of late elongation of the tendon allograft with subsequent lost of ACJ reduction.

It has been reported that infection rates are higher in the chronic setting than in the acute setting.[1,3] This issue may be due to the fact that in the chronic setting, surgical times may be longer, tendon allografts are used and surgical approaches are usually wider. In the acute setting, no deep surgical wounds infections have been described.[28] A systematic review of the literature describes that the overall rate of superficial infections is around 3.8% for arthroscopic procedures,[28] in contrast to a rate of up to 5% for procedures performed by means of open surgery[28]; and up to 8% in those procedures in which a tendon graft was used.[31,32] In the series of 17 patients described by Carofino and Mazzocca, one of the patients developed a chronic infection, requiring removal of the allograft and a lattissimus flap for soft tissue coverage.[30] In our series, no superficial or deep infections were registered. When compared to the rate of infections reported in the literature, it is possible that differences may be in relation to the low number of patients of our series.

We believe that if it is accepted that in the acute phase the native ligaments have potential to heal and to recover their biomechanical functions, surgeons must take advantage of this situation and save the incorporation of a biological augmentation, which sometimes increases the cost of the procedure (in case of allografts) or the morbidity (in case of autografts).

Considering these premises, with this study we wanted to provide evidences about the management in the acute setting with a procedure that pretends to guarantee mechanical stability and biological restoration (anatomically placed CC suspension devices and healed native CC ligaments), and about the management in the chronic setting with a procedure that also pretends to guarantee mechanical stability and biological restoration (conoid suspension device and anatomic CC reconstruction with tendon allograft).

Our hypothesis established that respecting mechanical and biological premises, the final outcomes might be comparable independently of the timing for surgery. This hypothesis was confirmed.

The main limitations of our study are its retrospective design and the low number of patients. There was not randomization before undergoing one treatment or the other and there was not a previous estimation of the population. The age range is wide. Many of the patients managed in the chronic setting were those that initially rejected the surgical management in the acute setting. Information about the presence or absence of preoperative scapular dyskinesis in the CHRONIC-group was not available. For the purposes of this study, clinical assessments through questionnaires were performed only once. This data collection was performed prospectively (patients were contacted and called to participate in the study, after the hypothesis was formulated).

Considering the mentioned limitations, and therefore despite the limited scope of the study, it might be taken into account that may be not all patients with unstable ACJ injuries should be encourage to have early surgery. In the process of decision-making, patients should be informed that early and late anatomic reconstructions may offer comparable outcomes, but if initial conservative measures are considered and fail, the time "invested" to have a painless and functional shoulder might finally be longer.

6. Conclusion

Patients with unstable ACJ injuries managed by means of an arthroscopy-assisted anatomic CC reconstruction performed in the acute or chronic setting show excellent clinical and radiological outcomes. Management in the acute or chronic setting may involve comparable outcomes if biological and mechanical aspects are considered.

Disclosures

Dr. Juan Sarasquete receives royalties from Biomet® Sports Medicine.

Conflicts of interest

The authors have none to declare.

References

1. Rolf O, Hann von Weyhern A, Ewers A, Boehm TD, Gohlke F. Acromioclavicular dislocation Rockwood III–V: results of early versus delayed surgical treatment. *Arch Orthop Trauma Surg.* 2008;128:1153–1157.

2. Weinstein DM, McCann PD, McIlveen SJ, Flatow EL, Bigliani LU. Surgical treatment of complete acromioclavicular dislocations. *Am J Sports Med.* 1995;23:324–331.
3. von Heideken J, Boström Windhamre H, Une-Larsson V, Ekelund A. Acute surgical treatment of acromioclavicular dislocation type V with a hook plate: superiority to late reconstruction. *J Shoulder Elbow Surg.* 2013;222:9–17.
4. Warth RJ, Martetschläger F, Gaskill TR, Millett PJ. Acromioclavicular joint separations. *Curr Rev Musculoskelet Med.* 2013;6:71–78. http://dx.doi.org/10.1007/s12178-012-9144-9.
5. LaPrade RF, Hilger B. Coracoclavicular ligament reconstruction using a semitendinosus graft for failed acromioclavicular separation surgery. *Arthroscopy.* 2005;21:1277.e1–1277.e5.
6. Beitzel K, Cote MP, Apostolakos J, et al. Current concepts in the treatment of acromioclavicular joint dislocations. *Arthroscopy.* 2013;29:387–397. http://dx.doi.org/10.1016/j.arthro.2012.11.023.
7. Beitzel K, Mazzocca AD, Bak K, et al. ISAKOS upper extremity committee consensus statement on the need for diversification of the Rockwood classification for acromioclavicular joint injuries. *Arthroscopy.* 2014;30:271–278. http://dx.doi.org/10.1016/j.arthro.2013.11.005.
8. Natera L, Sarasquete J, Abat F, Besalduch M, Monllau JC, Videla S. Acute unstable acromioclavicular joint injuries: quality of life comparison between patients managed operatively with a coracoclavicular suspension device arthroscopically placed versus patients managed non-operatively. *Eur Orthop Traumatol.* 2015;6(4):343–355. http://dx.doi.org/10.1007/s12570-015-0326-y.
9. Rockwood Jr CA, Williams Jr GR, Young DC. Disorders of the acromioclavicular joint. In: Rockwood Jr CA, Matsen 3rd FA, eds. In: *The Shoulder*. Philadelphia: WB Saunders; 1998:483–553.
10. Natera L, Sarasquete Reiriz J, Abat F. Anatomic reconstruction of chronic coracoclavicular ligament tears: arthroscopic-assisted approach with nonrigid mechanical fixation and graft augmentation. *Arthrosc Tech.* 2014;15(3(5)):e583–e588. http://dx.doi.org/10.1016/j.eats.2014.06.014.
11. Johansen JA, Grutter PW, McFarland EG, Petersen SA. Acromioclavicular joint injuries: indications for treatment and treatment options. *J Shoulder Elbow Surg.* 2011;20:70–82. http://dx.doi.org/10.1016/j.jse.2010.10.030.
12. Natera L, Sarasquete J, Besalduch M, Petrica A, Escolà A, Rodriguez J. Horizontal and vertical stabilization of acute unstable acromioclavicular joint injuries arthroscopy-assisted. *Arthrosc Tech.* 2015;4(6):721–729. http://dx.doi.org/10.1016/j.eats.2015.07.014.
13. Rios CG, Arciero RA, Mazzocca AD. Anatomy of the clavicle and coracoid process for reconstruction of the coracoclavicular ligaments. *Am J Sports Med.* 2007;35:811–817.
14. Rosenorn M, Pedersen EB. A comparison between conservative and operative treatment of acute acromioclavicular dislocation. *Acta Orthop Scand.* 1974;45:50–59.
15. Kibler WB, McMullen J. Scapular dyskinesis and its relation to shoulder pain. *J Am Acad Orthop Surg.* 2003;11:142–151.
16. Uhl TL, Kibler WB, Gecewich B, Tripp BL. Evaluation of clinical assessment methods for scapular dyskinesis. *Arthroscopy.* 2009;25:1240–1248. http://dx.doi.org/10.1016/j.arthro.2009.06.007.
17. Jensen G, Katthagen JC, Alvarado LE, Lill H, Voigt C. Has the arthroscopically assisted reduction of acute AC joint separations with the double tight-rope technique advantages over the clavicular hook plate fixation? *Knee Surg Sports Traumatol Arthrosc.* 2014;22:422–430. http://dx.doi.org/10.1007/s00167-012-2270-5.
18. Arrigoni P, Brady PC, Zottarelli L, et al. Associated lesions requiring additional surgical treatment in grade 3 acromioclavicular joint dislocations. *Arthroscopy.* 2014;30:6–10. http://dx.doi.org/10.1016/j.arthro.2013.10.006.
19. Warren-Smith CD, Ward MW. Operation for acromioclavicular dislocation. A review of 29 cases treated by one method. *J Bone Joint Surg Br.* 1987;69:715–718.
20. Scheibel M, Dröschel S, Gerhardt C, Kraus N. Arthroscopically assisted stabilization of acute high-grade acromioclavicular joint separations. *Am J Sports Med.* 2011;39(7):1507–1516.
21. Michlitsch MG, Adamson GJ, Pink M, Estess A, Shankwiler JA, Lee TQ. Biomechanical comparison of a modified Weaver–Dunn and a free-tissue graft reconstruction of the acromioclavicular joint complex. *Am J Sports Med.* 2010;38:1196–1203. http://dx.doi.org/10.1177/0363546509361160.
22. Mignani G, Rotini R, Olmi R, Marchiodi L, Veronesi CA. The surgical treatment of Rockwood grade III acromio-clavicular dislocations. *Chir Organ Mov.* 2002;87:153–161.
23. Dumontier C, Sautet A, Man M, Apoil A. Acromioclavicular dislocations: treatment by coracoacromial ligamentoplasty. *J Shoulder Elbow Surg.* 1995;4:130–134.
24. Grutter PW, Petersen SA. Anatomical acromioclavicular ligament reconstruction: a biomechanical comparison of reconstructive techniques of the acromioclavicular joint. *Am J Sports Med.* 2005;33:1723–1728. http://dx.doi.org/10.1177/0363546505275646.
25. Millett PJ, Horan MP, Warth RJ. Two-year outcomes after primary anatomic coracoclavicular ligament reconstruction. *Arthroscopy.* 2015;31(10):1962–1973. http://dx.doi.org/10.1016/j.arthro.2015.03.034.
26. Cook JB, Shaha JS, Rowles DJ, Bottoni CR, Shaha SH, Tokish JM. Early failures with single clavicular transosseous coracoclavicular ligament reconstruction. *J Shoulder Elbow Surg.* 2012;21(12):1746–1752.
27. Andreani L, Bonicoli E, Parchi P, Piolanti N, Michele L. Acromio-clavicular repair using two different techniques. *Eur J Orthop Surg Traumatol.* 2014;24:237–242. http://dx.doi.org/10.1007/s00590-013-1186-1.
28. Woodmass JM, Esposito JG, Ono Y, et al. Complications following arthroscopic fixation of acromioclavicular separations: a systematic review of the literature. *Open Access J Sports Med.* 2015;6:97–107. http://dx.doi.org/10.2147/OAJSM.S73211.
29. Milewski MD, Tompkins M, Giugale JM, Carson EW, Miller MD, Diduch DR. Complications related to anatomic reconstruction of the coracoclavicular ligaments. *Am J Sports Med.* 2012;40(7):1628–1634.
30. Carofino BC, Mazzocca AD. The anatomic coracoclavicular ligament reconstruction: surgical technique and indications. *J Shoulder Elbow Surg.* 2010;19(2):37–46. http://dx.doi.org/10.1016/j.jse.2010.01.004.
31. Tauber M, Gordon K, Koller H, Fox M, Resch H. Semitendinosus tendon graft versus a modified Weaver–Dunn procedure for acromioclavicular joint reconstruction in chronic cases: a prospective comparative study. *Am J Sports Med.* 2009;37:181–190. http://dx.doi.org/10.1177/0363546508323255.
32. Modi CS, Beazley J, Zywiel MG, Lawrence TM, Veillette CJ. Controversies relating to the management of acromioclavicular joint dislocations. *Bone Joint J.* 2013;95-B(12):1595–1602.

8.1.5

Prevalence of remaining horizontal instability in high-grade acromioclavicular joint injuries surgically managed

Luis Natera Cisneros & Juan Sarasquete Reiriz

European Journal of Orthopaedic Surgery & Traumatology

ISSN 1633-8065
Volume 27
Number 3

Eur J Orthop Surg Traumatol (2017)
27:323-333
DOI 10.1007/s00590-016-1898-0

Springer

Eur J Orthop Surg Traumatol (2017) 27:323–333
DOI 10.1007/s00590-016-1898-0

ORIGINAL ARTICLE • SHOULDER - TRAUMA

Prevalence of remaining horizontal instability in high-grade acromioclavicular joint injuries surgically managed

Luis Natera Cisneros[1,2] · **Juan Sarasquete Reiriz**[1,3]

Received: 6 September 2016 / Accepted: 15 December 2016 / Published online: 5 January 2017

Abstract
Purpose To determine the prevalence of remaining horizontal instability in high-grade acromioclavicular joint (ACJ) injuries surgically managed by means of four different surgical strategies and to assess its relation to the clinical outcomes and the quality of life.
Methods In this multicentric non-randomized retrospective study, 53 patients with high-grade ACJ injuries surgically managed (by means of open or arthroscopic surgery) were clinically and radiographically assessed at 24 months or more after shoulder surgery. The presence of post-surgical remaining horizontal instability was evaluated by means of Alexander or axillary X-ray views. The study population was divided into two groups: patients with evidence of post-surgical remaining horizontal instability and patients without evidence of post-surgical remaining horizontal instability at the last follow-up visit. The relationship between remaining horizontal instability and the quality-of-life questionnaires was analyzed.
Results 18.87% (10/53) of the Alexander or axillary X-rays views showed post-surgical remaining horizontal instability at the last follow-up visit (INSTAB-group). Results of the questionnaires were: (1) physical SF36 score (INSTAB-group 57.02 ± 3.17 and NO-INSTAB-group 57.66 ± 3.30, $p = 0.583$); (2) mental SF36 score (INSTAB-group 53.95 ± 3.98 and NO-INSTAB-group 55.71 ± 3.30, $p = 0.150$); (3) NRS for pain (INSTAB-group 1.30 ± 1.49 and NO-INSTAB-group 0.83 ± 1.08, $p = 0.260$); (4) DASH questionnaire (INSTAB-group 5.27 ± 5.42 and NO-INSTAB-group 3.06 ± 2.30, $p = 0.049$); (5) Constant score (INSTAB-group 93.4 ± 3.5 and NO-INSTAB-group 94.83 ± 4.3, $p = 0.333$); and Global satisfaction (INSTAB-group 8.7 ± 0.95 and NO-INSTAB-group 8.64 ± 1.03, $p = 0.874$).
Conclusion Independently of the type of procedure, post-surgical remaining horizontal instability was present in almost one-fifth of the patients, and this group of patients showed a significantly worse DASH score. The addition of an acromioclavicular augmentation might have to be considered, taking into account that its absence may have a negative impact in terms of shoulder disabilities.
Level of evidence Level IV, prognostic case series.

Keywords High-grade ACJ injuries · Horizontal instability · Shoulder disabilities · Acromioclavicular augmentation · Alexander X-ray · Axillary X-ray

Introduction

Traumatic acromioclavicular joint (ACJ) pathology is gaining popularity among the community of shoulder surgeons, because the biomechanical and clinical consequences that might arise from these injuries are currently better known [1]. In like manner, there is an increasing interest in anatomic coracoclavicular (CC) ligament reconstruction because anatomic strategies are aimed to recreate the force vectors of both the conoid and trapezoid ligaments, thus restoring the biomechanical functions of these structures, as well as ACJ stability [2]. Despite the recent development of numerous reconstructive techniques,

✉ Luis Natera Cisneros
luisgerardonaterac@gmail.com

[1] Hospital de la Santa Creu i Sant Pau, Universitat Autònoma de Barcelona, Sant Quintí 89, 08026 Barcelona, Spain

[2] Hospital General de Catalunya, Pedro i Pons 1, 08190 Sant Cugat del Vallés, Barcelona, Spain

[3] Hospital Quirón Teknon, Vilana 12, 08022 Barcelona, Spain

remaining anteroposterior post-surgical instability remains a matter of concern [3].

Biomechanical studies have shown that only reconstructing the CC ligaments does not provide sufficient horizontal stability of the lateral clavicle, and therefore have suggested the use of an additional acromioclavicular (AC) augmentation [4, 5]. The relative contribution of the AC capsule and the CC ligaments to the ACJ stability has already been described [6]. It has also been described that patients who had undergone surgery for unstable ACJ injury and present remaining anteroposterior post-surgical instability may have significantly worse clinical results [7].

The aim of this study was to determine the prevalence of remaining horizontal instability in high-grade ACJ injuries surgically managed by means of four different surgical strategies and to assess its relation to the clinical outcomes and the quality of life.

The hypothesis was that remaining horizontal instability would be related to worse clinical outcomes.

Materials and methods

Study design

A retrospective cohort study was performed in three tertiary hospitals. Patients with high-grade ACJ injuries (grades III–V according to the modified Rockwood classification) managed by means of surgery were included. The inclusion period ran from January 2008 to January 2013. Some of the information of the treatment groups was obtained from previous studies [8, 9]. Informed consent was obtained from all individual participants included in the study.

Population characteristics

The study population was conformed by these treatment groups:

Acute arthroscopy-assisted ACJ stabilization by means of 1 CC suspension device (1CC-group) (Figs. 1a–c, 2a–d), acute arthroscopy-assisted ACJ stabilization by means of 2 CC suspension devices (2CC-group) (Fig. 3a, b), acute open reduction and internal fixation with a hook plate (HOOK-group) (Fig. 4a, b), chronic arthroscopy-assisted anatomic reconstruction of the CC ligaments with a tendinous allograft and a CC suspension device (TENDON-group) (Fig. 5a, b).

1CC-group and 2CC-group included patients with acute ACJ injuries managed by the shoulder unit of two of the three institutions included in the study. These two groups of patients were managed by the same orthopedic surgeon (JS). 1CC-group included patients managed between 2008 and 2012, and 2CC-group included patients managed between 2012 and 2013. The treatment protocol of these two institutions evolved in 2012, from 1 CC suspension device to 2 CC suspension devices. The addition of a second CC suspension device was aimed to reduce the rate of secondary displacements.

HOOK-group included patients with acute ACJ injuries managed by the trauma-unit of the third institution. This group of patients was surgically treated by many trauma surgeons between 2008 and 2012. At this institution, ACJ injuries were managed by the trauma unit, and per protocol, the treatment strategy consisted of an ACJ fixation with a hook plate.

TENDON-group included patients with chronic ACJ injuries managed by the shoulder unit of two of the three institutions included in the study. This group of patients was managed by the same orthopedic surgeon (JS), once the conservative measures were considered to be unsuccessful.

ACJ injuries were considered acute if the decision for surgical management was taken within the first three weeks after shoulder injury; and chronic, after three weeks from shoulder injury [1].

Finally, the study population was divided into two groups: the group of patients with evidence of post-surgical remaining horizontal instability (INSTAB-group) and the group of patients without evidence of post-surgical remaining horizontal instability (NO-INSTAB-group) at the last follow-up visit.

Operative treatment

The surgical techniques have been previously described [2, 8–10]. In none of the treatment groups, an additional horizontal augmentation of the ACJ was performed.

All patients were placed in the beach chair position under general anesthesia and interscalene block. In the groups managed by means of an arthroscopy-assisted procedure (1CC-group, 2CC-group and TENDON-group), three standard arthroscopic portals were used: posterior, anterolateral and lateral. Diagnostic arthroscopic examination of the shoulder was performed in order to detect glenohumeral concomitant injuries. Anatomic reduction was confirmed by means of direct visualization and palpation. In the 1CC-group, the CC suspension device used was the TightRope (Arthrex, Inc, Naples, Florida, USA); and in the 2CC-group and TENDON-group, the CC suspension device used was the (ZipTight™, reference 904834, Biomet®, Warsaw, Indiana, USA). In the HOOK-group, a standard anterior approach to the clavicle was performed. The reduction was checked by means of fluoroscopic control. Hook plates (Synthes, West Chester, USA) were used in all patients. Closure of the deltotrapezial fascia was then performed to secure the reduction in all groups. The skin was sutured, and the arm was placed in a sling.

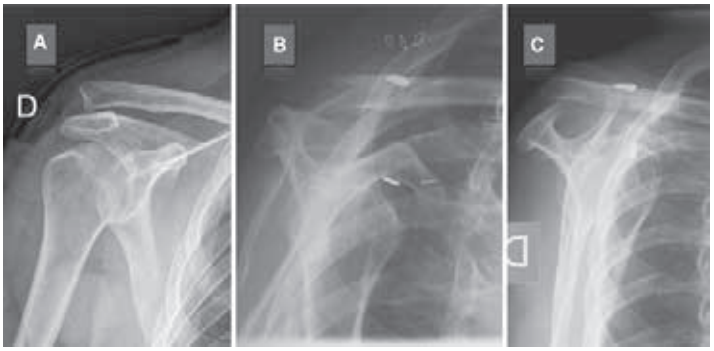


Fig. 1 **a** X-ray in anteroposterior view of a right shoulder with an ACJ injury Rockwood Grade V. Observe that the acromion is below the clavicle. **b**, **c** Postoperative X-ray in the Alexander view in which remaining horizontal instability can be observed. No additional acromioclavicular augmentation was performed in this case

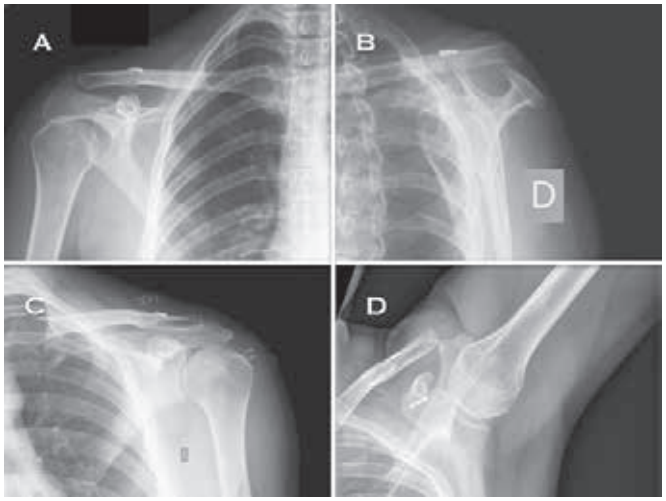


Fig. 2 **a** X-ray in anteroposterior view of a right shoulder in which a high-grade ACJ injury that was managed by means of 1 CC suspension device can be observed. No additional acromioclavicular augmentation was performed in this case. Note that in this X-ray projection, no evidence of horizontal instability can be noted. **b** X-ray in Alexander projection of the same shoulder. Observe that the acromion is below the clavicle, showing the presence of post-surgical remaining horizontal instability. **c** X-ray in anteroposterior view of a left shoulder in which a high-grade ACJ injury that was managed by means of 1 CC suspension device can be observed. No additional acromioclavicular augmentation was performed in this case. Note that in this X-ray projection, no evidence of horizontal instability can be noted. **d** X-ray in axillary projection of the same shoulder. Observe that the anterior border of the clavicle is not well aligned with the anterior border of the acromion, showing the presence of post-surgical remaining horizontal instability

The rehabilitation period involved wearing a sling for 3–4 weeks. Patients were initially allowed to move fully and actively the elbow, wrist and hand. Patients of the HOOK-group were allowed to passively move the shoulder no more than 90° of elevation in the plane of the scapula after the first week, and patients of 1CC-group, 2CC-group and TENDON-group three weeks after surgery. Pendulum exercises begin from the first week post-injury in all groups.

The active range of motion was progressively advanced from the sixth week onwards in all groups. Return to work without restrictions was allowed after 12–14 weeks, and major efforts were avoided for 4–6 months in all groups.

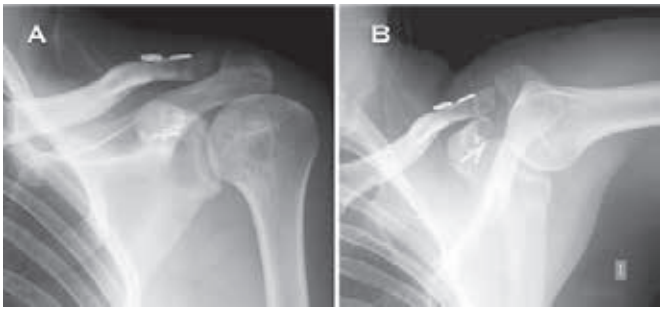


Fig. 3 **a** X-ray in anteroposterior view of a *left* shoulder in which a high-grade ACJ injury that was managed by means of 2 CC suspension devices can be observed. No additional acromioclavicular augmentation was performed in this case. Note that in this X-ray projection, no evidence of horizontal instability can be noted. **b** X-ray in axillary projection of the same shoulder. Observe that the anterior border of the clavicle is not well aligned with the anterior border of the acromion, showing the presence of post-surgical remaining horizontal instability

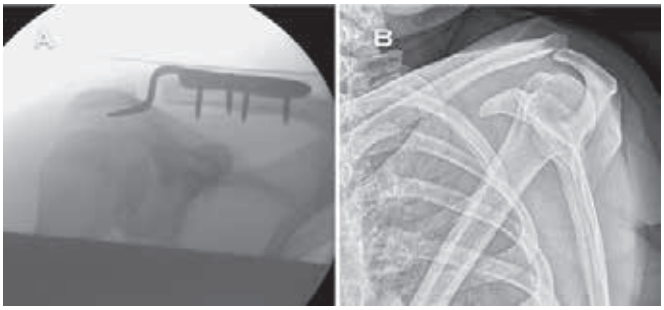


Fig. 4 **a** X-ray in anteroposterior view of a right shoulder in which a high-grade ACJ injury that was managed by means of a hook plate. No additional acromioclavicular augmentation was performed in this case. **b** X-ray in Alexander projection of the same shoulder once the plate was removed. Observe that the acromion is below the clavicle, showing the presence of post-surgical remaining horizontal instability

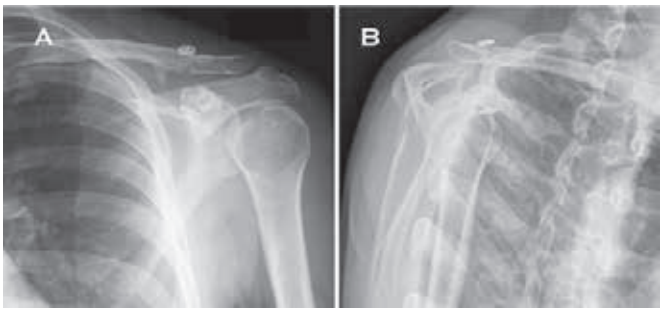


Fig. 5 **a** X-ray in anteroposterior view of a left shoulder in which a chronic high-grade ACJ injury that was managed by means of an anatomic CC reconstruction with tendon allograft plus a CC suspension device can be observed. No additional acromioclavicular augmentation was performed in this case. Note that in this X-ray projection, no evidence of horizontal instability can be noted. **b** X-ray in Alexander projection of the same shoulder. Observe that the acromion is below the level of the clavicle, showing the presence of post-surgical remaining horizontal instability

Radiological assessments

Radiographic follow-up evaluations were made based on the X-rays performed at the last follow-up visit. Radiographic examinations of both shoulders were performed. The presence of remaining horizontal instability was evaluated by means of bilateral Alexander X-rays views or axillary views. If there was observation of the acromion below the clavicle in the Alexander X-rays performed at the last follow-up visit (Figs. 1c, 2b, 4b and 5b), the ACJ was considered to show signs of remaining horizontal instability [11]. If the anterior tip of the acromion and the anterolateral edge of the distal clavicle were not in line with the ACJ in the axillary projection (Figs. 2d, 3b), the ACJ was considered to show signs of posterior subluxation or dislocation in terms of horizontal instability [12]. The relationship between post-surgical remaining horizontal instability and the clinical outcomes was analyzed.

Clinical assessments

All patients were clinically assessed at 24 months or more after surgery. Instruments for clinical evaluation were: (a) The SF36: 1–physical and 2–mental, (b) The numeric rating scale (NRS) for pain of the injured shoulder: "0" corresponding to "no pain" and "10" corresponding to "the worst pain imaginable," (c) The DASH questionnaire, (d) The Constant score and (e) The "Global Satisfaction" scale (numerical rating scale from 0 to 10; being 0, not satisfied with the treatment, and 10, completely satisfied with the results of the treatment).

Relationship between variables

The statistical relationships between the QoL questionnaires vs the type of surgery and vs the presence or absence of post-surgical remaining horizontal instability were assessed by means of a multivariate analysis. Likewise, quality-of-life questionnaires were stratified according to the presence or absence of remaining horizontal instability. Comparison between these two groups was performed by means of the Mann–Whitney test.

IRB approval and ethical standards

The protocol of the study was approved by the Hospital de la Santa Creu i Sant Pau Ethics Committee (code: IIBSP-LUX-2016-32). The study was performed in accordance with the ethical standards of the Declaration of Helsinki (amended in October 2013), and the level of confidentiality concerning the protection of personal data was as required by the Spanish laws (LOPD 15/1999).

Statistical analysis

Continuous variables are presented as mean and standard deviation (SD) or mean and range. All continuous variables were tested for normality by using the Shapiro–Wilk normality test. Categorical variables are presented as percentages and frequencies. The relationship between variables was analyzed with contingency tables for the categorical ones, and the inference was studied with the X2 test or Fisher's exact test depending on what corresponded. The Mann–Whitney and Kruskal–Wallis tests were applied to analyze quantitative variables with a non-normal distribution. Comparisons between the function of the injured shoulder and the uninjured one were not performed. Quality-of-life questionnaires were stratified according to the presence or absence of remaining horizontal instability. Comparison between these two groups was performed. A multivariate analysis (Two-way ANOVA, analysis of variance) in which the quality-of-life questionnaires were considered as dependent variables, and the type of surgery and the presence of post-surgical remaining horizontal instability were considered as independent variables, was performed in order to define a precise correlation. The level of significance was set at 5% ($\alpha = 0.05$). Data were analyzed by use of the SPSS 19 (SPSS Inc., Chicago, Illinois).

Results

Population characteristics

A total of 53 patients were included in the study: 20-1CC-group (3 Rockwood III, 3 IV and 14 V); 12-2CC-group (3 Rockwood III, 2 IV and 7 V); 11-HOOK-group (5 Rockwood III and 6 V) and 10-TENDON-group (1 Rockwood III, 1 IV, and 8 V).

Baseline characteristics of patients are shown in Table 1.

Radiological assessments

Remaining horizontal instability was assessed by means of Alexander and axillary X-ray views in 79.25% (42/53) of the patients, and only by means of the axillary views in 20.75% (11/53) of the patients. In the cases that were assessed both by means of Alexander and axillary views, there was evidence of horizontal instability equally in both of these views. 18.87% (10/53) of the cases showed remaining horizontal instability at the last follow-up visit. Prevalence of post-surgical remaining horizontal instability stratified by treatment groups is shown in Table 2.

Table 1 Baseline characteristics of patients by treatment groups

		Total ($n = 53$)	1CC-group ($n = 20$)	2CC-group ($n = 12$)	HOOK-group ($n = 11$)	TENDON-group ($n = 10$)
Age (year-old)	Mean [range]	37 [19–55]	36 [25–52]	31 [19–45]	41 [19–55]	41 [33–55]
Male/female	*n* (%)/ *n* (%)	50 (94.3%)/3 (5.7%)	17 (85%)/3 (15%)	12 (100%)/0 (0%)	11 (100%)/0 (0%)	10 (100%)/0 (0%)
Rockwood classification						
Grade III	*n* (%)	12 (22.6%)	3 (15%)	3 (25%)	5 (45.5%)	1 (10%)
Grade IV	*n* (%)	6 (11.3%)	3 (15%)	2 (16.7%)	–	1 (10%)
Grade V	*n* (%)	35 (66%)	14 (70%)	7 (58.3%)	6 (54.5%)	8 (80%)
Time elapsed from injury to surgery (days)	Mean [range]	29 [4–354]	9 [4–16]	8 [5–15]	7 [5–14]	203 [46–354]

Table 2 Prevalence of remaining horizontal instability assessed at the last follow-up visit stratified by treatment groups

Group of treatment	Remaining horizontal instability ($n = 10$)	No horizontal instability ($n = 43$)
1CC-group ($n = 20$)	20% (4/20)	80% (16/20)
2CC-group ($n = 12$)	16.67% (2/12)	83.33% (10/12)
HOOK-group ($n = 11$)	18.18% (2/11)	81.82% (9/11)
TENDON-group ($n = 10$)	20% (2/10)	80% (8/10)
Total ($n = 53$)	18.87% (10/53)	81.13% (43/53)

Clinical assessments

A statistically significant difference between the NO-INSTAB-group and the INSTAB-group was only obtained for the DASH score. Results of the questionnaires were: (1) physical SF36 score (INSTAB-group 57.02 $\pm$ 3.17 and NO-INSTAB-group 57.66 $\pm$ 3.30, $p = 0.583$); (2) mental SF36 score (INSTAB-group 53.95 $\pm$ 3.98 and NO-INSTAB-group 55.71 $\pm$ 3.30, $p = 0.150$); (3) NRS for pain (INSTAB-group 1.30 $\pm$ 1.49 and NO-INSTAB-group 0.83 $\pm$ 1.08, $p = 0.260$); and (4) DASH questionnaire (INSTAB-group 5.27 $\pm$ 5.42 and NO-INSTAB-group 3.06 $\pm$ 2.30, $p = 0.049$).

Clinical outcomes stratified by the presence or absence of post-surgical remaining horizontal instability are shown in Table 3.

Quality-of-life results and clinical outcomes stratified by surgical technique are shown in Table 4.

Relationship between variables assessed by means of the multivariate analysis (two-way ANOVA, analysis of variance)

Physical SF36 vs type of surgery and post-surgical remaining horizontal instability

There was a significant difference ($p = 0.002$) among the four surgical techniques, and the HOOK-group showed an inferior value than the rest of the groups. There was not a significant difference ($p = 0.629$) between the presence and absence of post-surgical remaining horizontal instability.

Mental SF36 vs type of surgery and post-surgical remaining horizontal instability

There was a significant difference ($p = 0.036$) among the four surgical techniques, and the HOOK-group showed an inferior value than the rest of the groups. There was not a significant difference ($p = 0.134$) between the presence and absence of post-surgical remaining horizontal instability.

NRS for pain vs type of surgery and post-surgical remaining horizontal instability

There was a significant difference ($p = 0.012$) among the four surgical techniques, and the TENDON-group showed the highest value. There was not a significant difference ($p = 0.137$) between the presence and absence of post-surgical remaining horizontal instability, and the interaction between the type of surgery and the presence of post-surgical remaining horizontal instability showed a significant difference ($p = 0.040$).

Table 3 Quality-of-life results stratified according to the presence or absence of remaining horizontal instability

Quality-of-life evaluations	Remaining horizontal instability ($n = 10$)	No horizontal instability ($n = 43$)	p value
SF36 physical	57.02 ± 3.17	57.66 ± 3.30	0.583
SF36 mental	53.95 ± 3.98	55.71 ± 3.30	0.150
NRS for pain	1.30 ± 1.49	0.83 ± 1.08	0.260
DASH	5.27 ± 5.42	3.06 ± 2.30	0.049*
Constant	93.40 ± 3.50	94.83 ± 4.30	0.333
Global satisfaction	8.70 ± 0.95	8.64 ± 1.03	0.874

* Significant difference

Table 4 Quality-of-life results stratified by treatment groups

Quality-of-life evaluations	1CC-group ($n = 20$)	2CC-group ($n = 12$)	HOOK-group ($n = 11$)	TENDON-group ($n = 10$)	Kruskal–Wallis p value
SF36 for physical domain	58.24 ± 2.16	58.33 ± 1.15	53.70 ± 4.33	59.58 ± 1.98	0.000
SF36 for mental domain	56.15 ± 2.21	55.25 ± 1.76	53.06 ± 6.10	56.62 ± 1.89	0.711
NRS for pain	0.40 ± 0.50	0.92 ± 0.79	1.45 ± 1.51	1.44 ± 1.74	0.039
DASH questionnaire	2.98 ± 2.03	3.80 ± 2.52	4.79 ± 5.60	2.61 ± 1.79	0.383
Constant score	95.30 ± 2.45	95.50 ± 2.58	91.36 ± 6.84	95.56 ± 3.28	0.036
Global satisfaction	8.85 ± 0.93	8.5 ± 0.9	8.00 ± 1.18	9.2 ± 0.67	0.030

DASH questionnaire vs type of surgery and post-surgical remaining horizontal instability

There was a significant difference ($p = 0.043$) among the four surgical techniques, and the HOOK-group showed a superior value than the rest of the groups. There was a significant difference ($p = 0.017$) between the presence and absence of post-surgical remaining horizontal instability. The DASH values assessed have been superior in the patients with evidence of post-surgical remaining horizontal instability.

Constant score vs type of surgery and post-surgical remaining horizontal instability

There was neither a significant difference ($p = 0.151$) among the four surgical techniques, nor in relation to the presence and absence of post-surgical remaining horizontal instability ($p = 0.337$).

Global satisfaction vs type of surgery and post-surgical remaining horizontal instability

There was neither a significant difference ($p = 0.206$) among the four surgical techniques, nor between the presence and absence of post-surgical remaining horizontal instability ($p = 0.896$).

This information is illustrated in Figs. 6 and 7.

Discussion

The main finding of this study was that remaining post-surgical horizontal instability was prevalent in 18.87% of the patients that were managed by means of a surgical procedure that did not include an additional horizontal stabilization.

It has been described that patients with unstable ACJ injuries that demonstrate persistent horizontal instability have significantly inferior clinical results [7]. Scheibel et al. [7] observed remaining horizontal instability in 42.9% of a group of patients managed by means of two suspension devices anatomically placed. To our knowledge, Gerhardt et al. [13] were the first authors in recognizing in a publication the importance of an additional horizontal augmentation to address this issue. Horizontal instability has been postulated as the only factor that might represent a negative influence on the patient's perception of the results [7]. In fact, there can be several causes of chronic pain after surgical treatment of ACJ injuries, and one of these causes is the persistent anteroposterior instability of the clavicle [14, 15]. It could be explained by the fact that when there is remaining anteroposterior instability may exist more shearing on the ACJ surfaces than when there is remaining vertical instability. Because of this reason, authors are starting to describe stabilization strategies in the horizontal plane in order to deal with this determinant issue [10, 16, 17]. Our results coincide with

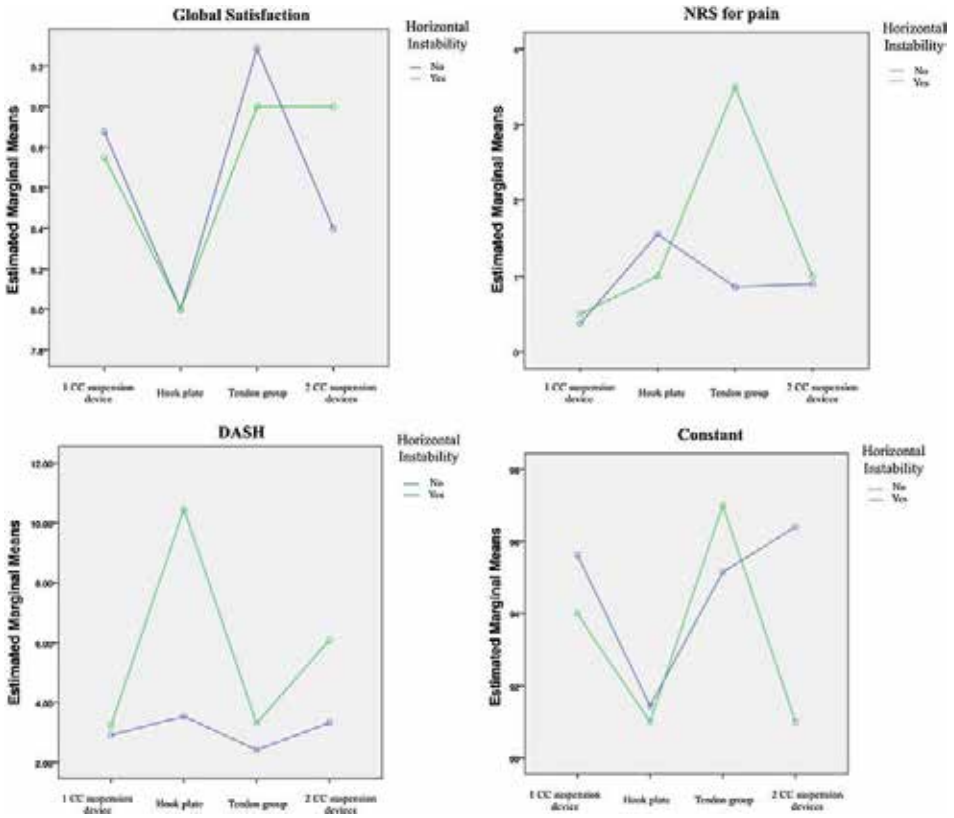


Fig. 6 *Line graph* in which the relationship between the presence or absence of post-surgical remaining horizontal instability and the type of treatment versus the Global satisfaction, the NRS for pain, the DASH and the Constant score can be observed

those published by Scheibel et al., reason why we strongly recommend a mandatory horizontal augmentation to address this specific problem [10].

In the prospective study described by Scheibel et al. [7] in which the double TightRope technique was used to treat acute ACJ dislocations grade V according to Rockwood, 28 patients were evaluated after a mean follow-up of 26.5 months. In this series, 57.1% (16/28) of the patients revealed a stable situation on the Alexander view, whereas 42.9% (12/28) were horizontally unstable. These authors developed the Acromioclavicular Joint Instability Score (ACJI), in which the best score is 100 points. This score assesses the pain (20 points equals to no pain), activities of daily living (10 points equals to no limitation), cosmesis (no asymmetry equals to 10 points), function (full range of motion and strength equals to 25 points), radiological assessments (35 points equals to no vertical nor horizontal instability, and no ACJ arthrosis). A stable situation in the horizontal plane was defined as a clavicle that was in line with the acromion (20 points). The clavicle was cataloged to be subluxated if the difference with the acromion was less than one clavicle shaft width (10 points), and if the difference was more than one width, the clavicle was defined as fully dislocated (0 points) [7].

In the mentioned study, patients who had a horizontally stable situation achieved superior results in all scores: 96.8% in the Subjective Shoulder Value (SSV), 91.9 points in the Constant score (CS), 11.4 points in the Taft score (TS), and 92.3 points in the ACJI. Patients with horizontal instability scored 92.9% in the SSV, 91.1 points in the Constant score, 9.2 points in the TS, and 63.3 points in the ACJI. However, only the TS and the ACJI showed

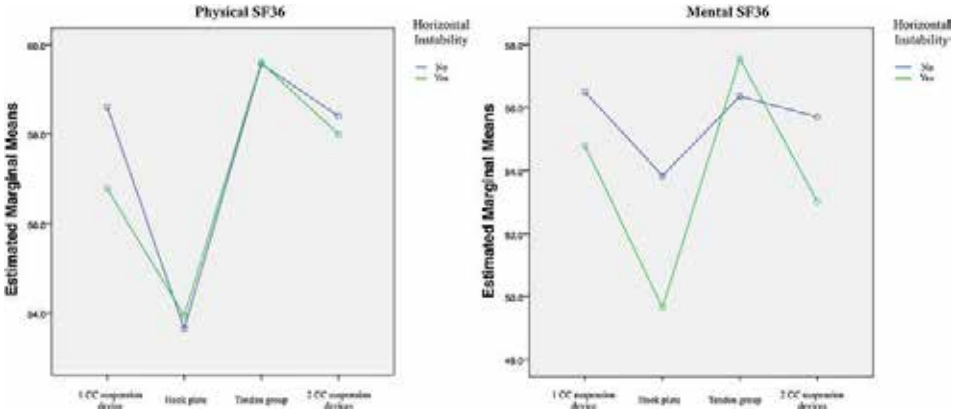


Fig. 7 *Line graph* in which the relationship between the presence or absence of post-surgical remaining horizontal instability and the type of treatment versus the SF36 (physical and mental) can be observed

statistically significant differences [7]. As far as we have knowledge, the study conducted by Scheibel et al. and our study represent the only two investigations that aimed to correlate the presence of ACJ horizontal instability with the final clinical outcomes. As well as in Scheibel's study, the group of patients with evidence of horizontal instability included in our study showed inferior clinical results than the group of patients that had a horizontally stable ACJ, although a significant difference was only encountered in the DASH score.

Horizontal instability can be assessed by means of a clinical assessment and/or by means of a radiographic evaluation of the ACJ in the Alexander or axillary X-ray views. Irlenbuschet et al. [18] have described the clinical evaluation of the horizontal stability of the ACJ. According to these authors, the lateral clavicle should be fixed between the fingers of one hand of the examiner, while the other hand is fixing the acromion. The magnitude of dorsal shift of the lateral clavicle against the acromion is then evaluated and differentiated in horizontally stable or unstable [18]. In regard to the radiological examination, there is evidence of remaining horizontal instability when the acromion is below the level of the distal third of the clavicle in the Alexander projection [26]; and if the anterior tip of the acromion and the anterolateral edge of the distal clavicle are not in line with the ACJ in the axillary view [12]. Likewise, ACJ injuries Rockwood Grade III are currently differentiated in IIIA (horizontally stable) and IIIB (horizontally unstable) according to the ISAKOS diversification of the Rockwood classification [26]. ACJ injuries IIIB are defined if the clavicle is overriding the acromion in the Alexander view [26]. In like manner, Tauber et al. [12] have described the gleno-acromio-clavicular angle (GACA), in order to allow the quantification of the horizontal instability in terms of angle differences calculated in three different X-rays projections. These authors have shown that functional axillary radiologic evaluation seems to represent a simple imaging tool to reveal dynamic horizontal instability [12]. In our retrospective study, remaining horizontal instability was assessed only by means of radiographic examinations. The clinical assessment of the horizontal behavior between the clavicle and the acromion in terms of the dorsal shift was not performed in all cases, or was not properly registered in the medical records.

Most of the authors use the Alexander views [19] to diagnose horizontal ACJ instability [7, 20]. Lädermann et al. [21] described the use of the axillary views to assess the horizontal stability in their series of patients with acute high-grade ACJ injuries that underwent open CC and AC stabilization with non-absorbable sutures. These authors describe excellent results in 91.9% of their patients, but they did not assess the presence or absence of post-surgical remaining horizontal instability. As mentioned before, besides the study published by Scheibel et al. [7], our study is one of the first publications that describes the prevalence of post-surgical remaining horizontal instability and its relation to the clinical outcomes; and as far as we have knowledge, our study is the first that includes more than one surgical strategy.

Debski et al. [22] described in their biomechanical study published in 2001 that horizontal stability of the ACJ cannot be completely restored by means of reconstructing only the CC ligaments. Likewise, recent biomechanical studies have shown that the only reconstruction of the CC ligaments does not provide sufficient horizontal stability of

the lateral clavicle, and therefore have described the importance of an additional AC augmentation [4, 5]. Dawson et al. [6] have shown in a biomechanical study that the repair of the ACJ capsule in addition to the reconstructed CC ligaments do have a beneficial effect. The majority of the described procedures focus on the reconstruction of the CC ligaments in order to restore the vertical stability of ACJ, and fewer studies focus on the reconstruction of the AC ligaments [1]. The results of our study reinforce the conclusion described by Scheibel et al. [7]: Post-surgical remaining horizontal instability may negatively influence the clinical outcomes.

The main vertical stabilizers of the ACJ are the CC ligaments [2]. The ACJ capsule is a robust structure that contributes significantly to the ACJ stability, especially in the horizontal plane [6]. The superior and posterior AC ligaments are the major structures responsible for limiting the posterior translation of the distal clavicle [23], producing 56 and 25% of the limitation, respectively [24]. Although the inferior AC ligament is thin, it is the main structure that limits the anterior translation of the distal clavicle [25]. For these reasons, in acute high-grade ACJ injuries, in which there is disruption of the CC and AC ligaments, the ideal treatment would be represented by the reconstruction of each component. Furthermore, in these injuries the aponeurosis of the deltoid and trapezoid muscles can partially detach, causing increased horizontal mobility of the distal clavicle. Considering all the evidence available, reconstructive strategies must give the same importance to the AC reconstruction than to the CC reconstruction [26]. In regard to surgical strategies in which temporary horizontal stabilization of the ACJ is achieved by means of using metal hardware, it should be mentioned that Kirschner's wires may destroy the ACJ surface and fibrocartilage plate, making this strategy prone to induce ACJ degeneration and osteoarthritis [27]. With regard to hook plates, in our study it can be seen that the clinical results that may be obtained with this technique might be worse than those clinical results that would be obtained by means of a ligament reconstruction technique. We consider that although the hook plate system is a technically "easy" procedure, it may represent a too aggressive strategy that may affect the patient self-perception of comfort and thus the clinical improvement.

Somehow, post-surgical remaining horizontal instability may reflect a poor initial management of the ACJ stability in the anteroposterior plane. In fact, as it can be seen in Fig. 1b, (in which the staples had not been removed yet), there are radiological signs of horizontal instability in the early period, which might reflect an improper management of this aspect, in terms of "malreduction."

A statistically significant difference between the NO-INSTAB-group and the INSTAB-group was only obtained for the DASH Score. On the contrary, comparisons among groups in all the other scores (SF-36 mental and Physical, NRS, Constant, Global satisfaction) did not show any significant difference. We recognize that the non-randomized methodology we used for collecting the population may had influenced these results. Therefore, we believe that the results obtained in this study may represent a precept for the development of a randomized, blind and prospective study, with a more homogeneous population, evaluated with more homogeneous assessments.

The clinical relevance of this study is that remaining horizontal instability is quite prevalent among ACJ injuries surgically managed, and represents a factor that may negatively influence the clinical outcomes. Because of this reason, a horizontal augmentation might have to be considered when managing these injuries.

The main limitation of this study is its retrospective design. Patients were not randomized before undergoing one treatment or the other. X-rays protocol was not the same in the three institutions. In the group of patients managed with the hook plate, horizontal instability was assessed only by means of axillary views, while in the other three treatment groups horizontal instability was assessed by means of Alexander and axillary views. Functional axillary radiologic evaluations were not performed. The results obtained were not stratified either according to the different grades of Rockwood or according to the timing of surgery. Although the distribution of the quantitative variables was non-normal, a multivariate analysis (Two-way ANOVA, analysis of variance) was performed. On the other hand, quality-of-life questionnaires were stratified according to the presence or absence of remaining horizontal instability, and comparison between these two groups was performed by means of the Mann–Whitney test. The p values obtained when the clinical results of the four different surgical techniques were compared by means of the multivariate analysis were similar but not the same than those obtained by means of the Kruskal–Wallis test.

Because of the retrospective nature of the study, clinical evaluations for the assessment of remaining horizontal instability were not performed or properly registered. Specific ACJ dislocations questionnaires were not applied. The outcome measures reported (SF36, NRS, DASH, Constant score and Global satisfaction) have not been formally validated for use in ACJ injuries, although they have been widely and commonly used in the literature.

Conclusion

Independently of the type of procedure, post-surgical remaining horizontal instability was present in almost one-fifth of the patients, and this group of patients showed a significantly worse DASH score. The addition of an

acromioclavicular augmentation might have to be considered, taking into account that its absence may have a negative impact in terms of shoulder disabilities.

Acknowledgements Authors would like to thank Ignasi Gich for his collaboration in the statistical calculations.

Compliance with ethical standards

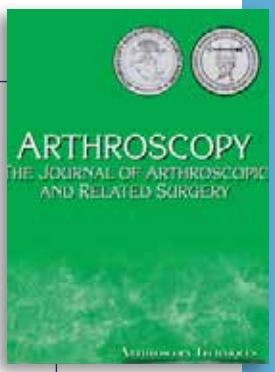
Conflict of interest Dr. Juan Sarasquete receives royalties from Biomet® Sports Medicine. The rest of the authors have no conflict of interest.

References

1. Beitzel K, Cote MP, Apostolakos J, Solovyova O, Judson CH, Ziegler CG, Edgar CM, Imhoff AB, Arciero RA, Mazzocca AD (2013) Current concepts in the treatment of acromioclavicular joint dislocations. Arthroscopy 29(2):387–397. doi:10.1016/j.arthro.2012.11.023
2. Natera L, Sarasquete J, Abat F (2014) Anatomic reconstruction of chronic coracoclavicular ligament tears: arthroscopic-assisted approach with nonrigid mechanical fixation and graft augmentation. Arthrosc Tech 3(5):583–588. doi:10.1016/j.eats.2014.06.014
3. Wellmann M, da Silva G, Lichtenberg S, Magosch P, Habermeyer P (2013) Instability pattern of acromioclavicular joint dislocations type Rockwood III: relevance of horizontal instability. Orthopade 42(4):271–277. doi:10.1007/s00132-013-2085-1
4. Beitzel K, Obopilwe E, Apostolakos J, Cote MP, Russell RP, Charette R, Singh H, Arciero RA, Imhoff AB, Mazzocca AD (2014) Rotational and translational stability of different methods for direct acromioclavicular ligament repair in anatomic acromioclavicular joint reconstruction. Am J Sports Med 42(9):2141–2148. doi:10.1177/0363546514538947
5. Saier T, Venjakob AJ, Minzlaff P, Föhr P, Lindell F, Imhoff AB, Vogt S, Braun S (2015) Value of additional acromioclavicular cerclage for horizontal stability in complete acromioclavicular separation: a biomechanical study. Knee Surg Sports Traumatol Arthrosc 23(5):1498–1505. doi:10.1007/s00167-014-2895-7
6. Dawson PA, Adamson GJ, Pink MM, Kornswiet M, Lin S, Shankwiler JA, Lee TQ (2009) Relative contribution of acromioclavicular joint capsule and coracoclavicular ligaments to acromioclavicular stability. J Shoulder Elbow Surg 18(2):237–244. doi:10.1016/j.jse.2008.08.003
7. Scheibel M, Dröschel S, Gerhardt C, Kraus N (2011) Arthroscopically assisted stabilization of acute high-grade acromioclavicular joint separations. Am J Sports Med 39(7):1507–1516
8. Natera-Cisneros L, Sarasquete-Reiriz J, Escolà-Benet A, Rodriguez-Miralles J (2016) Acute high-grade acromioclavicular joint injuries treatment: arthroscopic non-rigid coracoclavicular fixation provides better quality of life outcomes than hook plate ORIF. Orthop Traumatol Surg Res 102(1):31–39. doi:10.1016/j.otsr.2015.10.007
9. Natera L, Sarasquete J, Abat F, Besalduch M, Monllau JC, Videla S (2015) Acute unstable acromioclavicular joint injuries: quality of life comparison between patients managed operatively with a coracoclavicular suspension device arthroscopically placed versus patients managed non-operatively. Eur Orthop Traumatol 6(4):343–355. doi:10.1007/s12570-015-0326-y
10. Natera L, Sarasquete J, Besalduch M, Petrica A, Escolà A, Rodriguez J, Fallone J (2015) Horizontal and vertical stabilization of acute unstable acromioclavicular joint injuries arthroscopy-assisted. Arthrosc Tech 4(6):721–729. doi:10.1016/j.eats.2015.07.014
11. Beitzel K, Mazzocca AD, Bak K, Itoi E, Kibler WB, Mirzayan R, Imhoff AB, Calvo E, Arce G, Shea K (2014) ISAKOS upper extremity committee consensus statement on the need for diversification of the Rockwood classification for acromioclavicular joint injuries. Arthroscopy 30(2):271–278. doi:10.1016/j.arthro.2013.11.005
12. Tauber M, Koller H, Hitzl W, Resch H (2010) Dynamic radiologic evaluation of horizontal instability in acute acromioclavicular joint dislocations. Am J Sports Med 38(6):1188–1195. doi:10.1177/0363546510361951
13. Gerhardt C, Kraus N, Greiner S, Scheibel M (2011) Arthroscopic stabilization of acute acromioclavicular joint dislocation. Orthopade 40(1):61–69. doi:10.1007/s00132-010-1680-7
14. Andreani L, Bonicoli E, Parchi P, Piolanti N, Michele L (2014) Acromio-clavicular repair using two different techniques. Eur J Orthop Surg Traumatol 24(2):237–242. doi:10.1007/s00590-013-1186-1
15. Jerosch J, Filler T, Peuker E, Greig M, Siewering U (1999) Which stabilization technique corrects anatomy best in patients with AC-separation? An experimental study. Knee Surg Sports Traumatol Arthrosc 7(6):365–372
16. Braun S, Imhoff AB, Martetschläger F (2015) Arthroscopically assisted techniques for treatment of acute and chronic acromioclavicular joint injuries. Unfallchirurg 118(5):407–414. doi:10.1007/s00113-015-0004-0
17. Li H, Wang C, Wang J, Wu K, Hang D (2013) Restoration of horizontal stability in complete acromioclavicular joint separations: surgical technique and preliminary results. Eur J Med Res 18:42. doi:10.1186/2047-783X-18-42
18. Irlenbusch U (2012) Examination techniques of the shoulder—expert's evaluation based on literature analysis. Obere Extremitat 7(1):61
19. Alexander OM (1954) Radiography of the acromioclavicular articulation. Med Radiogr Photogr 30:34–39
20. Jensen G, Katthagen JC, Alvarado LE, Lill H, Voigt C (2014) Has the arthroscopically assisted reduction of acute AC joint separations with the double tight-rope technique advantages over the clavicular hook plate fixation? Knee Surg Sports Traumatol Arthrosc 22(2):422–430. doi:10.1007/s00167-012-2270-5
21. Lädermann A, Grosclaude M, Lübbeke A, Christofilopoulos P, Stern R, Rod T, Hoffmeyer P (2011) Acromioclavicular and coracoclavicular cerclage reconstruction for acute acromioclavicular joint dislocations. J Shoulder Elbow Surg 20(3):401–408. doi:10.1016/j.jse.2010.08.007
22. Debski RE, Parsons I, Woo SL, Fu FH (2001) Effect of capsular injury on acromioclavicular joint mechanics. J Bone Joint Surg Am 83-A(9):1344–1351
23. Beitzel K, Sablan N, Chowaniec DM, Obopilwe E, Cote MP, Arciero RA, Mazzocca AD (2012) Sequential resection of the distal clavicle and its effects on horizontal acromioclavicular joint translation. Am J Sports Med 40(3):681–685
24. Klimkiewicz JJ, Williams GR, Sher JS, Karduna A, Des Jardins JD, Iannotti JP (1999) The acromioclavicular capsule as a restraint to posterior translation of the clavicle: a biomechanical analysis. J Shoulder Elbow Surg 8(2):119–124
25. Lee K-W, Debski RE, Chen C-H, Woo SL-Y, Fu FH (1997) Functional evaluation of the ligaments at the acromioclavicular joint during anteroposterior and superoinferior translation. Am J Sports Med 25(6):858–862
26. Beitzel K, Mazzocca AD (2014) Open anatomic reconstruction of chronic acromioclavicular instability. Oper Orthop Traumatol 26(3):237–244. doi:10.1007/s00064-013-0277-9
27. Calvo E, Lopez-Franco M, Arribas IM (2006) Clinical and radiologic outcomes of surgical and conservative treatment of type III acromioclavicular joint injury. J Shoulder Elbow Surg 15(3):300–305

8.2 Publicaciones de soporte de la tesis doctoral

8.2.1



Anatomic Reconstruction of Chronic Coracoclavicular Ligament Tears: Arthroscopic-Assisted Approach With Nonrigid Mechanical Fixation and Graft Augmentation

Luis Natera, M.D., Juan Sarasquete Reiriz, M.D., and Ferran Abat, M.D., Ph.D.

Abstract: It has recently been suggested that all coracoclavicular ligament tears could be considered for surgery because nonoperative management might result in irreversible changes in the scapular position that could lead to muscle kinematic alterations that would perturb the shoulder girdle function and result in pain. In this technical note we describe an anatomic technique for the treatment of chronic coracoclavicular ligament tears that overcomes the issues related to open surgery, metal hardware, the inferior resistance to secondary displacement of only grafting and nonanatomic techniques, and the saw effect and anterior loop translation that can be seen in systems that surround the base of the coracoid. Our technique incorporates the use of a tendon graft and a nonrigid mechanical stabilizer that protects the graft from stretching during the process of healing and integration into bone, guaranteeing the maintenance of a reduced acromioclavicular joint.

The coracoclavicular (CC) ligaments are the main suspensory elements of the upper limb, and the synchronized motion between the clavicle and the scapula occurs through the link that they represent.[1] Treatment guides base indications on the radiologic magnitude of displacement between the clavicle and the acromion, which at the end is the indicator of a tear or not in the CC ligaments with affection or not of the deltotrapezial fascia.[2] It has recently been suggested that all CC ligament tears could be considered for surgery because nonoperative management might result in irreversible changes in the scapular position that could lead to muscle cinematic alterations that would perturb the shoulder girdle function and result in pain.[3]

Biomechanical studies have shown the importance of an anatomic reconstruction of the CC ligaments in cases of high-grade acromioclavicular joint (ACJ) dislocations, which indicates the presence of a tear in the CC ligaments and/or affection of the deltotrapezial fascia.[4] This issue relates to the fact that the conoid and trapezoid ligaments have different functions that depend on their native anatomic locations.[5] Many of the currently accepted treatments for chronic CC ligament tears do not contemplate CC reconstruction, and authors frequently do not specify whether these techniques have been used in acute cases or in chronic cases.[6] The treatment of a chronic CC ligament tear should incorporate biological augmentation because it is accepted that after 3 weeks from the injury, the CC ligaments lack healing potential.[7] The few arthroscopic approaches that have described a reconstruction technique that can be used in cases of high-grade ACJ dislocations either are nonanatomic[8] or lack a primary mechanical stabilizer.[9]

We describe the technical aspects of an anatomic reconstruction of the CC ligaments assisted by arthroscopy for cases of chronic CC ligament tears that incorporates a tendon graft and a nonrigid mechanical stabilizer that protects the graft during the process of healing and integration into bone.

From Hospital General de Catalunya (L.N.); Hospital de la Santa Creu i Sant Pau, Universitat Autònoma de Barcelona (L.N., J.S.R.); CO+T, Clínica Nostra Senyora Del Remei (L.N.); and CEREDE Sports Medicine (F.A.), Barcelona, Spain.

The authors report the following potential conflict of interest or source of funding: J.S.R. receives support from Biomet Sports Medicine.

Received April 16, 2014; accepted June 18, 2014.

Address correspondence to Luis Natera M.D., Hospital de la Santa Creu i Sant Pau, Universitat Autònoma de Barcelona, Sant Quintí 89, 08026, Barcelona, Spain. E-mail: luisgerardonaterac@gmail.com

2212-6287/14315/$36.00
http://dx.doi.org/10.1016/j.eats.2014.06.014

Surgical Technique

The steps of our technique are shown and explained in Video 1, following the sequence of the text.

Under general anesthesia and an interscalene block, the patient is placed in the beach-chair position with the arm forward flexed up to 50° to 70°, maintained by a weight of 3 kg. First, we perform an arthroscopic

examination of the glenohumeral joint through the posterior portal to detect associated lesions that could require treatment. If there is not any concomitant injury to repair, we avoid placing an anterior glenohumeral portal to have better control of the fluids. Afterward, the arthroscope is moved to the subacromial space through the lateral portal (2 cm distal to the lateral border of the acromion).

Identification of Base of Coracoid Process

The coracoacromial (CA) ligament is followed until its insertion in the coracoid. Through direct visualization from the lateral portal and using a needle as a guide, we make an anterior working portal that is located 1 cm lateral to the coracoid. A 5.5-mm shaver is used to perform bursectomy; this allows adequate visualization of the CA ligament. The synovial tissue posterior to the coracoid and anterior to the rotator interval should be cleaned to identify the base of the coracoid. The arthroscope is then directed inferiorly to see the base of the coracoid, which has to be carefully cleaned with a vaporizer by removing the synovial tissue that covers the subscapularis. It is important to be aware that the axillary bundle and the brachial plexus are located medial to the coracoid process.

Releasing Distal Third of Clavicle

Under arthroscopic control, the distal third of the clavicle must be released to achieve an anatomic reduction. Because the ACJ has been chronically dislocated, if the reduction cannot be achieved by applying direct pressure above the distal third of the clavicle and pushing the elbow upward, it could be necessary to excise 5 mm of the distal third of the clavicle.

Preparation of Tendinous Allograft

We prefer to use semitendinosus tendon allograft. Its length should be about 12 to 14 cm, and its diameter should be about 4.5 to 5.5 mm. The diameter has to be carefully probed by passing the graft without resistance through the measuring device. The allograft is prepared by placing a Krackow suture with a No. 2 metal-core suture (FiberWire; Arthrex, Naples, FL) in both of its limbs.

Tunneling Clavicle and Coracoid Process

A transverse incision with a length of 4 cm is made 3 cm medial to the lateral edge of the clavicle. This incision is made between the locations where the native origins of the conoid and trapezoid ligaments should be in the inferior aspect of the clavicle. The native origin of the conoid is 4.5-cm medial to the lateral edge of the clavicle, and the trapezoid is 2.5-cm from the lateral edge and slightly anterior when compared with the conoid.[5] Cross sectioning of the deltotrapezial fascia is then performed. The traction is released, and under arthroscopic visualization from the lateral portal, a Biomet acromioclavicular (AC) drilling guide (reference 909511; Biomet, Warsaw, IN) with a calibrated angulation of 80° to 90° is placed at the base of the coracoid, 10-mm anterior to the wall of the scapula, with the sliding tube of the guide located in the superior aspect of the clavicle, 4.5 cm medial to its lateral border (conoid native origin). A 2.4-mm K-wire is passed through the AC guide (Fig 1A). A cannulated 4.5- to 6-mm (depending on the graft diameter) drill is passed over the K-wire until it comes out from the inferior aspect of the coracoid (Fig 1B), where the AC guide catches it. The K-wire is removed, and the cannulated drill is kept in position. A shuttle suture (1-mm polydioxanone [PDS]) is passed from the clavicle to the coracoid through the cannulated drill, and it is then recovered with a grasper from the anterior portal. Two No. 2 FiberWire sutures are tied to the distal limb of the PDS that passes through the coracoid. One of these FiberWire sutures will be used to pass the graft and the other to pass the fixation device (ZipTight, reference 904834; Biomet). Afterward, the AC guide is lateralized

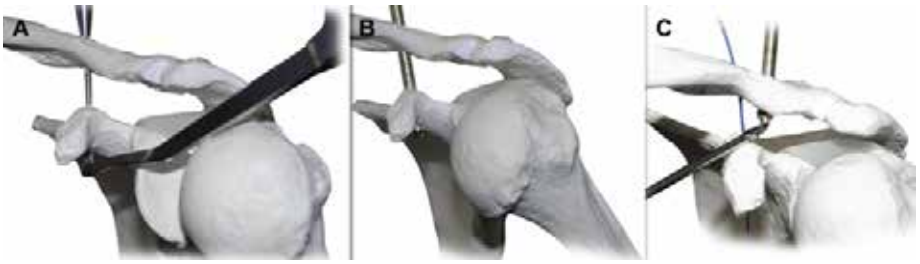


Fig 1. (A) The AC drilling guide is placed at the coracoid base with the sliding tube of the guide in the superior aspect of the clavicle, 4.5 cm medial to its lateral border (conoid native origin). A 2.4-mm K-wire is passed through the AC guide. (B) A cannulated 4.5- to 6-mm (depending on the graft diameter) drill is passed over the K-wire and comes out from the inferior aspect of the coracoid. (C) A shuttle 1-mm PDS suture is passed through the cannulated drill located in the trapezoid tunnel. The PDS is recovered with a grasper from the anterior portal.

to perform the tunneling of the trapezoid. The 2.4-mm K-wire is passed from the clavicle to a point lateral to the coracoid without perforating it, and afterward, the cannulated 4.5- to 6-mm drill is passed through the clavicle. The K-wire is removed, and the cannulated drill is kept in position. A shuttle 1-mm PDS suture is passed through the cannulated drill and then recovered with a grasper from the anterior portal (Fig 1C).

One of the FiberWire sutures that passes through the conoid tunnel is provisionally tied with a simple knot to the FiberWire of 1 of the limbs of the graft. The FiberWire of the other limb of the graft is provisionally tied with a simple knot to the PDS that comes from the trapezoid tunnel in the clavicle and comes out from the anterior portal. At this stage, both limbs of the graft are provisionally tied: 1 of the limbs to the FiberWire that comes from the conoid tunnel and the other limb to the PDS that comes from the trapezoid tunnel. In the conoid tunnel, there is still a free FiberWire that will be used for passing the ZipTight once the graft has been passed. To pass the graft through both tunnels, the FiberWire that comes out from the conoid tunnel in the superior aspect of the clavicle is pulled out. Afterward, the PDS that arises from the trapezoid tunnel in the clavicle is pulled out in a cranial direction to recover the limb of the graft that is going then to surround the base of the coracoid at its lateral aspect, coming from its tunnel and then being directed laterally and superiorly (Fig 2A), configuring the anatomic "V" shape of the graft. Once the graft has passed through both clavicle tunnels, the ZipTight is tied to the distal limb of the shuttle FiberWire that is still free in the conoid tunnel (Fig 2B). The FiberWire is pulled cranially to pass the ZipTight in a retrograde direction. Once the titanium flip button of the ZipTight has blocked in the inferior aspect of the coracoid, final reduction and fixation can be performed.

ACJ Reduction and Stabilization

Before the ZipTight is tensioned, the sliding sutures of the system should be threaded in the washer to make it descend until it touches the clavicle, and afterward, the graft should be fixed in the clavicular portion of the conoid tunnel with a 4.5- to 5.5-mm (same diameter of the tunnel) Bio-Tenodesis interference screw (Arthrex) (Fig 2C). To avoid any harm to the sutures of the ZipTight with the screw, the graft should be placed in an intermediate position between the screw and the sutures. Afterward, the surgical assistants should reduce the ACJ by pushing the elbow upward and the clavicle downward at the same time. The limb of the graft that corresponds to the trapezoid is then fixed with another 4.5- to 5.5-mm Bio-Tenodesis interference screw. Once both limbs of the graft have been fixed and the flip is properly supported in the inferior aspect of the coracoid (Fig 3A), the ZipTight is tied by pulling alternatively on both limbs of the blue traction sutures in a cranial direction (Fig 3B) to make the washer go down until it touches the clavicle and self-locks, providing mechanical stabilization of the reconstruction. The reduction is checked with direct palpation, direct arthroscopic visualization, and/or intraoperative radiographs. The traction suture is then removed. Both limbs of the graft are crossed to each other and sutured to themselves with No. 1.0 Vicryl (Ethicon, Somerville, NJ) (Fig 3C). The remnant of the graft is sectioned and removed. The deltotrapezial fascia is carefully closed with No. 1.0 Vicryl. Finally, the shuttle suture that was coming out from the inferior aspect of the coracoid is removed, and the skin is closed with No. 4-0 Prolene (Ethicon).

Table 1 shows tips, pearls, pitfalls, risks, key points, indications, and contraindications of the technique.

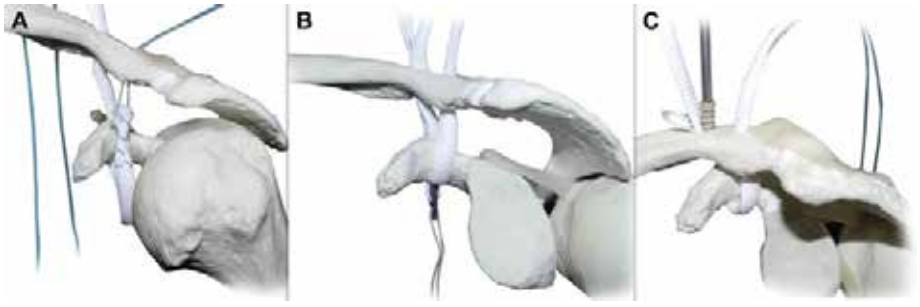


Fig 2. (A) The PDS that arises from the trapezoid tunnel in the clavicle is pulled out in a cranial direction to recover the limb of the graft that is going to surround the base of the coracoid at its lateral aspect, coming from its tunnel and then being directed laterally and superiorly, configuring the anatomic V shape of the graft. (B) Once the graft has passed through both clavicle tunnels, the ZipTight is tied to the distal limb of the shuttle FiberWire that is still free in the conoid tunnel. (C) Before the ZipTight is tensioned, the graft should be fixed in the clavicular portion of the conoid tunnel with a 4.5- to 5.5-mm (same diameter of the tunnel) Bio-Tenodesis interference screw.

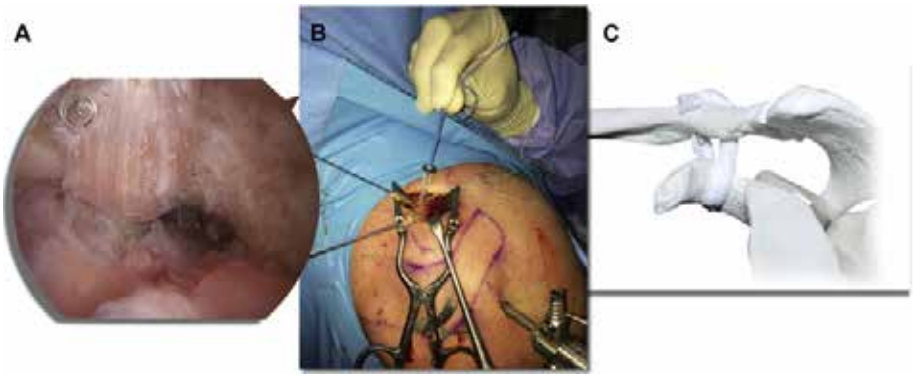


Fig 3. (A) Final arthroscopic view from lateral portal. The graft is coming out from the coracoid tunnel, ascending toward the trapezoid tunnel in the clavicle. The flip of the ZipTight is supported in the inferior aspect of the coracoid. (B) Both limbs of graft coming out from clavicle once fixed in both tunnels with Bio-Tenodesis interference screws. The ZipTight is tied by threading the sliding suture in the washer. (C) Final anatomic V configuration of reconstruction with flip of ZipTight in inferior aspect of coracoid and both limbs of graft crossed to each other and sutured to themselves.

Table 1. Pearls, Pitfalls, Risks, Key Points, Indications, and Contraindications of Technique

Pearls
The base of the coracoid should be properly debrided to guarantee the correct positioning of the AC guide.
The ends of the graft should be properly sharpened, and suturing should be carefully performed to avoid an "accordion" effect when the graft is passed through the tunnels.
The proper reduction of the ACJ can be controlled by fluoroscopy in case there is any doubt when ensuring the proper reduction through straight visualization.
The traction should be released before reduction.
The deltotrapezial fascia should be carefully sutured to achieve the best vertical and horizontal control of the ACJ.
To avoid any harm to the sutures of the suspension device with the Bio-Tenodesis screw, the graft should be placed in an intermediate position between the screw and the sutures.
Pitfalls and risks
Orthopaedic surgeons who are not well familiarized with arthroscopic techniques should be aware of the potential risks related to the neurovascular structures underneath the clavicle and medial to the coracoid.
There is a risk of fracture of the lateral aspect of the coracoid when tunneling its base if the AC guide is placed too laterally.
Implant cost is a consideration when using a CC nonrigid suspension device.
Allografts are not available in some countries, so in these cases the use of palmaris longus or semitendinosus autografts could be necessary to consider.
Correct anatomic placement of the clavicle tunnels and the correct distance between them are crucial to prevent fractures when using large drills.
Key points
Nonoperative management of CC ligament tears might result in irreversible changes in the scapular position that could lead to muscle kinematic alterations that would perturb the shoulder girdle function and result in pain.
Anatomic reconstruction techniques have shown biomechanical and clinical advantages over nonanatomic techniques in cases of high-grade ACJ dislocations.
Our technique incorporates the use of a tendon graft and a nonrigid mechanical stabilizer that protects the graft from stretching during the process of healing and integration into bone.
Our technique overcomes the issues related to open surgery, metal hardware, the inferior resistance to secondary displacement of only grafting and nonanatomic techniques, and the saw effect and anterior loop translation that can be seen in systems that surround the base of the coracoid.
Indications
Chronic CC ligament tears (high-grade ACJ dislocations considered to be treated 3 weeks after injury)
Acute CC ligament tears in cases of patients with high functional demands
Contraindications
Elderly patients
Patients with comorbid factors that contraindicate the need for elective surgery

Rehabilitation Protocol

The shoulder is maintained in a sling for 4 to 6 weeks to facilitate the healing period of the reconstruction. Patients are allowed from the very beginning to fully and actively move the elbow, wrist, and hand and are allowed to passively move the shoulder into no more than 90° of elevation in the plane of the scapula. The exercise program is started after the sixth week. Pendulum exercises begin in the fourth week, and active range of motion is allowed from the sixth week onward. Exercises to regain strength are initiated once the patient achieves full, pain-free passive and active range of motion; they are primarily directed toward scapular stabilization. Return to work without restrictions is allowed at 12 to 16 weeks after surgery, and contact sports and tasks requiring major effort should be avoided for 4 to 6 months after surgery. Achieving a full recovery and returning to maximum strength and function can take 9 to 12 months.

Patients

The described procedure has been performed in 10 patients with a diagnosis of a chronic CC ligament tear. The time from injury to surgery was greater than 3 weeks in all cases. Clinical outcomes and radiographic controls were obtained in all cases at a minimum follow-up time of 6 months. The preliminary results are described as excellent because all patients have had complete functional recovery and have no residual pain.

Discussion

The procedure presented in this technical note overcomes the issues related to open surgery, metal hardware, the inferior resistance to secondary displacement of only grafting and nonanatomic techniques, and the saw effect and anterior loop translation that can be seen in systems that surround the base of the coracoid.

Regarding the approach to the coracoid, some authors have described placement of a skin incision over the coracoid tip to bluntly dissect and then palpate its base for placement of a drill guide.[10] Such a technique is performed in a blind manner and lacks the precision that straight visualization can offer. For improved visualization of the inferior aspect of the coracoid, different arthroscopic techniques that facilitate tunneling and implant placement have been described.[8] The subacromial approach has an advantage over the glenohumeral approach because there is no need to release the superior and middle glenohumeral ligaments to allow access to the coracoid.[11]

Regarding the strategy for reconstruction, biomechanical studies have shown that the structure of the CA ligament offers inferior resistance to vertical translation when compared with graft reconstructions.[12] The arthroscopic technique for both acute and chronic ACJ dislocations described by Lafosse et al.,[13] in which the CA ligament transfer is proposed to reconstruct the torn CC ligaments, could theoretically involve the disadvantage in terms of strength that would arise from a Weaver-Dunn procedure. We use a semitendinosus graft placed in the anatomic location of the native ligaments, which restores the anatomy and makes our technique more faithful to the biomechanical concepts that are currently accepted.

Regarding the fixation method of the reconstruction in the coracoid, it has been described that subcoracoid loops that surround its base tend to dislocate anteriorly because of the ascending slope of the inferior aspect of the coracoid.[14] It also has been shown that the placement of CC loops could involve the development of bony erosions because of a "sawing" effect.[15] Our procedure overcomes this issue by incorporating tunnel making both in the coracoid and in the clavicle for graft passage and implant fixation.

Regarding the primary stability of the construct and the possibility of a secondary displacement developing, 1 advantage that our procedure can offer, among others, is that we combine a mechanical primary nonrigid stable fixation, provided by the suspension device, and a biological and permanent fixation that will be represented by the graft once integrated into bone. In the nonanatomic open technique described by LaPrade and Hilger,[9] in which they propose the use of a semitendinosus graft that passes through 1 tunnel in the clavicle and 1 in the coracoid, which does not include any primary mechanical fixation and does not take into consideration the native origins of the CC ligaments, they recognize that in some patients stretching of the graft can occur, causing a subtle superior subluxation of the clavicle. Yoo et al.[16] recently described an anatomic technique that attempts to make transosseous tunnels within the natural footprints of the CC ligaments, but they also did not contemplate the use of any mechanical stabilizer that protects the graft from stretching during the healing process.

Another advantage that arthroscopy can offer over open surgery in cases of CC ligament reconstruction is that glenohumeral-associated lesions can be diagnosed and treated, which is not possible through open surgery. Some authors have reported that the incidence of associated lesions in cases of high-grade ACJ dislocations is as high as 30%.[17]

Regarding the tunneling of the coracoid, there is a potential risk of fracture creation if the tunnel placement is improper. Use of our technique should be considered only by experienced arthroscopic surgeons to avoid these complications and thus guarantee the safety of the procedure.

It is important to keep in mind that the described procedure is an arthroscopic-assisted approach, and it is critical to ensure that the deltotrapezial fascia is not

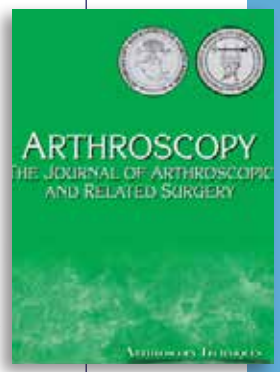
interposed between the clavicle and the acromion. This can only be achieved by a mini-open approach on top of the ACJ. Once the join surfaces of the clavicle and the acromion are properly faced, the deltotrapezial fascia should be carefully reconstructed to guarantee proper vertical stability. When the reconstructed deltotrapezial fascia is healed over the ACJ, it also plays a role in the horizontal control and stabilization of the ACJ in the anteroposterior plane.

Our surgical technique provides excellent initial fixation and restores the anatomy by reconstructing the torn CC ligaments by placing tunnels in their native locations. We must evaluate the clinical outcome of our series of patients once follow-up for a minimal period of 2 years has been accomplished.

References

1. Mazzocca AD, Arciero RA, Bicos J. Evaluation and treatment of acromioclavicular joint injuries. *Am J Sports Med* 2007;35:316-329.
2. Bahk MS, Kuhn JE, Galatz LM, Connor PM, Williams GR Jr. Acromioclavicular and sternoclavicular injuries and clavicular, glenoid, and scapular fractures. *Instr Course Lect* 2010;59:209-226.
3. Murena L, Canton G, Vulcano E, Cherubino P. Scapular dyskinesis and SICK scapula syndrome following surgical treatment of type III acute acromioclavicular dislocations. *Knee Surg Sports Traumatol Arthrosc* 2013;21:1146-1150.
4. Lee SJ, Nicholas SJ, Akizuki KH, McHugh MP, Kremenic IJ, Ben-Avi S. Reconstruction of the coracoclavicular ligaments with tendon grafts: A comparative biomechanical study. *Am J Sports Med* 2003;31:648-654.
5. Rios CG, Arciero RA, Mazzocca AD. Anatomy of the clavicle and coracoid process for reconstruction of the coracoclavicular ligaments. *Am J Sports Med* 2007;35:811-817.
6. Gstettner C, Tauber M, Hitzl W, Resch H. Rockwood type III acromioclavicular dislocation: Surgical versus conservative treatment. *J Shoulder Elbow Surg* 2008;17:220-225.
7. Weinstein DM, McCann PD, McIlveen SJ, Flatow EL, Bigliani LU. Surgical treatment of complete acromioclavicular dislocations. *Am J Sports Med* 1995;23:324-331.
8. Rolla PR, Surace MF, Murena L. Arthroscopic treatment of acute acromioclavicular joint dislocation. *Arthroscopy* 2004;20:662-668.
9. LaPrade RF, Hilger B. Coracoclavicular ligament reconstruction using a semitendinosus graft for failed acromioclavicular separation surgery. *Arthroscopy* 2005;21:1277.e1-1277.e5. Available at www.arthroscopyjournal.org.
10. Wellmann M, Zantop T, Petersen W. Minimally invasive coracoclavicular ligament augmentation with a flip button/polydioxanone repair for treatment of total acromioclavicular joint dislocation. *Arthroscopy* 2007;23:1132.e1-1132.e5. Available at www.arthroscopyjournal.org.
11. Baumgarten KM, Altchek DW, Cordasco FA. Arthroscopically assisted acromioclavicular joint reconstruction. *Arthroscopy* 2006;22:228.e1-228.e6. Available at www.arthroscopyjournal.org.
12. Grutter PW, Petersen SA. Anatomical acromioclavicular ligament reconstruction: A biomechanical comparison of reconstructive techniques of the acromioclavicular joint. *Am J Sports Med* 2005;33:1723-1728.
13. Lafosse L, Baier GP, Leuzinger J. Arthroscopic treatment of acute and chronic acromioclavicular joint dislocation. *Arthroscopy* 2005;21:1017.
14. Jerosch J, Filler T, Peuker E, Greig M, Siewering U. Which stabilization technique corrects anatomy best in patients with AC-separation? An experimental study. *Knee Surg Sports Traumatol Arthrosc* 1999;7:365-372.
15. Guttmann D, Paksima NE, Zuckerman JD. Complications of treatment of complete acromioclavicular joint dislocations. *Instr Course Lect* 2000;49:407-413.
16. Yoo YS, Seo YJ, Noh KC, Patro BP, Kim DY. Arthroscopically assisted anatomical coracoclavicular ligament reconstruction using tendon graft. *Int Orthop* 2011;35:1025-1030.
17. Pauly S, Kraus N, Greiner S, Scheibel M. Prevalence and pattern of glenohumeral injuries among acute high-grade acromioclavicular joint instabilities. *J Shoulder Elbow Surg* 2013;22:760-766.

8.2.2



Horizontal and Vertical Stabilization of Acute Unstable Acromioclavicular Joint Injuries Arthroscopy-Assisted

Luis Natera Cisneros, M.D., Juan Sarasquete Reiriz, M.D., Marina Besalduch, M.D., Alexandru Petrica, M.D., Ana Escolà, M.D., Joaquim Rodriguez, Ph.D., and Jan Carlo Fallone, M.D.

Abstract: We describe the technical aspects of an arthroscopy-assisted procedure indicated for the management of acute unstable acromioclavicular joint injuries, consisting of a synthetic augmentation of both the coracoclavicular and acromioclavicular ligaments, that anatomically reproduces the coracoclavicular biomechanics and offers fixation that keeps the torn ends of the ligaments facing one another, thus allowing healing of the native structures without the need for a second surgical procedure for metal hardware removal.

Acromioclavicular joint (ACJ) injuries are the most common shoulder injuries in the young athletic population.[1] The treatment indications are an issue of debate because of the lack of consensus regarding the optimal management. It is accepted that some conservatively treated patients might have persistent shoulder pain[2] because of the occurrence of changes in the scapular orientation that lead to kinematic alterations of the muscles' actions perturbing the shoulder girdle function.[3] These kinematic alterations might also be the reason early surgical treatment has been shown to provide better functional results than late surgical treatment[4]; moreover, delaying surgical treatment could compromise the possibility of obtaining the best result in the late period.

Surgical management of acute unstable ACJ injuries should be focused on realigning the torn ends of the ligaments because it is accepted that in the acute phase, they still have healing potential.[4] The most propagated methods of treatment incorporate the use of metal hardware that alters the biomechanics of the ACJ, implying the need for a second surgical procedure for hardware removal once the ligaments have healed.[5] Fixation with a hook plate, ACJ transfixion with K-wires (Phemister technique), and coracoclavicular (CC) fixation with a screw (Bosworth technique) are recognized as nonanatomic procedures related to high rates of failure of fixation and complications.[6]

Arthroscopy-assisted procedures that incorporate a CC suspension device aim to narrow the CC space, thus allowing the realigning of the torn CC ligaments. The use of one isometric suspension device has shown good clinical outcomes, but secondary subluxations have been a matter of concern.[7] Likewise, biomechanical studies have shown the importance of an anatomic reconstruction of both the conoid and trapezoid ligaments.[8] This issue lies in the fact that they have different functions that depend on their native anatomic locations.[9]

To reproduce the native origins and orientations of both the conoid and trapezoid ligaments and thus improve the biomechanics and stability of the fixation, techniques that incorporate a second CC suspension device have been described.[10] Despite these improvements, horizontal instability remains a matter of concern.[11] We describe the technical aspects of an arthroscopically assisted procedure indicated for the management of acute unstable ACJ injuries, consisting of a synthetic augmentation of both the CC and acromioclavicular (AC) ligaments, that reproduces the ACJ biomechanics and offers fixation that keeps the torn

From Hospital de la Santa Creu i Sant Pau, Universitat Autònoma de Barcelona (L.N.C., J.S.R., M.B., A.P., J.C.F.), Barcelona; Hospital General de Catalunya (L.N.C., A.E., J.R.), Sant Cugat del Vallés; Hospital Quirón Teknon (J.S.R.), Barcelona; and Mutua de Accidentes Laborales Egarsat (J.C.F.), Terrassa, Spain.

The authors report the following potential conflict of interest or source of funding: J.S.R. receives support from Biomet.

Received March 16, 2015; accepted July 24, 2015.

Address correspondence to Luis Natera Cisneros, Hospital de la Santa Creu i Sant Pau, Universitat Autònoma de Barcelona, Carrer Sant Quintí 89, Barcelona, Catalunya 08026, Spain. E-mail: luisgerardonaterac@gmail.com

2212-6287/15250/$36.00
http://dx.doi.org/10.1016/j.eats.2015.07.014

ends of the CC and AC ligaments aligned, thus allowing healing of the native structures without the need for a second surgical procedure for metal hardware removal.

Surgical Technique

Under general anesthesia and an interscalene block, the patient is placed in the beach-chair position with the arm forward flexed up to 50° to 70°, maintained by a weight of 3 kg (Video 1). First, we perform an arthroscopic examination of the glenohumeral joint through the posterior portal to diagnose associated lesions that could require treatment. If there is no concomitant injury to repair, we avoid creating an anterior glenohumeral portal to have better control of the fluids. Afterward, the arthroscope is moved to the subacromial space through the lateral portal (2 cm distal to the lateral border of the acromion).

Identification of Base of Coracoid Process

The coracoacromial (CA) ligament is followed until its insertion in the coracoid. Through direct visualization from the lateral portal and using a needle as a guide, we create an anterior working portal, which is located 1 cm lateral to the coracoid. A 5.5-mm full-radius shaver blade (Biomet, Warsaw, IN) is used to perform bursectomy, which allows adequate visualization of the CA ligament. The synovial tissue posterior to the coracoid and anterior to the rotator interval should be cleaned to identify the base of the coracoid. The arthroscope is then directed inferiorly to see the base of the coracoid, which has to be carefully cleaned with a vaporizer (ArthroCare Sports Medicine, Sunnyvale, CA) by removing the synovial tissue that covers the subscapularis. It is important to be aware that the axillary bundle and the brachial plexus are located medial to the coracoid process.

Tunneling of Clavicle and Coracoid Process

First, it should be mentioned that the suspension devices could be passed through the tunnels in an antegrade or retrograde direction. This should be decided before drilling to establish the proper diameter of the tunnels. For the purposes of our technique, we advocate the retrograde direction (from coracoid to clavicle), which implies making CC tunnels with a diameter of 3.5 mm, thus minimizing the probability of coracoid fracture. When one is planning to pass the suspension devices in a retrograde direction, the subcoracoid titanium flip device does not pass through the tunnel. When one is using the antegrade direction, the subcoracoid titanium flip device has to pass through the whole CC tunnel, which implies making tunnels with a diameter of 4.5 mm.

A transverse incision with a length of 3 cm is made 2 cm medial to the lateral edge of the clavicle. This incision is made between the locations where the native origins of the conoid and trapezoid ligaments should be in the inferior aspect of the clavicle. The native origin of the conoid is 4.5 cm medial to the lateral edge of the clavicle, and the trapezoid is 2.5 cm medial and slightly anterior when compared with the conoid.[5] A cross section of the deltotrapezial fascia is then performed. The traction is released, and with arthroscopic visualization from the lateral portal, we prepare to pass the K-wire of the conoid tunnel. A Biomet AC drilling guide (reference 909511) with a calibrated angulation of 80° to 90° is placed at the base of the coracoid, adjacent to the wall of the scapula, and 5 mm lateral to the medial border of the coracoid, with the sliding tube of the guide located in the superior aspect of the clavicle, 4.5 cm medial to the ACJ (conoid native origin). A 2.4-mm K-wire is passed through the AC guide. The location of the AC guide is then changed. In the inferior aspect of the coracoid, the AC guide is placed 5 mm medial to the lateral border of the coracoid and slightly anterior when compared with the location of the conoid K-wire. In the superior aspect of the clavicle, the sliding tube should be located in the trapezoid native origin, which is 2.5 cm medial to the ACJ and slightly anterior when compared with the location of the previous K-wire (Fig 1A). The distance between K-wires in the inferior aspect of the coracoid should be 1.5 cm. A 2.4-mm K-wire is passed from the clavicle to the coracoid, following the anatomic orientation of the trapezoid ligament (Fig 1B). Afterward, a 3.5-mm cannulated drill is passed over the conoid K-wire until it comes out from the inferior aspect of the coracoid, where the AC guide catches it (Fig 1C). The conoid K-wire is removed, and the cannulated drill is kept in position.

A shuttle suture (1-mm polydioxanone suture [PDS]; Ethicon, Somerville, NJ) is passed from the clavicle to the coracoid through the cannulated drill and is then recovered with a grasper from the anterior portal (Fig 1D). A No. 2 MaxBraid suture (Arthrotek [Biomet]) is tied to the distal limb of the PDS that passes through the conoid tunnel, and the PDS is then pulled out cranially to make the shuttle MaxBraid pass through the tunnel. This MaxBraid will be used later to pass the conoid suspension device.

Next, the 3.5-mm cannulated drill is passed over the trapezoid K-wire (Fig 1E). The trapezoid K-wire is removed, and the cannulated drill is kept in position. Another 1-mm PDS shuttle suture is passed from the clavicle to the coracoid through the cannulated drill and is recovered with a grasper from the anterior portal. A No. 2 MaxBraid suture is tied to the distal limb of the PDS that passes through the trapezoid tunnel, and the PDS is then pulled out cranially to make the shuttle MaxBraid pass through the tunnel. This MaxBraid will be used later to pass the trapezoid suspension device.

The conoid suspension device (ZipTight, reference 904834; Biomet) is first passed through the tunnel. This

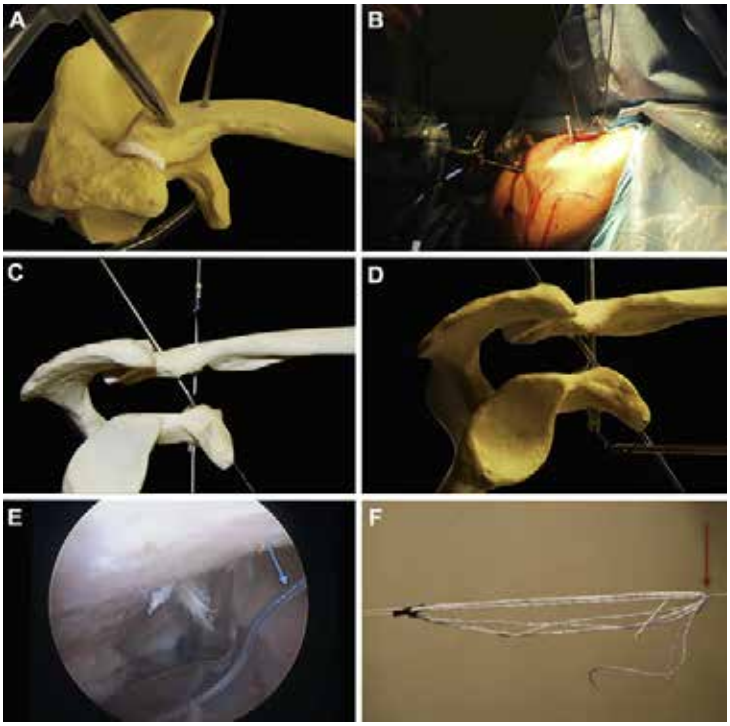


Fig 1. (A) Acromioclavicular (AC) Sawbones model (Pacific Research Laboratories, Vashon, WA), in which the AC guide is placed in the anatomic location of the trapezoid ligament to pass the K-wire from the clavicle to the coracoid. (B) Rear perspective of a left shoulder. The conoid and trapezoid K-wires have been passed through the clavicle and coracoid by use of the AC guide, which was previously located in the anatomic locations of the ligaments. (C) AC Sawbones model, in which the cannulated drill is passing over the conoid K-wire until it comes out from the inferior aspect of the coracoid, where the AC guide should catch it. (D) AC Sawbones model, in which a shuttle suture (1-mm PDS) is passed from the clavicle to the coracoid through the cannulated drill located in the conoid tunnel and is recovered with a grasper, which should be introduced from the anterior portal. (E) Arthroscopic visualization from the lateral portal. The cannulated drill is passing over the trapezoid K-wire until it comes out from the inferior aspect of the coracoid, where the AC guide catches it. Previously, the AC guide was introduced through the anterior portal and placed at the base of the coracoid, 5 mm medial to its lateral border and slightly anterior when compared with the location of the conoid K-wire. The blue arrow is pointing to the shuttle MaxBraid of the conoid tunnel, which was previously introduced. (F) The distal limb of 1 of the shuttle MaxBraids is provisionally tied to the sliding sutures of 1 of the suspension devices (this procedure should be repeated twice—conoid and trapezoid). The red arrow is pointing to the provisional knot. Once the ZipTight has been passed in a retrograde direction through the tunnel, the provisional knot is untied.

is performed in a retrograde direction. The distal limb of the conoid shuttle MaxBraid is provisionally tied to the sliding sutures of the suspension device (Fig 1F). This shuttle MaxBraid, which is coming out from the conoid tunnel in the clavicle, should be pulled out cranially to make the suspension device pass through the tunnel. The white suture of the titanium flip device can now be removed by pulling out 1 of its limbs, which are coming out from the anterior portal. The same procedure of passing the suspension device in a retrograde direction is repeated in the trapezoid tunnel.

The conoid suspension device should not be fixed until the trapezoid suspension device has been passed through its respective tunnel as well (Fig 2 A and B). Once both suspension devices have been passed through each tunnel, the titanium flip devices of both are properly placed in the inferior aspect of the coracoid (Fig 2 C and D). At this point, horizontal stabilization of

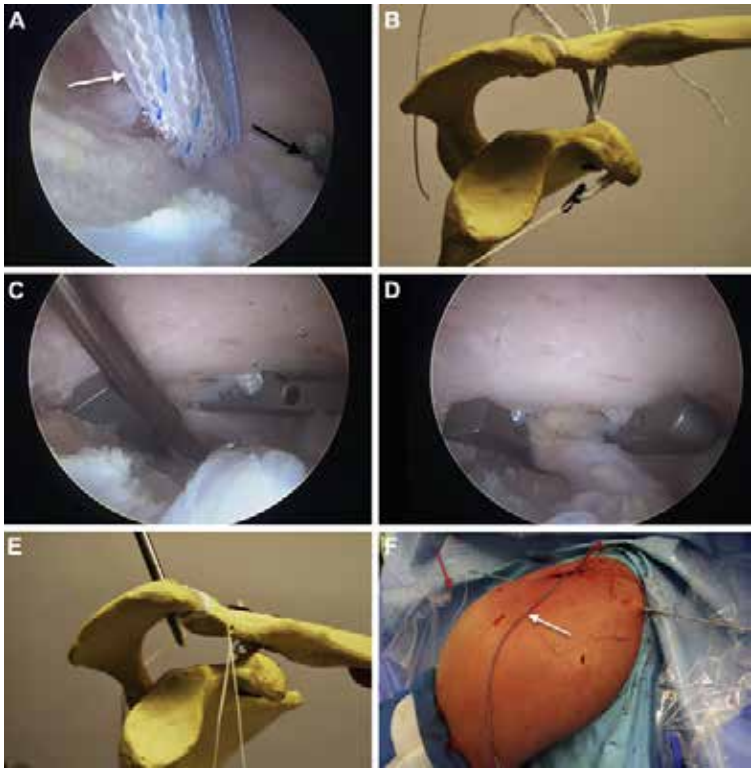


Fig 2. (A) Arthroscopic visualization from the lateral portal. The suspension device of the trapezoid is entering the coracoid tunnel in a retrograde direction. The white arrow is pointing to the sliding sutures of the suspension device. The black arrow is pointing to the titanium flip device of the conoid suspension device, which was previously placed. (B) Acromioclavicular (AC) Sawbones model, in which the suspension device of the trapezoid is entering the coracoid tunnel in a retrograde direction, once the titanium flip device of the conoid suspension device has been placed. (C) Arthroscopic visualization from the lateral portal. Once the flip devices of the 2 suspension devices have been placed in the inferior aspect of the coracoid, proper positioning between them is achieved by using a palpation device, which is introduced through the anterior portal. (D) Arthroscopic visualization from the lateral portal. The flip devices of the 2 suspension devices are properly placed and positioned in the inferior aspect of the coracoid. (E) AC Sawbones model, in which a JuggerKnot soft anchor is being inserted on top of the acromion, 1 cm lateral to the AC joint. (F) Rear perspective of a left shoulder. The K-wire with an eyelet at its base was passed through the clavicle in an anteroposterior direction. Two shuttle MaxBraids (red arrow) were passed through the hole of the K-wire. The white arrow is pointing to the blue and white sutures of the JuggerKnot anchor that was previously inserted at the superior aspect of the acromion, 1 cm lateral to the AC joint.

the ACJ should be performed before fixation of the 2 suspension devices.

ACJ Horizontal Stabilization

To horizontally stabilize the ACJ, we perform a synthetic reconstruction of the AC ligaments by using a JuggerKnot soft anchor (2.9 mm; Biomet), which is inserted on top of the acromion, 1 cm lateral to the ACJ (Fig 2E). Afterward, the AC guide—previously used to make the CC tunnels—is horizontally positioned at the clavicle 1 cm medial to the ACJ. A 2.4-mm universal K-wire with an eyelet at its base (used for anterior cruciate ligament reconstruction) is passed through the AC guide and through the clavicle, from anterior to posterior (Fig 2F). Two MaxBraids (which are going to be used as shuttles) are passed through the eyelet located at the base of the K-wire, which is crossing the clavicle (Fig 2F). The K-wire is pulled from its tip and then recovered from the posterior aspect of the shoulder to make the shuttle MaxBraids pass through

the transverse tunnel created in the clavicle. The 2 white limbs (the surgeon could also use the 2 blue limbs) of the JuggerKnot are tied with a double knot to the posterior limb of 1 of the MaxBraids. This MaxBraid is pulled out from the anterior aspect of the shoulder to make the 2 white limbs of the JuggerKnot pass from posterior to anterior and emerge from the anterior aspect of the transverse clavicle tunnel. The 2 blue limbs of the JuggerKnot are also tied with a double knot but are tied to the anterior limb of the other MaxBraid. This MaxBraid should be retrieved from the posterior aspect of the shoulder to make the 2 blue limbs of the JuggerKnot pass from anterior to posterior and emerge from the posterior aspect of the clavicle tunnel. At this stage, the sutures of the JuggerKnot already have a triangular configuration. The base is represented by the sutures passing through the transverse clavicle tunnel, and the apex is represented by the acromial insertion of the JuggerKnot.

CC Reduction

Before tensioning of the ZipTights is performed, the sliding sutures of the system should be threaded in the washers to make them descend until they touch the clavicle. We prefer to first do this with the conoid suspension device (Fig 3A).

Afterward, the surgical assistants should reduce the ACJ by pushing the elbow upward and the clavicle downward at the same time. Once the flip device of the conoid ZipTight has been properly supported in the inferior aspect of the coracoid, it is tied and fixed by pulling alternatively on both limbs of the sliding sutures in a cranial direction to make the washer go down until it touches the clavicle and self-locks. The fixation achieved when the conoid suspension device has been locked is enough to maintain the reduction, so the fixation and locking of the trapezoid ZipTight can be performed without needing to push the elbow upward and the clavicle downward. Once the 2 ZipTights have been locked (Fig 3B), the final CC interval reduction can be checked with intraoperative radiographs. The ACJ reduction is checked by direct palpation, direct arthroscopic visualization (Fig 3C), or intraoperative radiographs (or some combination thereof). Special attention should be paid to avoid overcorrection.

Ensuring CC and AC Fixation

To complete the narrowing of the CC space and the anatomic reduction of the ACJ, the surgical assistants should again reduce the ACJ by pushing the elbow upward and the clavicle downward at the same time. Afterward, the 2 limbs of the blue suture of the JuggerKnot are tied to the 2 limbs of the white suture of the JuggerKnot (Fig 3D). This triangular configuration of the fixation (Fig 3 E and F) aims to stabilize the ACJ and thus maintain the torn ends of the native AC ligaments properly aligned during the healing process.

Both ZipTights are completely fixed by pulling alternatively on both limbs of the sliding sutures in a cranial direction. The remnants of the sliding sutures are now cut, and the blue traction sutures of the clavicle washers are removed.

The deltotrapezial fascia is carefully closed and reconstructed with No. 1 Vicryl (Ethicon). Finally, the shuttle suture that was coming out from the inferior aspect of the coracoid is removed, and the skin is closed. Table 1 shows tips, pearls, pitfalls, risks, key points, indications, and contraindications of the technique.

Rehabilitation Protocol

The shoulder should be maintained in a sling for 4 to 6 weeks to facilitate healing. Patients are allowed immediately postoperatively to fully and actively move the elbow, wrist, and hand and are allowed to passively move the shoulder to no more than 90° of elevation in the plane of the scapula. Participation in an exercise program is started after the fourth week. Active range of motion begins in the sixth week onward. Exercises to regain strength are initiated once the patient has full, pain-free passive and active range of motion; they are primarily directed toward scapular stabilization. Return to work without restrictions is allowed at 12 to 16 weeks after surgery, and contact sports or major efforts should be avoided for 4 to 6 months after surgery.

Patients

The described procedure has been performed in 9 patients diagnosed with unstable ACJ injuries. The time from injury to surgery was less than 3 weeks in all cases. Clinical and radiographic assessments were performed in all cases at a minimum follow-up time of 12 months. The preliminary results are considered excellent because all patients had complete functional recovery with no residual pain. No secondary subluxations of the ACJ have been observed on the Zanca or Alexander view.

Discussion

The presented procedure overcomes the issues related to open surgery, metal hardware, the inferior resistance to secondary displacement of nonanatomic techniques, and the saw effect and anterior loop translation that can be seen with those systems that surround the base of the coracoid. Our technique incorporates an ACJ fixation with an all—suture anchor method that guarantees horizontal stability, as well as the use of 2 CC suspension devices that are anatomically placed and emulate the function and biomechanics of both the conoid and trapezoid ligaments during the healing process of the torn native structures.

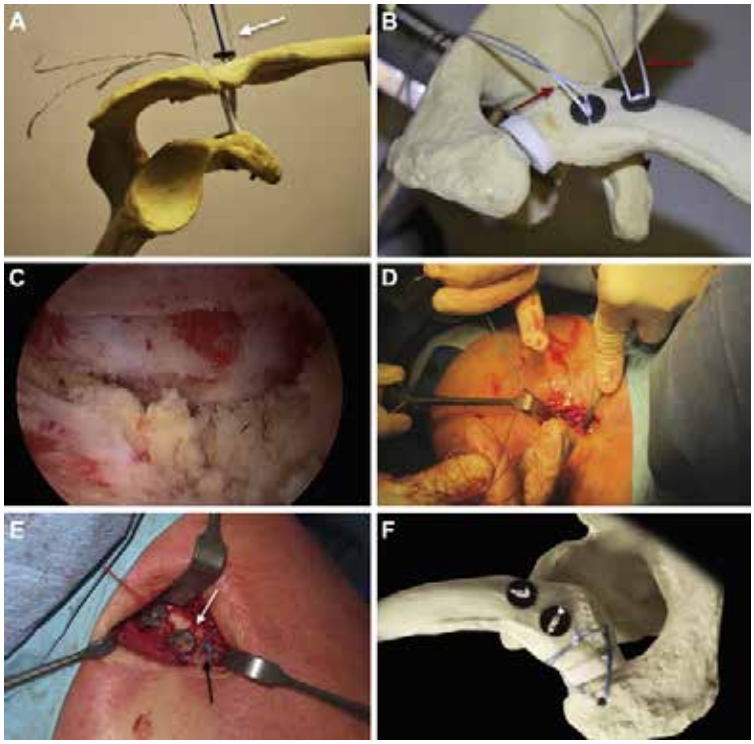


Fig 3. (A) Acromioclavicular (AC) Sawbones model, in which the ZipTight is being fixed by pulling alternatively on both limbs of the sliding sutures (white arrow) in a cranial direction to make the washer go down until it touches the clavicle and self-locks. (B) AC Sawbones model, in which both washers are supported in the superior aspect of the clavicle. The remnants of the sliding sutures (red arrows) should not be cut until step 5 of the technique. (C) Arthroscopic visualization from the lateral portal. Once the 2 suspension devices have been locked and fixed, AC joint reduction is checked by direct arthroscopic visualization. (D) Top perspective of a left shoulder. The 2 limbs of the blue suture of the JuggerKnot are tied to the 2 limbs of the white suture of the JuggerKnot. (E) Top perspective of a left shoulder. The clavicle washers of the 2 suspension devices are properly locked on top of the clavicle, with the red arrow indicating the washer of the conoid suspension device and the white arrow indicating the washer of the trapezoid suspension device. One should note that the washer of the trapezoid suspension device is slightly anterior when compared with the washer of the conoid suspension device. The 2 limbs of the blue suture of the JuggerKnot are tied to the 2 limbs of the white suture of the JuggerKnot (black arrow). (F) Superior aspect of AC Sawbones model, in which the synthetic reconstruction of the AC ligaments in a triangular configuration can be appreciated.

Surgeons' understanding of the shoulder biomechanical consequences that result from unstable ACJ injuries has increased significantly over recent years. It has been shown that in many patients with unstable ACJ injuries that are managed nonoperatively, the development of scapular dyskinesis might be involved—a situation that could result in loss of strength and weakness.[2] Likewise, it has been shown that the prevalence of scapular dyskinesis in patients who have been treated operatively is lower than that in patients managed nonoperatively.[3,12]

The fact that many different surgical techniques have been described indicates that there is also a lack of consensus regarding the optimal surgical management, and the clinical result depends directly on the type of technique performed.[2] The literature is full of descriptions regarding treatment options for patients with ACJ injuries. The 5 main alternatives are (1) conservative measures based on scapular stabilization; (2) ACJ fixation with metal hardware, such as K-wires (as in the Phemister technique) or a hook plate; (3) CA ligament transfer (Weaver-Dunn procedure); (4) CC

Table 1. Pearls, Pitfalls, Risks, Key Points, Indications, and Contraindications of Technique

Pearls
The base of the coracoid should be properly debrided to guarantee the correct positioning of the AC guide.
To establish the proper diameter of the tunnels, the direction (antegrade or retrograde) for passing the suspension devices should be decided before surgery.
When the surgeon is making the CC tunnel of the conoid, the tip of the caudal portion of the AC guide should be located adjacent to the wall of the scapula and 5 mm lateral to the medial border of the coracoid, with the sliding tube of the guide located at the superior aspect of the clavicle, 4.5 cm medial to its lateral border.
When the surgeon is making the CC tunnel of the trapezoid, the tip of the caudal portion of the AC guide should be located 5 mm medial to the lateral border of the coracoid and slightly anterior when compared with the location of the conoid K-wire.
At the inferior aspect of the coracoid, the distance between the K-wires should be 1.5 cm.
If there is any doubt when checking the ACJ reduction through straight visualization, the use of fluoroscopy may be considered.
Traction should be released before reduction.
The deltotrapezial fascia should be carefully reconstructed to achieve the best horizontal and vertical stabilization.
Pitfalls and risks
Orthopaedic surgeons who are not well familiarized with arthroscopic techniques should be aware of the potential risks related to the neurovascular structures underneath the clavicle and medial to the coracoid.
There is a risk of fracture in the lateral aspect of the coracoid when tunneling its base if the AC guide is placed too laterally.
Implant cost is a consideration when using CC suspension devices.
The correct placement of the coracoid tunnels and the correct distance between them are crucial to prevent tunnel coalition and coracoid fracture.
Key points
Nonoperative management of unstable ACJ injuries might cause changes in the scapular position that could lead to muscle kinematic alterations that would perturb the shoulder girdle function and result in pain.
Surgical management of acute unstable ACJ injuries should be focused on realigning the torn ends of the ligaments, because it is accepted that in the acute phase, they still have healing potential.
The most propagated methods of treatment in cases of unstable ACJ injuries incorporate the use of metal hardware that alters the biomechanics of the ACJ, implying the need for a second surgical procedure for hardware removal once the ligaments have healed.
Anatomic reconstruction techniques have shown biomechanical and clinical advantages over nonanatomic techniques in cases of unstable ACJ injuries.
Our technique incorporates an ACJ fixation with an all−suture anchor method that guarantees horizontal stability, as well as the use of 2 anatomically placed CC suspension devices that emulate the function and biomechanics of both the conoid and trapezoid ligaments during the process of healing of the torn native structures.
Indications
Unstable ACJ injuries in acute phase (within first 3 weeks after injury)
Contraindications
Elderly patients
Patients with comorbid factors that contraindicate the need for elective surgery

AC, acromioclavicular; ACJ, acromioclavicular joint; CC, coracoclavicular.

interval fixation, both rigid (with a screw, as in the Bosworth technique) and non-rigid (suspension devices with sutures, flip devices, and washers); and (5) AC and/or CC ligament reconstruction (with tendon allografts).[2] CA ligament transfer, hook-plate fixation, AC K-wire fixation, and CC screw fixation have been previously reported to be biomechanically insufficient and inappropriate.[13] The technique performed may have a considerable influence on the outcome, especially if open reduction−internal fixation procedures with rigid metal hardware are performed.

Several arthroscopy-assisted procedures have been described for the management of unstable ACJ injuries. The advantages that arthroscopy can offer over open techniques are as follows: less morbidity; the possibility of diagnosing and treating associated lesions, with additional surgical treatment being required at a reported rate of 29.5%[14]; and the possibility of having straight visualization of the inferior aspect of the base of the coracoid, which is convenient when placing CC fixation systems.

Besides these potential advantages, many of the arthroscopic procedures that have been described for the management of acute unstable ACJ injuries are believed to involve the biomechanical disadvantage of being nonanatomic.[15] The arthroscopic technique for both acute and chronic ACJ dislocations described by Lafosse et al.,[16] in which the CA ligament transfer is proposed to reconstruct the torn CC ligaments, involves the disadvantage in terms of strength that would arise from a Weaver-Dunn procedure.[17]

For improved visualization of the inferior aspect of the coracoid, both the glenohumeral and the subacromial arthroscopic approaches facilitate tunneling and implant placement. We recommend the subacromial approach when performing the described technique because there is no need to release the superior and middle glenohumeral ligaments to allow access to the coracoid, which is an advantage over the glenohumeral approach.[18] Regarding the tunneling of the coracoid, there is a potential risk of fracture creation if the tunnel placement is improper. One of the advantages that our

technique offers over other techniques is that we advocate using the retrograde direction (from coracoid to clavicle) for passing the suspension devices, which implies making CC tunnels with a diameter of 3.5 mm instead of 4.5 mm, thus minimizing the probability of coracoid fracture. When one is planning to pass the suspension devices in a retrograde direction, the subcoracoid titanium flip device does not pass through the tunnel. When one is using the antegrade direction (which we do not recommend when making 2 CC tunnels), the subcoracoid titanium flip device has to pass through the whole tunnel, a situation that implies making tunnels with a diameter of 4.5 mm. Use of the described technique should be considered only by experienced shoulder surgeons to avoid potential complications and so guarantee the safety of the procedure.

Regarding the fixation method for CC implants in the coracoid, it has been reported that subcoracoid loops might involve the development of bony erosions because of a "sawing" effect.[19] Our procedure overcomes this issue by incorporating tunnel creation both in the coracoid and in the clavicle for implant fixation.

It has been reported that patients with unstable ACJ injuries showing remaining horizontal instability have significantly inferior clinical results.[20] Scheibel et al.[20] observed remaining horizontal instability in 42.9% of patients managed with 2 anatomically placed suspension devices. Likewise, horizontal instability has been described as the only factor showing a negative influence on patients' score results; for this reason, authors are starting to recommend an additional horizontal augmentation to address this specific problem.[20] To our knowledge, our technique represents one of the first in vivo descriptions including an AC augmentation in addition to the anatomic CC synthetic reconstruction. The fact that both vertical and horizontal stability could be properly controlled by synthetic augmentations allows the native structures to be properly reduced to heal.

It is important to bear in mind that our procedure is an arthroscopy-assisted approach, and it is critical to ensure that the deltotrapezial fascia is not interposed between the clavicle and the acromion. This can only be achieved by using a mini-open approach on top of the ACJ. Once the joint surfaces of the clavicle and the acromion are properly faced, the deltotrapezial fascia should be carefully reconstructed to guarantee proper horizontal and vertical stability. Our surgical technique provides excellent primary horizontal and vertical stabilization and restores the anatomy and biomechanics by synthetically reconstructing the torn CC and AC ligaments.

References

1. Pallis M, Cameron KL, Svoboda SJ, Owens BD. Epidemiology of acromioclavicular joint injury in young athletes. *Am J Sports Med* 2012;40:2072-2077.
2. Beitzel K, Mazzocca AD, Bak K, et al. ISAKOS Upper Extremity ommittee consensus statement on the need for diversification of the Rockwood classification for acromioclavicular joint injuries. *Arthroscopy* 2014;30:271-278.
3. Gumina S, Carbone S, Postacchini F. Scapular dyskinesis and SICK scapula syndrome in patients with chronic type III acromioclavicular dislocation. *Arthroscopy* 2009;25:40-45.
4. Millett PJ, Horan MP, Warth RJ. Two-year outcomes after primary anatomic coracoclavicular ligament reconstruction. *Arthroscopy* 2015;31:1962-1973.
5. Johansen JA, Grutter PW, McFarland EG, Petersen SA. Acromioclavicular joint injuries: Indications for treatment and treatment options. *J Shoulder Elbow Surg* 2011;20:70-82.
6. Beitzel K, Cote MP, Apostolakos J, et al. Current concepts in the treatment of acromioclavicular joint dislocations. *Arthroscopy* 2013;29:387-397.
7. Shin SJ, Kim NK. Complications after arthroscopic coracoclavicular reconstruction using a single adjustable-loop-length suspensory fixation device in acute acromioclavicular joint dislocation. *Arthroscopy* 2015;31:816-824.
8. Walz L, Salzmann GM, Fabbro T, Eichhorn S, Imhoff AB. The anatomic reconstruction of acromioclavicular joint dislocations using 2 TightRope devices: A biomechanical study. *Am J Sports Med* 2008;36:2398-2406.
9. Seo YJ, Yoo YS, Noh KC, et al. Dynamic function of coracoclavicular ligament at different shoulder abduction angles: A study using a 3-dimensional finite element model. *Arthroscopy* 2012;28:778-787.
10. Salzmann GM, Walz L, Buchmann S, Glabgly P, Venjakob A, Imhoff AB. Arthroscopically assisted 2-bundle anatomical reduction of acute acromioclavicular joint separations. *Am J Sports Med* 2010;38:1179-1187.
11. Wellmann M, da Silva G, Lichtenberg S, Magosch P, Habermeyer P. Instability pattern of acromioclavicular joint dislocations type Rockwood III: Relevance of horizontal instability. *Orthopade* 2013;42:271-277 [in German].
12. Murena L, Canton G, Vulcano E, Cherubino P. Scapular dyskinesis and SICK scapula syndrome following surgical treatment of type III acute acromioclavicular dislocations. *Knee Surg Sports Traumatol Arthrosc* 2013;21:1146-1150.
13. Jari R, Costic RS, Rodosky MW, Debski RE. Biomechanical function of surgical procedures for acromioclavicular joint dislocations. *Arthroscopy* 2004;20:237-245.
14. Arrigoni P, Brady PC, Zottarelli L, et al. Associated lesions requiring additional surgical treatment in grade 3 acromioclavicular joint dislocations. *Arthroscopy* 2014;30:6-10.
15. Rolla PR, Surace MF, Murena L. Arthroscopic treatment of acute acromioclavicular joint dislocation. *Arthroscopy* 2004;20:662-668.
16. Lafosse L, Baier GP, Leuzinger J. Arthroscopic treatment of acute and chronic acromioclavicular joint dislocation. *Arthroscopy* 2005;21:1017.
17. Clevenger T, Vance RE, Bachus KN, Burks RT, Tashjian RZ. Biomechanical comparison of acromioclavicular joint

reconstructions using coracoclavicular tendon grafts with and without coracoacromial ligament transfer. *Arthroscopy* 2011;27:24-30.
18. Natera L, Sarasquete Reiriz J, Abat F. Anatomic reconstruction of chronic coracoclavicular ligament tears: Arthroscopic-assisted approach with nonrigid mechanical fixation and graft augmentation. *Arthrosc Tech* 2014;3: e583-e588.
19. Boileau P, Old J, Gastaud O, Brassart N, Roussanne Y. All-arthroscopic Weaver-Dunn-Chuinard procedure with double-button fixation for chronic acromioclavicular joint dislocation. *Arthroscopy* 2010;26:149-160.
20. Scheibel M, Dröschel S, Gerhardt C, Kraus N. Arthroscopically assisted stabilization of acute high-grade acromioclavicular joint separations. *Am J Sports Med* 2011;39: 1507-1516.

8.2.3

Management of acute unstable acromioclavicular joint injuries

Luis Natera Cisneros & Juan Sarasquete Reiriz

European Journal of Orthopaedic Surgery & Traumatology

ISSN 1633-8065
Volume 26
Number 8

Eur J Orthop Surg Traumatol (2016)
26:817-830
DOI 10.1007/s00590-016-1836-1

Springer

Eur J Orthop Surg Traumatol (2016) 26:817–830
DOI 10.1007/s00590-016-1836-1

GENERAL REVIEW • SHOULDER - ARTHROSCOPY

Management of acute unstable acromioclavicular joint injuries

Luis Natera Cisneros[1,2] · **Juan Sarasquete Reiriz**[1,3]

Received: 14 June 2016 / Accepted: 1 August 2016 / Published online: 19 August 2016

Abstract Surgical management of acute unstable acromioclavicular joint injuries should be focused on realigning the torn ends of the ligaments to allow for healing potential. The most widely utilized treatment methods incorporate the use of metal hardware, which can alter the biomechanics of the acromioclavicular joint. This leads to a second surgical procedure for hardware removal once the ligaments have healed. Patients with unstable acromioclavicular joint injuries managed with arthroscopy-assisted procedures have shown good and excellent clinical outcomes, without the need for a second operation. These procedures incorporate a coracoclavicular suspension device aimed to function as an internal brace, narrowing the coracoclavicular space thus allowing for healing of the torn coracoclavicular ligaments. The lesser morbidity of a minimally invasive approach and the possibility to diagnose and treat concomitant intraarticular injuries; no obligatory implant removal, and the possibility of having a straight visualization of the inferior aspect of the base of the coracoid (convenient when placing coracoclavicular fixation systems) are the main advantages of the arthroscopic approach over classic open procedures. This article consists on a narrative review of the literature in regard to the management of acute acromioclavicular joint instability.

Keywords Unstable acromioclavicular joint injuries · Acute setting · Anatomic ligament reconstruction · Arthroscopically assisted management · Coracoclavicular suspension devices · Metal hardware

✉ Luis Natera Cisneros
luisgerardonaterac@gmail.com

[1] Hospital de la Santa Creu i Sant Pau, Universitat Autònoma de Barcelona, Street Sant Quintí 89, 08026 Barcelona, Catalunya, Spain

[2] Hospital General de Catalunya, Street Pedro i Pons 1, 08190 Sant Cugat del Vallés, Catalunya, Spain

[3] Hospital Quirón Teknon, Street Vilana 12, 08022 Barcelona, Catalunya, Spain

Introduction

Surgical management of acute unstable acromioclavicular joint (ACJ) injuries should be focused on realigning the torn ends of the ligaments to allow for healing potential [1]. The most widely utilized treatment methods incorporate the use of metal hardware, which can alter the biomechanics of the ACJ. This leads to a second surgical procedure for hardware removal once the ligaments have healed [2]. The hook plate, ACJ transfixion with K-wires (Phemister technique), and fixation of the coracoclavicular (CC) ligaments with a screw (Bosworth technique) are all recognized as nonanatomic procedures related to high rates of failures of fixation and complications [3].

Patients with unstable ACJ injuries managed with arthroscopy-assisted procedures have shown good and excellent clinical outcomes, without the need for a second operation [4]. These procedures incorporate a CC suspension device aimed to function as an internal brace, narrowing the CC space thus allowing for healing of the torn CC ligaments.

The fact that many different surgical techniques have been described indicates that there is also lack of consensus regarding the optimal surgical management. Often the clinical results depend on the type of technique performed [2]. A review of the literature on treatment options for patients with ACJ injuries is abundant; however, we noted

5 main concepts: (1) conservative measures based on scapular stabilization; (2) ACJ fixation with metal hardware: K-wires (as in the Phemister technique) or hook plate; (3) coracoacromial (CA) ligament transfer (Weaver–Dunn procedure); (4) CC interval fixation, including rigid techniques (with a screw, as in the Bosworth procedure) and nonrigid techniques (with suspension devices with metal-core sutures, subcoracoid flip and washer), and (5) acromioclavicular (AC) and/or CC ligaments reconstruction (with tendon allografts). The CA ligament transfer, hook plate fixation, AC K-wire fixation, and CC screw fixation have been previously reported to be biomechanically insufficient [5]. The technique used may have a considerable influence on the outcome, especially if open reduction and internal fixation (ORIF) procedures with rigid metal hardware are performed.

Controversies of the surgical management of acute unstable ACJ injuries

Arthroscopy-assisted management of unstable ACJ injuries

The management of unstable ACJ injuries by means of an arthroscopy-assisted procedure involves several advantages among open procedures in which metal hardware is implanted. The lesser morbidity of a minimally invasive approach and the possibility to diagnose and treat concomitant intraarticular injuries; no obligatory implant removal, and the possibility of having a straight visualization of the inferior aspect of the base of the coracoid (convenient when placing CC fixation systems) (Fig. 1) are the main advantages of the arthroscopic approach [4].

Associated concomitant glenohumeral injuries

It has been shown that almost one third of the patients with unstable ACJ injuries may have concomitant glenohumeral injuries [6–9]. One of the possible reasons for failure of the conservative management, or the management performed by means of an open procedure without revision of the glenohumeral space, might be the presence of simultaneous post-traumatic injuries that are overlooked in the context of the evident ACJ dislocation. Although this idea seems to be logical, the relation between these variables has not been proved yet. As far as we have knowledge, since 2009, four-specific studies about intraarticular lesions associated with unstable ACJ injuries have been published [6–9].

Pauly et al. described that traumatic concomitant glenohumeral lesions were found in 6 out of 40 patients (15 %) [6]. Tischer et al. described that intraarticular injuries were found in 14 out of 77 patients (18.2 %) [7]. Pauly et al. described again, 4 years later than in their first report, that concomitant glenohumeral pathology was found in 38 out of 125 patients (30.4 %) [8]; Arrigoni et al. described that 42 out of 98 patients (42.8 %) were diagnosed with at least 1 additional pathologic lesion, and 29 out of 98 (29.5 %) required a dedicated additional treatment [9].

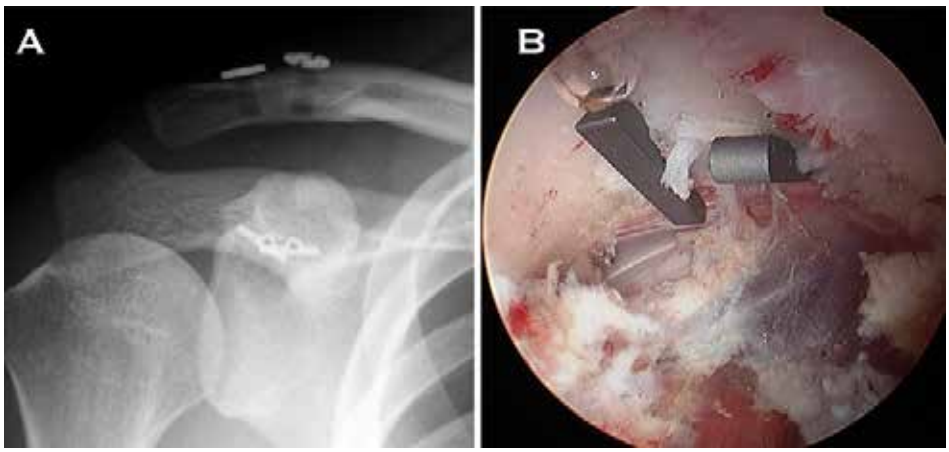


Fig. 1 **a** AP X-ray showing a right shoulder with history of unstable ACJ injury that was managed by means of 2 CC suspension devices anatomically placed. **b** Arthroscopic visualization from the lateral portal. The 2 flips of the suspension devices are properly placed in the inferior aspect of the coracoid

Table 1 Rate of associate glenohumeral injuries

References	*n*	Mean time elapsed from injury until surgery	% of concomitant glenohumeral injuries	Type of injuries
Pauly et al. [6]	40	6.9 days	15 % (6/40)	Two partial subscapularis tears. One combined tear of subscapularis and supraspinatus. Two type II and 1 type VI SLAPs
Tischer et al. [7]	77	11 days	18.2 % (14/77)	Eleven SLAPs. One complete supraspinatus tear. Two PASTA lesions
Pauly et al. [8]	125	6.8 days	30.4 % (38/125) Acute lesions in 7.2 % (9/125). Degenerative lesions in 14.4 % (18/125) and unclear traumatic correlation in 8.8 % (11/125)	One Posterior labral lesion and reversed Hill-Sachs, 3 subscapularis tears, 1 GLAD lesion, 1 rotator interval tear, 1 partial LHB tear, 2 supraspinatus tears
Jensen et al. [38]	26 arthroscopies	Less than 3 weeks after trauma	23 % (6/26)	Three lesions of the rotator cuff. Two SLAP I. One small traumatic cartilage lesion of the humeral head
Arrigoni et al. [9]	98	Within the first 30 days after injury	42 (42.8 %) were diagnosed with at least 1 additional lesion and 29 (29.5 %) required an additional treatment	Three chondral lesions, 15 type II SLAPs, 2 labral lesions, 4 biceps degenerations, 2 subscapularis lesions, 9 Posterosuperior cuff lesions
Natera et al. [59]	20	Within the first 3-weeks post-injury	20 % (4/20)	One posterior Bankart, 2 SLAPs type II, and 1 rotator cuff tear

In these four studies, the predominant pathology was related to the long head of the biceps, the superior labrum, and the rotator cuff. Taking in account all the available evidence, Imhoff et al. have suggested that magnetic resonance imaging (MRI) studies should have to be considered for the proper assessment of unstable ACJ injuries [10]. Because of the high energy involved in the production of a high-grade ACJ injury, the physician should suspect that this ACJ injury "might be more" than just the evident ACJ injury. A summary of the studies that assessed the presence of an acute associated glenohumeral injury is shown in Table 1.

Approach to the coracoid process

For an improved visualization of the inferior aspect of the coracoid, and in order to make the tunnels and place the implants, both the glenohumeral and the subacromial arthroscopic approaches have been described [11]. The subacromial approach has the advantage over the glenohumeral approach of not requiring the release the superior and middle glenohumeral ligaments [12].

Fixation method in the coracoid process

When performing CC fixations, the described methods consist on: CC screw, subcoracoid loops with sutures, coracoid anchors, and flip-button suspension devices. The coracoid fixation with a screw has been described to be the stiffest construct [13]. This issue may alter the biomechanics of the shoulder girdle and may lead to stress fractures [13]. It has been described that subcoracoid loops that surrounds its base tend to dislocate anteriorly because of the ascending slope of the inferior aspect of the coracoid [14]. It has been also shown that CC loops may involve the development of bony erosions because of a "sawing" effect [15]. Lädermann et al. have shown in their biomechanical study that subcoracoid cerclages, and a CC suspension devices may involve a similar biomechanical performance [16]. Likewise, Wellmann et al. have described similar biomechanical results when comparing a flip-button procedure versus a subcoracoid cerclage [17]. These authors have also shown that the ultimate load to failure of the flip-button procedure reaches the level of the native CC ligaments [17]. On the other side, flip-button suspension devices and subcoracoid cerclages revealed significant higher loads to failure than suture anchor repairs [17]. These authors concluded their study recommending the flip-button procedure because it represents a secure subcoracoidal fixation with no risk of anterior implant dislocation nor neurovascular damage [17].

Deshmukh et al. have compared in a biomechanical study, the load to failure of the Weaver–Dunn procedure, the subcoracoid suture cerclage, and 4 different suture anchors. These authors concluded that although none of the augmentative methods restored the ACJ stability to

normality, all proved to be superior to the Weaver–Dunn reconstruction alone [18].

Zooker et al. have described in a biomechanical study in which they augmented a Weaver–Dunn construct with a TightRope or with a subcoracoid cerclage, that superoinferior and anteroposterior translation with TightRope augmentation was lower than with the subcoracoid cerclage [19]. It has also been shown that anatomic CC reconstructions with 2 suspension devices lead to favorable in vitro results, requiring equal or even higher forces to achieve failure of the reconstruction, than the native CC ligaments [20]. Because of the mentioned reasons, for the acute setting, the subcoracoid fixation with 2 CC suspension devices anatomically placed may be considered as one of the more suitable strategies. This system provides greater fixation strength and resistance, and also emulates the function and biomechanics of the torn CC ligaments, while the healing process of the native structures takes place.

Secondary vertical displacements

It has described that despite the postsurgical remaining vertical instability, the clinical outcomes do not seem to be significantly affected [21]. It has been also shown that partial loss of reduction does not influence the overall result, but a complete loss might lead to worse results [21]. A possible explanation for the fact that clinical improvements persist despite the partial loss of reduction, could be that an elongated reconstructed ligament may result in enough stability to relieve symptoms and improve the shoulder function. Authors have postulated that a stiff reconstruction might cause less favorable results and more pain [22], but this postulation needs further investigation [23]. Woodmass et al. published a systematic review of the literature, describing complications following arthroscopic fixation of ACJ injuries, and reported a remaining dislocation rate of 8 % as a summary of all the studies in which the reconstruction was performed in the acute setting, and only using suspension devices (without tendon allografts) [24]. Venjakob et al. reported the 58-month findings of a series of 23 patients with acute ACJ injuries managed by means of an anatomic reduction using 2 suture-button devices [25]. They described that 17.39 % (4/23) of the patients showed a radiological failure of the reconstruction, in terms of remaining vertical instability. These authors also described that there was no significant difference in patient satisfaction or clinical outcomes when comparing anatomically reduced patients with those who were noted on radiographs to be under or overcorrected [25]. A summary of the studies that assessed the development of secondary displacements is shown in Table 2.

Role of acromioclavicular augmentation and remaining horizontal instability

The main vertical stabilizers of the ACJ are the CC ligaments [11] (Fig. 2a, b), and the main horizontal stabilizer is the AC capsule [26] (Fig. 2c). The superior and posterior AC ligaments are the major structures responsible for limiting the posterior translation of the distal clavicle [27]. Debski et al. described in their biomechanical study published in 2001 that horizontal stability of the ACJ cannot be completely restored by means of only reconstructing the CC ligaments [28]. Fukuda et al. have shown that the AC ligaments act as a primary constraint for posterior displacement of the clavicle and posterior axial rotation [29]. The conoid ligament plays a primary role in constraining anterior and superior rotation as well as anterior and superior displacement of the clavicle. The trapezoid ligament contributes less constraint to movement of the

Table 2 Rate of secondary displacements according to different studies

References	*n*	Surgical strategy	Mean follow-up (months)	Rate of secondary displacements
Salzmann et al. [4]	23	2 Flip-button devices	30.6	35 % (8/23)
Venjakob et al. [25]	23	2 Suture-button devices	58	35 % (8/23). When comparing with 24-month data, 17 of 20 radiographs remained unchanged; 1 case of previous overcorrection drifted into normal AC alignment and 2 cases increased in posterior subluxation of the clavicle
Jensen et al. [38]	56	30 Hook plate and 26 double TightRope technique	Hook plates were evaluated at a median of 48 months and TightRopes 17 months after surgery	Loss of reduction between 4 and 8 mm was found in 40 % (12/30) of the hook plates and in 33 % (9/26) of the tightropes
Scheibel et al. [31]	28	The double TightRope technique	26.5	57.1 % (16/28) revealed a stable situation on the Alexander view 42.9 % (12/28) were unstable
Natera et al. [59]	20	The single TightRope technique	36	40 % (8/20)

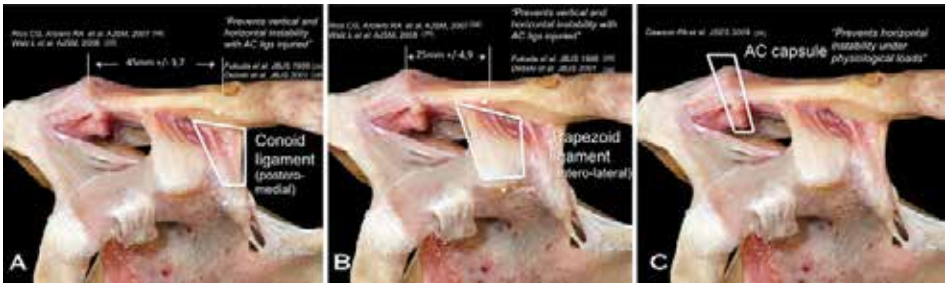


Fig. 2 Anatomic specimens of a right shoulder. Courtesy of Pau Golano. **a** The anatomic origin, disposition and main functions of the conoid ligament. **b** The anatomic origin, disposition and main functions of the trapezoid ligament. **c** The anatomic structure of the acromioclavicular capsule and its main function

clavicle in both the horizontal and vertical plane, except when the clavicle moves in axial compression toward the acromion [29]. Debski et al. have shown that the conoid and trapezoid ligaments should not be considered as one structure when surgical treatment is considered. These authors also described that transection of the AC capsule results in a shift of load to the CC ligaments, which may render the intact CC ligaments more likely to fail with anterior or posterior loading. It seems clear that the reconstructed CC ligaments cannot compensate for the loss of capsular function during anterior-posterior loading [28].

The evidence points toward the fact that proper management of the horizontal plane does have a determinant impact over the clinical outcome [30]. Remaining horizontal instability has been described as the only factor that may have a negative impact on the final clinical result [31]. It could be explained by the fact that when remaining horizontal instability might exist more shear effect on the surfaces of the ACJ than when there is remaining vertical instability. Scheibel et al. observed remaining horizontal instability in 42.9 % of a group of patients managed by means of 2 suspension devices anatomically placed [31]. Because of this high prevalence, these authors recommend an additional mandatory horizontal augmentation to address this specific problem [31]. Other authors are starting to describe stabilization strategies in the horizontal plane in order to deal with this determinant issue [32].

The remaining horizontal instability can be assessed by means of a clinical and manual assessment [33] and/or by means of a radiographic evaluation of the ACJ in the Alexander views [30]. For clinical evaluation of the horizontal stability of the ACJ, the lateral clavicle must be fixed between the fingers of one hand of the examiner, while the other hand fixes the acromion [33]. The magnitude of dorsal shift of the lateral clavicle against the acromion is then assessed and differentiated in stable or unstable [33]. In regard to the radiological examination, there is evidence of remaining horizontal instability when the distal third of the clavicle is overriding the acromion in the Alexander projection [34]. ACJ injuries Rockwood Grade III are differentiated in IIIA and IIIB according to the ISAKOS diversification of the Rockwood classification [34]. ACJ injuries IIIB are defined if the clavicle is overriding the acromion in the cross-body adduction view (Fig. 3). In like manner, Tauber et al. have described the gleno-acromio-clavicular angle (GACA), in order to allow quantification of the horizontal instability in terms of angle differences [35]. Considering all these evidences, when surgically managing unstable ACJ injuries, horizontal augmentation of the ACJ should be considered mandatory.

Procedures that involve the use of metal hardware

Many methods of treatment incorporate the use of metal hardware, situation that may alter the biomechanics of the ACJ, thus involving a second surgical procedure for hardware removal once the ligaments have healed [2]. The hook plate, the ACJ transfixion with K-wires, and the CC fixation with a screw are recognized as nonanatomic procedures related to high rates of fixation failures and complications [36]. Likewise, outcomes depend on the technique performed [37].

Patients with unstable ACJ injuries managed with the hook plate system have shown good and excellent clinical outcomes [38]. On the other side, hook plates must be removed 8–12 weeks after surgery, situation that involves the need of a second surgery. Likewise, it has been widely reported that the period while the plate is implanted involves functional limitations and pain for the patients [39]. This implant should be removed before allowing overhead shoulder activities, and motion restriction should be emphasized until removal [40]. Orthopedic surgeons' main concern is that hook plates may cause subacromial impingement and even rotator cuff tears [41], as well as other serious complications, such as cutting upward of the

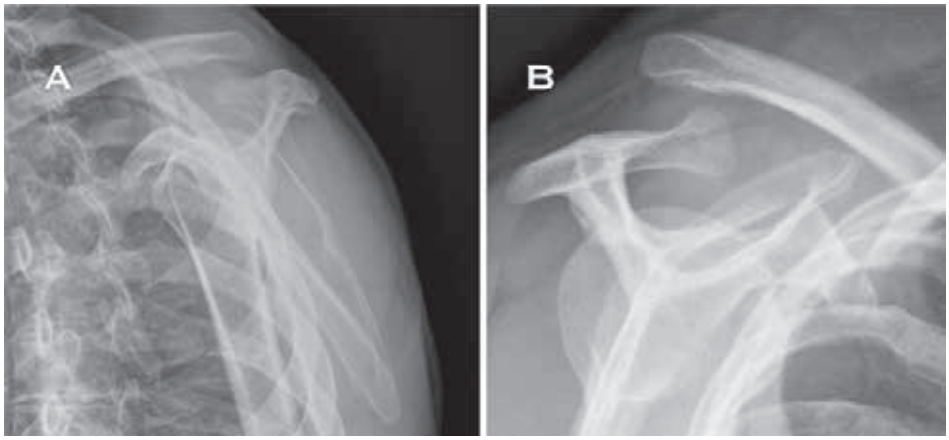


Fig. 3 Cross-body adduction X-rays in which ACJ injuries Rockwood IIIB can be identified. Observe that the clavicle is overriding the acromion, which indicates an increase of the scapular protraction and internal rotation

hook through the acromion [42], acromial osteolysis [43] and fracture [44], ACJ osteoarthritis, subacromial impingement [45], and plate bending [46]. Despite timely removal of the plate, there could be also an increased risk of fracture of the distal clavicle after low-energy trauma [47]. These implant-related adverse effects may influence patient's final functional outcome [48].

In vivo analysis of ACJ motion after hook plate fixation has shown that the clavicular motion and the ACJ biomechanics changed significantly [49]. Biomechanical studies have shown that the hook plate could suppose a biomechanical disadvantage in terms of the vertical stability, when compared to CC fixations with suspension devices. The CC displacement during cyclic loading has been shown to be higher for the hook plate fixations [16]. Likewise, it has been shown that loss of reduction after plate removal often occurs [50]. Despite this biomechanical and clinical evidence, comparable partial recurrent vertical instability has been observed when comparing CC fixation systems to the hook plate [38]. The technique chosen does have a strong influence on the result, especially if open procedures and fixation with metal hardware are performed.

Arthroscopy-assisted techniques for the management of acute unstable ACJ injuries

Arthroscopically assisted hook plate fixation

Gille et al. described in 2013 a technique indicated for acute ACJ injuries in which they propose arthroscopic assistance for the placement hook plates [51]. They concluded that arthroscopically assisted AC-hook plate fixation in ACJ injuries may be a useful innovation, which offers all advantages of a minimally invasive surgical procedure, and the possibility to diagnose and treat concomitant glenohumeral injuries [51]. These authors describe that under subacromial visualization, the drill hole for the hook of the plate can be exactly positioned in the acromion and that the hook plate is put in place under visual control. The initial results ($n = 3$) are described as promising, with good to excellent results with a median follow-up time after the index procedure of 7 months. In regard to the ACJ fixation with a hook plate, the inconveniences of this strategy are the mandatory need for a second operation, and the ACJ biomechanical alterations that arise from this type of temporary fixation.

Arthroscopically assisted Bosworth procedure

Rolla et al. described in 2004 a technique which consists of a closed reduction and stabilization of the ACJ, positioning a cannulated screw between the clavicle and the coracoid under arthroscopic control, without any exposure to X-rays [52]. The procedure has been performed in 9 patients with excellent functional outcomes. These authors argue that the advantages of this technique are that it does not require specific instrumentation, it represents a minimally invasive approach, it involves the possibility of evaluating the glenohumeral joint in order to diagnose associated lesions and eventually treat them, and also involves the benefits of not exposing the patient or surgical team to ionizing

radiation [52]. In regard to the Bosworth procedure *per se*, it has been shown that it represents rigid fixation that does not respect the biomechanics of the ACJ, thus implying need for mandatory hardware removal, because otherwise it would involve risk of coracoid fracture [36].

Arthroscopic Weaver–Dunn procedure

The majority of the arthroscopic procedures that have been described for the management of acute unstable ACJ injuries imply the biomechanical disadvantage of being nonanatomic techniques [18]. Lafosse et al. described an arthroscopic technique for both acute and chronic ACJ dislocations, in which the CA ligament transfer is aimed to emulate the torn CC ligaments [53]. Boileau et al. described an all-arthroscopic Weaver–Dunn–Chuinard procedure with double-button fixation for chronic ACJ injuries [54]. These techniques may involve the biomechanical disadvantage of the Weaver–Dunn procedure [55]. Currently there is enough biomechanical and clinical evidence that supports the consideration of other reconstructive techniques before the Weaver–Dunn procedure [21, 55].

CC suspension device

The use of only one suspension device was a strategy that became fashionable during the last decade (Fig. 4a). The possibility to narrow the CC space without the mandatory need for a second surgery for hardware removal, and the potential less morbidity that arises from a minimally

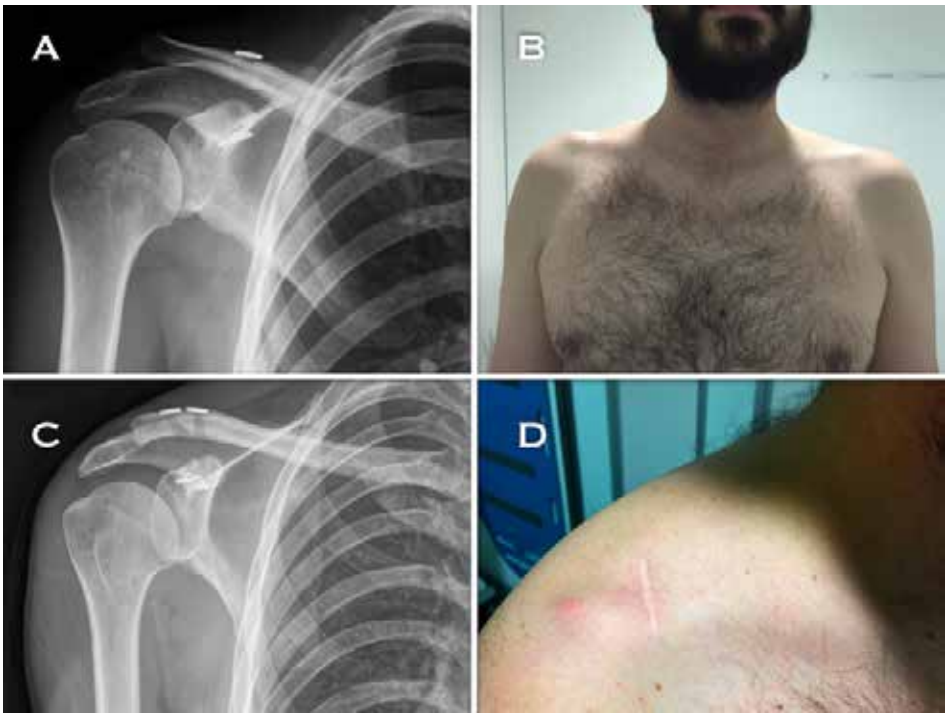


Fig. 4 **a** AP X-rays showing a right shoulder with history of unstable ACJ injury that was managed by means of 1 CC suspension device located at the isometric CC location. Observe the postsurgical remaining vertical instability. **b** Anterior perspective of the patient with history of an unstable ACJ injury that was managed by means of 1 suspension device and that developed a secondary displacement. **c** AP X-rays showing a right shoulder with history of unstable ACJ injury that was managed by means of 2 CC suspension devices anatomically placed. **d** Anterolateral perspective of a right shoulder with history of an unstable ACJ injury that was managed by means of two suspension devices. Observe the scar of the mini-open approach that had to be performed in order to guarantee there was no interposition of the deltotrapezial fascia between the clavicle and the acromion

invasive procedure were the main features that made this technique quite popular.

Arthroscopic-assisted procedures, which incorporate a CC suspension device, are aimed to reduce the CC space thus allowing the aligning of the torn CC ligaments. With the use of one suspension device located at the isometric point of the CC ligaments, good clinical outcomes have been described [56], but secondary subluxations have been matter of concern [56] (Fig. 4b). Only 1 isometric CC suspension device does not reproduce the biomechanics of the CC ligaments, and the fixation it provides seems to be not enough to maintain the reduction of the ACJ [57]. The reasons for the development of secondary displacements are mainly mechanical [57].

The concept and importance of an "anatomic reconstruction" of the injured structures in order to emulate their function became later popular, so the use of only one suspension device started to be replaced by the use of two suspension devices anatomically placed [31].

CC suspension devices anatomically placed

Biomechanical studies have demonstrated the importance of an anatomic reconstruction of both the conoid and trapezoid ligaments [20]. This importance relies on the fact that they have different functions that depend of their native anatomic locations [58]. In order to reproduce the anatomic orientation of both the conoid and trapezoid ligaments, and thus improve the biomechanics of the fixation, arthroscopic techniques that incorporate a second CC suspension device have been developed [31] (Fig. 4c). It is important to keep in mind that the mentioned procedure is an arthroscopic-assisted approach, and it is critical to ensure that the deltotrapezial fascia is not interposed between the clavicle and the acromion. This can only be achieved by a mini-open approach on top of the ACJ (Fig. 4d).

Walz, Salzmann, and Imhoff have shown in a biomechanical study that the reconstruction of the conoid and trapezoid ligaments by means of 2 TightRope devices, leads to favorable in vitro results with equal or even higher forces than native CC ligaments [20]. The group of Scheibel et al. has shown in a consecutive series of 28 patients with acute unstable ACJ injuries with a mean follow-up of 26.5 months, that the combined arthroscopy-assisted and image intensifier–controlled double TightRope technique represents a safe procedure and yields good to excellent clinical results despite the presence of partial recurrent vertical and horizontal ACJ instability [31]. Later on, the group of Imhoff et al. has shown in a consecutive series of 23 patients with acute unstable ACJ injuries, with a mean follow-up of 58 months that arthroscopically assisted reduction and anatomic fixation using 2 suture-button devices provide satisfactory clinical results [25].

Because of the biomechanical and clinical evidence currently available regarding the management of these injuries in the acute setting, a synthetic anatomic reconstruction of both the conoid and trapezoid ligaments by using 2 suspension devices located in the native origins of the torn structures can be considered as a feasible and reliable procedure. A summary of the clinical outcomes obtained by means of several surgical techniques is shown in Table 3.

Authors preferred technique

This technique has been previously described [32].

In order to address all the previously mentioned issues, when managing acute unstable ACJ injuries our concept involves the anatomic synthetic reconstruction of both the conoid and trapezoid ligaments with 2 CC suspension devices placed in the native origin of the CC ligaments (Fig. 5a); the addition of a horizontal stabilization represented by an all suture anchor placed in the superior aspect of the acromion, with its sutures going through a transverse tunnel made in the clavicle (Fig. 5b).

We use the beach chair position. First of all, we perform a glenohumeral examination in order to diagnose and treat concomitant glenohumeral injuries. We use the subacromial approach to the coracoid. We pass the two suspension devices in a retrograde direction, so the subcoracoid flip does not need to go through the whole CC tunnel (Fig. 6a, b). In this way, the diameter of the tunnel is smaller. With two CC tunnels with a diameter of 3.5 mm each, the possibility of having a fracture in the coracoid may be lower. Once we passed the two suspension devices, and before locking the clavicle washer, we place the all suture anchor on top of the acromion, 1 cm lateral to the ACJ (Fig. 6c). We pass an anteroposterior K-wire with eyelet at its base, in which we place two metal-core sutures, which are going to be used as shuttles (Fig. 6d). Once we have fixed the AC augmentation, we proceed to lock the clavicle washer of the 2 suspension devices (Fig. 6a, b). We tie the sutures of the all suture anchor to the shuttle sutures, and we get a triangle configuration of the AC reconstruction (Fig. 6c). We make a careful reconstruction of the deltotrapezial fascia.

This procedure has been performed in 9 patients diagnosed of unstable ACJ injury. The time from injury to surgery was less than 3 weeks in all cases. Clinical and radiographic assessments were performed in all cases at a minimum follow-up time of 12 months. The preliminary results are considered excellent because all patients had a complete functional recovery with no residual pain. No secondary subluxations of the ACJ have been observed in the Zanca or Alexander views (Fig. 7).

Table 3 Clinical outcomes obtained by means of several surgical techniques

References	Year	Technique	Scale	Results	Follow-up (m)	*N*/failed	Level of evidence
Salzmann et al. [4]	2010	2 Flip-button devices	VAS/SST SF36/ Constant score	VAS and Constant score showed improvements from pre-op 4.5 and 34.3 to post-op 0.25 and 94.3, respectively	30.6	23/8	IV
Yoo et al. [68]	2010	Single-tunnel CC reconstruction using autogenous semitendinosus tendon	ACJ Separation Questionnaire, UCLA/ Constant score	10 patients achieved an "excellent" result and 11 a "good" result according to the AC scoring. Mean Constant 84.7 and mean UCLA 30	33	21/4	IV
Dimakopoulos et al. [67]	2006	CC stabilization with 2 pairs of Ethibond No. 5 nonabsorbable sutures	Constant score	Mean Constant 93.5 points	33	38/5	IV
Shin et al. [66]	2008	Reconstruction of CC ligaments using 2 suture anchors and CA ligament transfer	Constant score	Mean Constant 97 points	28	29/5	IV
Tauber et al. [21]	2009	12 Modified Weaver–Dunn and 12 autogenous semitendinosus graft	American Shoulder and Elbow Surgeons shoulder score (ASES)/ Constant	Mean ASES improved from 74 pre-op to 86 postop in the Weaver–Dunn group, and from 74 to 96 in the semitendinosus tendon group. The Constant improved from 70 to 81 in the Weaver–Dunn group, and from 71 to 93 in the semitendinosus tendon group	37	24/CC distance of 12.3 mm in the Weaver–Dunn group increasing to 14.9 mm under stress loading, compared with 11.4 mm increasing to 11.8 mm under stress in the semitendinosus tendon group	II
Choi et al. [65]	2008	Suture anchors from clavicle to coracoid	Constant score	The mean Constant score was 89.5	41.2	20/2	IV

Postoperative rehabilitation period

The rehabilitation period should involve wearing a sling for 3–4 weeks. Patients are initially allowed to move fully and actively the elbow, wrist, and hand. Pendulum exercises are begun from the second or third week postsurgery in the patients managed by means of CC suspension devices and may be started from the first week post-injury in patients managed by means of metal hardware procedures. Patients are allowed to passively move the shoulder no more than 90° of elevation in the plane of the scapula after 3 weeks since surgery. Patients managed by means of a hook plate should not be allowed to elevate the shoulder more than 90° in the plane of the scapula during the whole period, while the plate is implanted, in order to avoid damage by the hook of the underlying structures. Active range of motion is progressively advanced from the sixth week onwards. Exercises to regain strength were initiated once the patient had full, pain-free passive and active range of motion, and exercises are primarily directed toward scapular stabilization. Return to work without restrictions is allowed after 12–14 weeks, and contact sports or major efforts should be avoided for 6 months.

Complications

It has been described that ACJ reconstruction techniques may carry a different profile of complications, depending on the type of surgical procedure, and the moment surgery is performed.

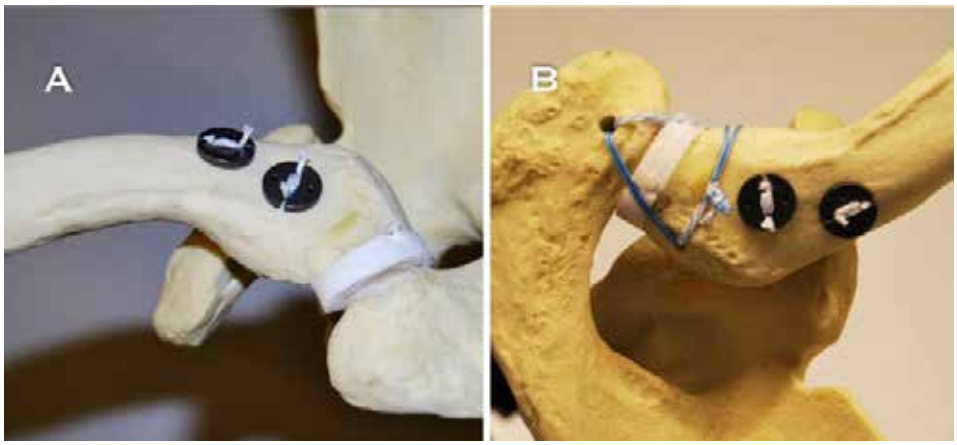


Fig. 5 AC sawbones. **a** Superolateral perspective in which the conoid and trapezoid washers of the anatomically placed suspension devices can be observed. Notice that the trapezoid suspension device is slightly anterior than the conoid suspension device. **b** Superior perspective in which an AC fixation with an all suture anchor is providing the horizontal stability of the reconstruction

In the acute setting, endobutton techniques provide good clinical and radiological outcomes at the expense of hardware irritation [24]. The proportion of hardware irritation (clavicle washers) when using CC suspension devices has been described to be around 35 % of the cases [24]. Despite this evidence, and as far as we have knowledge, revision surgery for hardware removal has not been reported to be routinely performed [24].

In regard to the maintenance of the reduction, the TightRope/Endobutton technique has the lowest radiographic failure rate [24]. In a previous study in which we described the clinical and radiological outcomes of 20 patients with history of an unstable ACJ injury managed by means of 1 CC suspension device, we noted a high prevalence of remaining vertical instability (40 % of the cases) [59]. This is the reason why we now recommend the use of 2 CC suspension devices, in order to improve the biomechanical resistance of the reconstruction [32, 60]. On the other side, graft reconstructions without a primary mechanical stabilizer have demonstrated a high risk for loss of reduction [21]. The failure rate after fixation using only tendon graft has been described to be around 50 % or more [24, 61], while the failure rate after management in the acute setting with CC suspension devices has been described to be around 26.8 % [24]. In the series of 17 patients described by Carofino and Mazzocca, in which the CC ligaments were reconstructed using a semitendinosus allograft passed beneath the coracoid and through bone tunnels in the clavicle, there was a failure rate of 17.65 % (3/17) [62]. We believe that making a tunnel in the coracoid and thus promoting integration to bone of the tendon allograft, and incorporating a suspension device, minimize the probabilities of late elongation of the tendon allograft with subsequent lost of ACJ reduction [11].

It has been reported that infection rates are higher in the chronic setting than in the acute setting [63]. This issue may be due to the fact that in the chronic setting, surgical times may be longer, tendon allografts are often used, and surgical approaches are usually wider. A systematic review of the literature describes that the overall rate of superficial infections is around 3.8 % for arthroscopic procedures [24], in contrast to a rate of up to 5 % for procedures performed by means of open surgery [24] and up to 8 % in those procedures in which a tendon graft was used [21, 64]. In the acute setting, no deep surgical wounds infections have been described [24]. In the series of 17 patients managed in the chronic setting described by Carofino and Mazzocca, one of the patients developed a chronic infection, requiring removal of the allograft and a lattissimus flap for soft tissue coverage [62].

It should be noted that there is a potential risk of fracture during coracoid tunnelling when placing CC suspension devices. The pooled rate of fractures (clavicle or coracoid) both in the acute and in the chronic setting has been described to be 5.3 % [24]. We advocate the retrograde passing of the CC suspension devices (from coracoid to clavicle), because in this manner the subcoracoid titanium flip does not need to pass through the tunnel. This implies making the CC tunnels with a diameter of 3.5-mm instead of 4.5-mm, thus minimizing the probabilities of coracoid

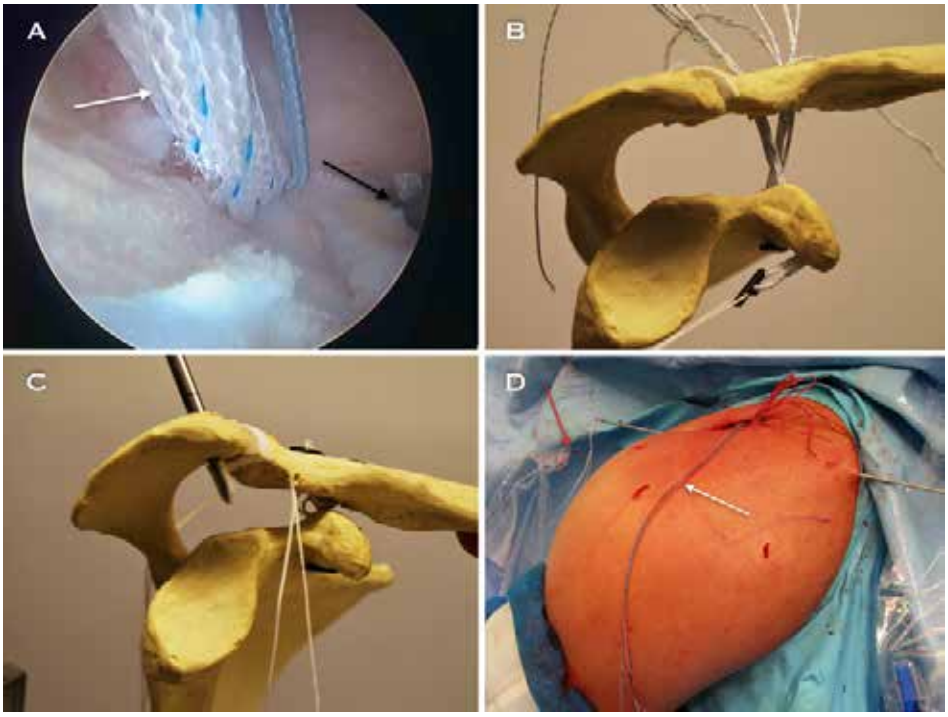


Fig. 6 Reproduced with permission and copyright© of Arthroscopy Techniques, Elsevier. **a** Arthroscopic visualization from the lateral portal. The suspension device of the trapezoid is entering the coracoid tunnel in a retrograde direction. The *white arrow* is pointing to the sliding sutures of the suspension device. The *black arrow* is pointing to the titanium flip device of the conoid suspension device, which was previously placed. **b** Acromioclavicular (AC) Sawbones model, in which the suspension device of the trapezoid is entering the coracoid tunnel in a retrograde direction, once the titanium flip device of the conoid suspension device has been placed. **c** AC Sawbones model, in which a JuggerKnot soft anchor is being inserted on top of the acromion, 1 cm lateral to the AC joint. **d** Rear perspective of a left shoulder. The K-wire with an eyelet at its base was passed through the clavicle in an anteroposterior direction. Two shuttle MaxBraids (*red arrow*) were passed through the hole of the K-wire. The *white arrow* is pointing to the *blue and white sutures* of the JuggerKnot anchor that was previously inserted at the superior aspect of the acromion, 1 cm lateral to the AC joint (color figure online)

fracture. When using the antegrade direction (which we do not recommend when making 2 CC tunnels), the subcoracoid titanium flip has to pass through the whole tunnel, situation that implies making tunnels with a diameter of 4.5-mm.

Overview

The evidence currently available about the management of acute unstable ACJ injuries indicates that arthroscopy-assisted techniques may involve advantages over traditional open procedures. The main advantages of an arthroscopy-assisted approach are the possibility to diagnose and treat concomitant glenohumeral injuries, no mandatory implant removal, less aggression to the soft tissues and a better cosmetic appearance. Most of the clinical and radiological outcomes of the published series of patients managed by means of CC suspension devices placed by means of an arthroscopy-assisted procedure can be considered as good or excellent. Detractors of CC suspension devices base their arguments on the potential risk of iatrogenic coracoid fracture. It is now known that this risk may be minimized by making CC tunnels with a smaller diameter and using the retrograde direction when passing the suspension devices. The biomechanical evidence currently available supports the performance of an anatomic reconstruction of the torn CC ligaments when managing unstable ACJ

Fig. 7 Reproduced with permission and copyright© of Arthroscopy Techniques, Elsevier. **a** Acromioclavicular (AC) Sawbones model, in which the ZipTight is being fixed by pulling alternatively on both limbs of the sliding sutures (*white arrow*) in a cranial direction to make the washer go down until it touches the clavicle and self-locks. **b** AC Sawbones model, in which both washers are supported in the superior aspect of the clavicle. The remnants of the sliding sutures (*red arrows*) should not be cut until step 5 of the technique. **c** Top perspective of a left shoulder. The clavicle washers of the 2 suspension devices are properly locked on top of the clavicle, with the *red arrow* indicating the washer of the conoid suspension device and the *white arrow* indicating the washer of the trapezoid suspension device. One should note that the washer of the trapezoid suspension device is slightly anterior when compared with the washer of the conoid suspension device. The 2 limbs of the *blue suture* of the JuggerKnot are tied to the 2 limbs of the *white suture* of the JuggerKnot (*black arrow*) (color figure online)

injuries in the acute setting, in order to restore the biomechanical role of the CC connection to the dynamic of the shoulder girdle. The role of the AC augmentation to control the horizontal instability is actually clear. Independently of the surgical strategy chosen from the variety of procedures, this surgical gesture should be considered mandatory.

Acknowledgments Authors would like to thank our colleague and friend, Pau Golano, for his contribution with the pictures of the cadaveric specimens of Fig. 2.

Compliance with ethical standards

Conflict of interest Dr. Luis Natera declares that has no conflict of interest. Dr. Juan Sarasquete receives royalties from Biomet® Sports Medicine.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent For the purposes of this study, there was no need for informed consent from any individual participants included in the study.

References

1. Weinstein DM, McCann PD, McIlveen SJ, Flatow EL, Bigliani LU (1995) Surgical treatment of complete acromiocla–vicular dislocations. Am J Sports Med 23:324–331
2. Johansen JA, Grutter PW, McFarland EG, Petersen SA (2011) Acromioclavicular joint injuries: indications for treatment and treatment options. J Shoulder Elbow Sur 20:70–82. doi:10.1016/j.jse.2010.10.030
3. Warth RJ, Martetschläger F, Gaskill TR, Millett PJ (2013) Acromioclavicular joint separation. Curr Rev Musculoskelet Med 6:71–78. doi:10.1007/s12178-012-9144-9
4. Salzmann GM, Walz L, Buchmann S, Glabgly P, Venjakob A (2010) Arthroscopically assisted 2-bundle anatomical reduction of acute acromioclavicular joint separations. Am J Sports Med 38:1179–1187. doi:10.1177/0363546509355645
5. Jari R, Costic RS, Rodosky MW, Debski RE (2004) Biomechanical function of surgical procedures for acromioclavicular joint dislocations. Arthroscopy 20:237–245
6. Pauly S, Gerhardt C, Haas NP, Scheibel M (2009) Prevalence of concomitant intraarticular lesions in patients treated operatively for high-grade acromioclavicular joint separations. Knee Surg Sports Traumatol Arthrosc 17:513–517. doi:10.1007/s00167-008-0666-z
7. Tischer T, Salzmann GM, El-Azab H, Vogt S, Imhoff AB (2009) Incidence of associated injuries with acute acromioclavicular joint dislocations types III through V. Am J Sports Med 37(1):136–139. doi:10.1177/0363546508322891
8. Pauly S, Kraus N, Greiner S, Scheibel M (2013) Prevalence and pattern of glenohumeral injuries among acute high-grade acromioclavicular joint instabilities. J Shoulder Elbow Surg 22(6):760–766. doi:10.1016/j.jse.2012.08.016 (**Epub 2012 Sep 28**)
9. Arrigoni P, Brady PC, Zottarelli L, Barth J, Narbona P, Huberty D, Koo SS, Adams CR, Parten P, Denard PJ, Burkhart SS (2014) Associated lesions requiring additional surgical treatment in grade 3 acromioclavicular joint dislocations. Arthroscopy 30:6–10. doi:10.1016/j.arthro.2013.10.006
10. Braun S, Imhoff A, Martetschlaeger F (2014) Primary fixation of acromioclavicular joint disruption. Oper Tech Sports Med 22:221–226
11. Natera L, Sarasquete Reiriz J, Abat F (2014) Anatomic reconstruction of chronic coracoclavicular ligament tears: arthroscopic-assisted approach with nonrigid mechanical fixation and graft augmentation. Arthrosc Tech 3(5):e583–e588. doi:10.1016/j.eats.2014.06.014 (**eCollection 2014 Oct**)
12. Baumgarten KM, Altchek DW, Cordasco FA (2006) Arthroscopically assisted acromioclavicular joint reconstruction. Arthroscopy 22:228.e1–228.e6
13. McConnell AJ, Yoo DJ, Zdero R, Schemitsch EH, McKee MD (2007) Methods of operative fixation of the acromio-clavicular joint: a biomechanical comparison. J Orthop Trauma 21(4):248–253
14. Jerosch J, Filler T, Peuker E, Greig M, Siewering U (1999) Which stabilization technique corrects anatomy best in patients

with AC-separation? An experimental study. Knee Surg Sports Traumatol Arthrosc 7:365–372
15. Guttmann D, Paksima NE, Zuckerman JD (2000) Complications of treatment of complete acromioclavicular joint dislocations. Instr Course Lect 49:407–413
16. Lädermann A, Gueorguiev B, Stimec B, Fasel J, Rothstock S, Hoffmeyer P (2013) Acromioclavicular joint reconstruction: a comparative biomechanical study of three techniques. J Shoulder Elbow Surg 22(2):171–178. doi:10.1016/j.jse.2012.01.020 (**Epub 2012 Apr 27**)
17. Wellmann M, Zantop T, Weimann A, Raschke MJ, Petersen W (2007) Biomechanical evaluation of minimally invasive repairs for complete acromioclavicular joint dislocation. Am J Sports Med 35(6):955–961 (**Epub 2007 Feb 22**)
18. Deshmukh AV, Wilson DR, Zilberfarb JL, Perlmutter GS (2004) Stability of acromioclavicular joint reconstruction: biomechanical testing of various surgical techniques in a cadaveric model. Am J Sports Med 32(6):1492–1498 (**Epub 2004 Jul 20**)
19. Zooker CC, Parks BG, White KL, Hinton RY (2010) TightRope versus fiber mesh tape augmentation of acromioclavicular joint reconstruction: a biomechanical study. Am J Sports Med 38(6):1204–1208. doi:10.1177/0363546509359064 (**Epub 2010 Apr 14**)
20. Walz L, Salzmann GM, Fabbro T, Eichhorn S, Imhoff AB (2008) The anatomic reconstruction of acromioclavicular joint dislocations using 2 TightRope devices: a biomechanical study. Am J Sports Med 36:2398–2406. doi:10.1177/0363546508322524
21. Tauber M, Gordon K, Koller H, Fox M, Resch H (2009) Semitendinosus tendon graft versus a modified Weaver–Dunn procedure for acromio-clavicular joint reconstruction in chronic cases: a prospective comparative study. Am J Sports Med 37:181–190. doi:10.1177/0363546508323255
22. Natera-Cisneros L, Sarasquete-Reiriz J, Escolà-Benet A, Rodriguez-Miralles J (2016) Acute high-grade acromioclavicular joint injuries treatment: arthroscopic non-rigid coracoclavicular fixation provides better quality of life outcomes than hook plate ORIF. Orthop Traumatol Surg Res 102(1):31–39. doi:10.1016/j.otsr.2015.10.007
23. Boström Windhamre HA, von Heideken JP, Une-Larsson VE, Ekelund AL (2010) Surgical treatment of chronic acromioclavicular dislocations: a comparative study of Weaver–Dunn augmented with PDS-braid or hook plate. J Shoulder Elbow Surg 19(7):1040–1048. doi:10.1016/j.jse.2010.02.006
24. Woodmass JM, Esposito JG, Ono Y, Nelson AA, Boorman RS, Thornton GM, Lo IK (2015) Complications following arthroscopic fixation of acromioclavicular separations: a systematic review of the literature. Open Access J Sports Med 10(6):97–107. doi:10.2147/OAJSM.S73211 (**eCollection 2015**)
25. Venjakob AJ, Salzmann GM, Gabel F, Buchmann S, Walz L, Spang JT, Vogt S, Imhoff AB (2013) Arthroscopically assisted 2-bundle anatomic reduction of acute acromioclavicular joint separations: 58-month findings. Am J Sports Med 41(3):615–621. doi:10.1177/0363546512473438 (**Epub 2013 Jan 31**)
26. Dawson PA, Adamson GJ, Pink MM, Kornswiet M, Lin S, Shankwiler JA, Lee TQ (2009) Relative contribution of acromioclavicular joint capsule and coracoclavicular ligaments to acromioclavicular stability. J Shoulder Elbow Surg 18(2):237–244. doi:10.1016/j.jse.2008.08.003
27. Beitzel K, Sablan N, Chowaniec DM, Obopilwe E, Cote MP, Arciero RA, Mazzocca AD (2012) Sequential resection of the distal clavicle and its effects on horizontal acromioclavicular joint translation. Am J Sports Med 40(3):681–685
28. Debski RE, Parsons IM, Woo SL, Fu FH (2001) Effect of capsular injury on acromioclavicular joint mechanics. J Bone Joint Surg Am 83(9):1344–1351
29. Fukuda K, Craig EV, An KN, Cofield RH, Chao EY (1986) Biomechanical study of the ligamentous system of the acromioclavicular joint. J Bone Joint Surg Am 68(3):434–440
30. Wellmann M, da Silva G, Lichtenberg S, Magosch P, Habermeyer P (2013) Instability pattern of acromioclavicular joint dislocations type Rockwood III: relevance of horizontal instability. Orthopade 42:271–277. doi:10.1007/s00132-013-2085-1
31. Scheibel M, Dröschel S, Gerhardt C, Kraus N (2011) Arthroscopically assisted stabilization of acute high-grade acromioclavicular joint separations. Am J Sports Med 39(7):1507–1516
32. Natera L, Sarasquete J, Besalduch M, Petrica A, Escolà A, Rodriguez J, Fallone J (2015) Horizontal and vertical stabilization of acute unstable acromioclavicular joint injuries arthroscopy-assisted. Arthrosc Tech 4(6):721–729. doi:10.1016/j.eats.2015.07.014
33. Irlenbusch U (2012) Examination techniques of the shoulder—expert's evaluation based on literature analysis. Obere Extremitat 1:61
34. Beitzel K, Mazzocca AD, Bak K, Itoi E, Kibler WB, Mirzayan R, Imhoff AB, Calvo E, Arce G, Shea K (2014) ISAKOS upper extremity committee consensus statement on the need for diversification of the Rockwood classification for acromioclavicular joint injuries. Arthroscopy 30:271–278. doi:10.1016/j.arthro.2013.11.005
35. Tauber M, Koller H, Hitzl W, Resch H. Dynamic radiologic evaluation of horizontal instability in acute acromioclavicular joint dislocations (2010) Am J Sports Med 38(6):1188–1195. doi:10.1177/0363546510361951 (**Epub 2010 Apr 1**)
36. Warth RJ, Martetschläger F, Gaskill TR, Millett PJ (2013) Acromioclavicular joint separations. Curr Rev Musculoskelet Med 6:71–78. doi:10.1007/s12178-012-9144-9
37. Beitzel K, Cote MP, Apostolakos J, Solovyova O, Judson CH, Ziegler CG, Edgar CM, Imhoff AB, Arciero RA, Mazzocca AD (2013) Current concepts in the treatment of acromioclavicular joint dislocations. Arthroscopy 29:387–397. doi:10.1016/j.arthro.2012.11.023
38. Jensen G, Katthagen JC, Alvarado LE, Lill H, Voigt C (2014) Has the arthroscopically assisted reduction of acute AC joint separations with the double tight-rope technique advantages over the clavicular hook plate fixation? Knee Surg Sports Traumatol Arthrosc 22:422–430. doi:10.1007/s00167-012-2270-5
39. Kienast B, Thietje R, Queitsch C, Gille J, Schulz AP, Meiners J (2011) Mid-term results after operative treatment of rockwood grade III-V acromioclavicular joint dislocations with an AC-hook-plate. Eur J Med Res 16:52–56
40. Ding M, Ni J, Hu J, Song D (2011) Rare complication of clavicular hook plate: clavicle fracture at the medial end of the plate. J Shoulder Elbow Surg 20:18–20. doi:10.1016/j.jse.2011.06.005
41. Hackenberger J, Schmidt J, Altmann T (2004) The effects of hook plates on the subacromial space—a clinical and MRT study. Z Orthop Ihre Grenzgeb 142:603–610
42. Gstettner C, Tauber M, Hitzl W, Resch H (2008) Rockwood type III acromioclavicular dislocation: surgical versus conservative treatment. J Shoulder Elbow Surg 17:220–225. doi:10.1016/j.jse.2007.07.017
43. Chiang CL, Yang SW, Tsai MY, Kuen-Huang Chen C (2010) Acromion osteolysis and fracture after hook plate fixation for acromioclavicular joint dislocation: a case report. J Shoulder Elbow Surg 19:13–15. doi:10.1016/j.jse.2009.12.005
44. Hoffler CE, Karas SG (2010) Transacromial erosion of a locked subacromial hook plate: case report and review of literature. J Shoulder Elbow Surg 19:e12–e15. doi:10.1016/j.jse.2009.10.019
45. Bahk MS, Kuhn JE, Galatz LM, Connor PM, Williams GR Jr (2010) Acromioclavicular and sternoclavicular injuries and

clavicular, glenoid, and scapular fractures. Instr Course Lect. J Bone Joint Surg Am 59:209–226
46. Sim E, Schwarz N, Hocker K, Berzlanovich A (1995) Repair of complete acromioclavicular separations using the acromioclavicular-hook plate. Clin Orthop Relat Res 314:134–142. doi:10.1097/00003086-05000-00017
47. Nadarajah R, Mahaluxmivala J, Amin A (2005) Goodier DW (2005) Clavicular hook-plate: complications of retaining the implant. Injury 36:681–683. doi:10.1016/j.injury.2004.08.010
48. Lin HY, Wong PK, Ho WP, Chuang TY, Liao YS, Wong CC (2014) Clavicular hook plate may induce subacromial shoulder impingement and rotator cuff lesion—dynamic sonographic evaluation. J Orthop Surg Res 6(9):6. doi:10.1186/1749-799X-9-6
49. Kim YS, Yoo YS, Jang SW, Nair AV, Jin H, Song HS (2015) In vivo analysis of acromioclavicular joint motion after hook plate fixation using three-dimensional computed tomography. J Shoulder Elbow Surg 24(7):1106–1111. doi:10.1016/j.jse.2014.12.012
50. Kienast B, Thietje R, Queitsch C, Gille J, Schulz AP, Meiners J (2011) Mid-term results after operative treatment of rockwood grade III-V acromioclavicular joint dislocations with an AC-hook-plate. Eur J Med Res 16(2):52–56
51. Gille J, Heinrichs G, Unger A, Riepenhof H, Herzog J, Kienast B, Oheim R (2013) Arthroscopic-assisted hook plate fixation for acromioclavicular joint dislocation. Int Orthop 37(1):77–82. doi:10.1007/s00264-012-1691-6
52. Rolla PR, Surace MF, Murena L (2004) Arthroscopic treatment of acute acromioclavicular joint dislocation. Arthroscopy 20:662–668
53. Lafosse L, Baier GP, Leuzinger J (2005) Arthroscopic treatment of acute and chronic acromioclavicular joint dislocation. Arthroscopy 21:1017
54. Boileau P, Old J, Gastaud O, Brassart N, Roussanne Y (2010) All-arthroscopic Weaver–Dunn–Chuinard procedure with double-button fixation for chronic acromioclavicular joint dislocation. Arthroscopy 26(2):149–160. doi:10.1016/j.arthro.2009.08.008
55. Clevenger T, Vance RE, Bachus KN, Burks RT, Tashjian RZ (2011) Biomechanical comparison of acromioclavicular joint reconstructions using coracoclavicular tendon grafts with and without coracoacromial ligament transfer. Arthroscopy 27:24–30. doi:10.1016/j.arthro.2010.05.023
56. Shin SJ, Kim NK (2015) Complications after arthroscopic coracoclavicular reconstruction using a single adjustable-loop-length suspensory fixation device in acute acromioclavicular joint dislocation. Arthroscopy 31(5):816–824. doi:10.1016/j.arthro.2014.11.013
57. Patzer T, Clauss C, Kühne CA, Ziring E, Efe T, Ruchholtz S, Mann D (2013) Arthroscopically assisted reduction of acute acromioclavicular joint separations: comparison of clinical and radiological results of single versus double TightRope™ technique. Unfallchirurg 116(5):442–450. doi:10.1007/s00113-011-2135-2
58. Rios CG, Arciero RA, Mazzocca AD (2007) Anatomy of the clavicle and coracoid process for reconstruction of the coracoclavicular ligaments. Am J Sports Med 35:811–817
59. Natera L, Sarasquete J, Abat F, Besalduch M, Monllau JC, Videla S (2015) Acute unstable acromioclavicular joint injuries: quality of life comparison between patients managed operatively with a coracoclavicular suspension device arthroscopically placed versus patients managed non-operatively. Eur Orthop Traumatol 6:343–355. doi:10.1007/s12570-015-0326-y
60. Abat F, Sarasquete J, Natera LG, Calvo Á, Pérez-España M, Zurita N, Ferrer J, del Real JC, Paz-Jimenez E, Forriol F (2015) Biomechanical analysis of acromioclavicular joint dislocation repair using coracoclavicular suspension devices in two different configurations. J Orthop Traumatol 16(3):215–219. doi:10.1007/s10195-015-0346-y
61. Milewski MD, Tompkins M, Giugale JM, Carson EW, Miller MD, Diduch DR (2012) Complications related to anatomic reconstruction of the coracoclavicular ligaments. Am J Sports Med 40(7):1628–1634
62. Carofino BC, Mazzocca AD (2010) The anatomic coracoclavicular ligament reconstruction: surgical technique and indications. J Shoulder Elbow Surg 19(2):37–46. doi:10.1016/j.jse.2010.01.004
63. Rolf O, Hann von Weyhern A, Ewers A, Boehm TD, Gohlke F (2008) Acromioclavicular dislocation Rockwood III–V: results of early versus delayed surgical treatment. Arch Orthop Trauma Surg 128:1153–1157
64. Modi CS, Beazley J, Zywiel MG, Lawrence TM, Veillette CJ (2013) Controversies relating to the management of acromioclavicular joint dislocations. Bone Joint J 95-B(12):1595–1602
65. Choi SW, Lee TJ, Moon KH, Cho KJ, Lee SY (2008) Minimally invasive coracoclavicular stabilization with suture anchors for acute acromioclavicular dislocation. Am J Sports Med 36(5):961–965. doi:10.1177/0363546507312643
66. Shin SJ, Yun YH, Yoo JD (2009) Coracoclavicular ligament reconstruction for acromioclavicular dislocation using 2 suture anchors and coracoacromial ligament transfer. Am J Sports Med 37(2):346–351. doi:10.1177/0363546508324968
67. Dimakopoulos P, Panagopoulos A, Syggelos SA, Panagiotopoulos E, Lambiris E (2006) Double-loop suture repair for acute acromioclavicular joint disruption. Am J Sports Med 34(7):1112–1119
68. Yoo JC, Ahn JH, Yoon JR, Yang JH (2010) Clinical results of single-tunnel coracoclavicular ligament reconstruction using autogenous semitendinosus tendon. Am J Sports Med 38(5):950–957. doi:10.1177/0363546509356976

8.2.4

J Orthop Traumatol (2017) 18:305–318
DOI 10.1007/s10195-017-0452-0

REVIEW ARTICLE

Management of chronic unstable acromioclavicular joint injuries

Luis Natera Cisneros[1,2] · **Juan Sarasquete Reiriz**[1,3]

Received: 22 April 2016 / Accepted: 13 February 2017 / Published online: 8 March 2017

Abstract The acromioclavicular joint represents the link between the clavicle and the scapula, which is responsible for the synchronized dynamic of the shoulder girdle. Chronic acromioclavicular joint instability involves changes in the orientation of the scapula, which provokes cinematic alterations that might result in chronic pain. Several surgical strategies for the management of patients with chronic and symptomatic acromioclavicular joint instability have been described. The range of possibilities includes anatomical and non-anatomical techniques, open and arthroscopy-assisted procedures, and biological and synthetic grafts. Surgical management of chronic acromioclavicular joint instability should involve the reconstruction of the torn ligaments because it is accepted that from three weeks after the injury, these structures may lack healing potential. Here, we provide a review of the literature regarding the management of chronic acromioclavicular joint instability.

Level of evidence Expert opinion, Level V.

Keywords Unstable acromioclavicular joint injuries · Chronic setting · Arthroscopically assisted management · Anatomical ligament reconstruction · Coracoclavicular ligaments · Scapular dyskinesis

✉ Luis Natera Cisneros
luisgerardonaterac@gmail.com

[1] Hospital de la Santa Creu i Sant Pau, Universitat Autònoma de Barcelona, Street Sant Quintí 89, 08026 Barcelona, Spain

[2] Hospital General de Catalunya, Street Pedro i Pons 1, 08190 Sant Cugat Del Vallés, Barcelona, Spain

[3] Hospital Quirón Teknon, Street Vilana 12, 08022 Barcelona, Spain

Introduction

The acromioclavicular joint (ACJ) represents the link between the clavicle and the scapula, which is responsible for the synchronized dynamic of the shoulder girdle [1]. It has been shown that most patients with a history of unstable ACJ injuries managed conservatively develop changes in the anatomical orientation of the scapula, which provokes alterations in the dynamics of the rotator cuff, which can eventually predispose chronic pain [2].

Biomechanical studies have demonstrated the importance of anatomical reconstruction of the coracoclavicular (CC) ligaments in cases of unstable ACJ injuries [3]. This importance lies in the fact that the conoid and trapezoid ligaments have different functions, which depend on their anatomical location and orientation [4].

Many of the procedures for the treatment of unstable ACJ injuries are non-anatomical [5]. The therapeutic approach for chronic ACJ instability should be different from that for acute ACJ instability. In the acute phase, it is accepted that the acromioclavicular (AC) and CC ligaments still have the potential to heal, so surgical techniques may aim to align the ends of the torn ligaments while tissue-healing takes place [6]. On the other hand, as the AC and CC ligaments lose their potential to heal from 3 weeks after the ACJ injury [6], the management of chronic ACJ instability must involve biological augmentation as well as mechanical fixation [7].

Many strategies that have been described for the management of chronic ACJ instability are non-anatomical [8]

and lack primary mechanical fixation [9] that protects the graft during integration to the bone.

Here, we present a review of the literature regarding the management of chronic unstable ACJ injuries. As this review is narrative, we only included studies that were found to be of interest in supporting the concepts that we aim to transmit.

Surgical management

Indications for treatment

It is currently accepted that reasonable management for grade III ACJ injuries consists of conservative measures. A second examination (3–6 weeks after shoulder injury) must be carried out to assess the evolution of symptoms. If at 3 months after the shoulder injury (already in chronic phase) a patient with a grade III ACJ injury still complains of symptoms of scapular dyskinesis, and radiographic examinations show overriding of the distal third of the clavicle over the acromion in the Alexander projection, surgical treatment is recommended [10].

Patients with chronic and symptomatic ACJ instability (Rockwood grade III–V) must be informed about the internationally accepted recommendations regarding the surgical treatment of these injuries once the conservative measures have failed. However, they must also be informed about the potential risks of a surgical procedure and about the physical limitations of the postoperative period. In contact players, we initially consider their immediate shoulder requirements, and if they are professional or semi-professional players, we also consider the stage of the season in which they are involved. The indication for surgical treatment in this group of patients must always take the performance expectations of the athlete for the rest of the season into consideration.

Timing for surgery

Weinstein et al. described the time point distinguishing acute versus delayed surgery as 3 weeks after the date of the shoulder injury [6]. In their comparative study, the surgical procedure was the modified Weaver–Dunn technique in 15 of 27 cases managed in the acute setting and in 14 of 17 cases managed in the chronic setting. The rest of the repairs were performed by means of AC non-absorbable sutures. Satisfactory results were obtained in 96% of cases treated in the acute phase and in 76% of cases treated in the chronic phase. The differences were statistically significant in favor of treatment in the acute phase [6].

Rolf et al. compared a group of patients treated immediately after the occurrence of shoulder injury (29 patients, using the modified Phemister technique, adding a CC fixation with sutures) with a group of patients who had undergone surgery after failure of conservative treatment (20 patients using the modified Weaver–Dunn procedure) [11]. The results were significantly superior in the group of patients managed in the acute phase [11].

Mignani et al. compared 25 patients treated in the acute phase with 15 patients treated in the chronic phase [12]. In both groups the management consisted of AC and CC temporary fixations with Kirschner wires and concomitant excision of the distal third of the clavicle. The authors reported satisfactory results in 100% of patients in the acute group and 93% of patients in the chronic group, with no statistically significant differences [12].

Dumontier et al. compared 32 patients treated in the acute phase (first 3 weeks) with 24 patients treated in the chronic phase (>3 weeks) [13]. All patients were treated by means of transposition of the coracoacromial (CA) ligament. The results were satisfactory in 81% of patients treated in the acute phase and in 79% of patients treated in the chronic phase [13]. The study reported no significant differences between groups.

Von Heideken et al. compared 22 patients treated in the acute phase (within the first 4 weeks after injury) with 15 patients treated in the chronic phase (after a minimum of 4 months of conservative measures) [14]. The technique used was ACJ fixation with a hook plate. The results were significantly superior, both in the clinical and radiological aspects, in the group of patients managed in the acute phase [14]. A summary of the main aspects of these studies is shown in Table 1.

Surgical techniques for the management of chronic ACJ instability

Coracoacromial ligament transposition

The most classical method for the surgical management of chronic ACJ instability is the technique that involves transposition of the CA ligament (Fig. 1) [15, 16]. The technique described by Weaver and Dunn involves excision of the distal third of the clavicle, detachment of the AC ligament from the acromion, and transposition of this ligament to the distal third of the clavicle [16]. The modifications made to the original Weaver–Dunn procedure aimed to increase the primary mechanical stability of the fixation, by means of adding a CC fixation with subcoracoid suture loops [17], coracoid suture anchors [18], or tendon grafts. Another described modification consists of the addition of a hook plate [19].

Table 1 Management in the chronic setting versus management in the acute setting

Study	*n*	Type of treatment	Mean follow-up	Results
Weinstein et al. [6]	44	Modified Weaver–Dunn technique in 15/27 acute cases, and in 14/17 chronic cases. The rest of the repairs were performed by means of AC non-absorbable sutures	4 years (range 2–9)	Satisfactory results in 96% of acute cases and 76% of chronic cases. The differences were statistically significant in favor of acute cases
Rolf et al. [11]	49	29 patients using the modified Phemister technique versus a group of patients who underwent surgery after failure of conservative treatment (20 modified Weaver–Dunn)	53 months (range 20–92)	The results were significantly superior in the group of patients managed in the acute phase
von Heideken et al. [12]	37	22 patients treated in the acute phase versus 15 patients treated in the chronic phase. Hook plate in all cases	22 acute patients were re-evaluated at average of 38 months (range 15–96 months) after surgery, and 15 chronic patients were re-evaluated at an average of 36 months (range 18–62) after surgery	The results significantly favored both the clinical and radiological aspects, to the group of patients treated in the acute phase
Mignani et al. [13]	40	25 patients in the acute phase versus 15 patients in the chronic phase. In both groups the management consisted of AC and CC temporary fixations with K-wires	Unknown	Satisfactory results in 100% of patients in the acute group and 93% of patients in the chronic group. No statistically significant differences
Dumontier et al. [14]	56	32 patients in the acute phase versus 24 patients in the chronic phase. All patients were treated by means of CA ligament transposition	Acute group (mean follow-up 46 months) and chronic group (mean follow-up 51 months)	The results were satisfactory in 81% of patients treated in the acute phase and in 79% of patients treated in the chronic phase, with no significant differences

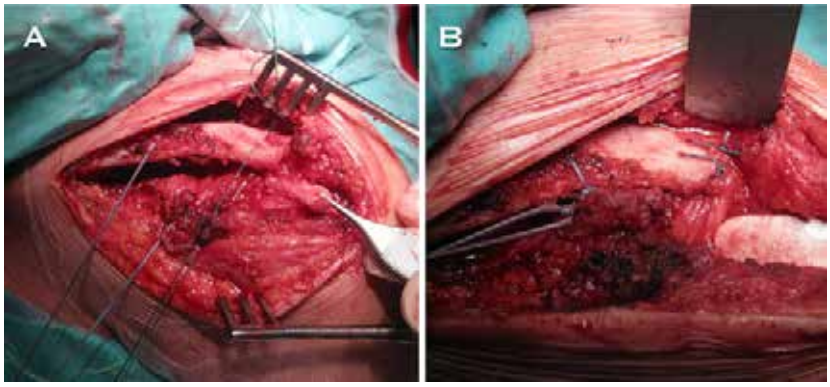


Fig. 1 Superolateral intraoperative perspective of a left shoulder with a history of chronic ACJ dislocation, that was managed by means of a modified Weaver–Dunn procedure. **a** Visualization of the coracoacromial (CA) ligament previous to its transfer to the distal third of the clavicle. Sutures have already been passed through the bone tunnels. The most medial tunnel aimed to achieve coracoclavicular (CC) fixation. This suture was previously passed beneath the coracoid process. **b** Details of the final suture fixation. Sutures are passed through the bone tunnels created in the clavicle

Boileau et al. described an all-arthroscopic Weaver–Dunn–Chuinard procedure with double-button fixation for chronic ACJ dislocations [15]. The authors performed the above-mentioned technique in 10 consecutive patients with ACJ injuries (Rockwood type III or IV). After a mean follow-up of 12.8 months, the authors reported that patients

were satisfied or very satisfied with the cosmesis; 9 of 10 patients returned to previous sports, and all symptoms resolved in all patients. They concluded that the bone block transfer (Weaver–Dunn–Chuinard procedure) involves the advantage of being a stronger repair, providing bone-to-bone healing by using free, autologous, vascularized tissue [15]. The authors reported that double-button fixation has the advantage of maintaining the reduction during the biological healing process. We believe that this technique involves a biomechanical disadvantage related to the transposition of the CA ligament [20].

Studies have shown the inferior characteristics of the CA ligament compared to the native ACJ [20]. The clinical outcomes obtained by means of the described modifications to the Weaver–Dunn technique have been described as satisfactory [17–19]. However, it is noteworthy that the use of the hook plate has been associated with a higher rate of complications, including infection, plate dislocation and need for re-operation [19]. Coracoid suture anchors have been associated with a higher rate of secondary displacements [18].

Two of the modifications made to the Weaver–Dunn technique have been compared (CC fixation with PDS vs hook plate) [17]. Clinical results were similar between groups, but the authors stated that the advantage of CC fixation with PDS over the hook plate relies on the fact that there is no need for a second operation for removing the implant [17].

Anatomical reconstruction of the CC and AC ligaments

Several biomechanical studies have demonstrated the superiority of anatomical reconstructions over other procedures with regard to the potential to emulate the properties of the native ligaments [21].

Carofino and Mazzocca developed a reconstructive technique that involves a tendon graft fixation in the native locations of the CC ligaments [22]. They performed clavicular tunnels and placed the graft in a figure-of-eight fashion, which was fixed with interferential bio-tenodesis screws [22]. The authors proposed a subcoracoid pass of the tendon graft (without coracoid tunnel), which finally rises from the coracoid to the clavicle; both ends of the graft cross between them to form the above-mentioned configuration. In a series of 106 cases with a mean follow-up of 21 months, they reported a significant improvement of the preoperative clinical results [22].

Yoo et al. described the anatomical reconstruction of the CC ligaments assisted by arthroscopy, in which three bone tunnels were performed in the native origins of the CC ligaments—two tunnels in the clavicle and one in the coracoid [23]. The authors argue that making only one tunnel in the coracoid carries a low risk of iatrogenic fracture. The described technique does not involve the use of a primary mechanical stabilizer that would protect the graft during the integration process to the bone tunnels; a reason why it can be inferred that their reconstructions may be prone to distraction forces that might affect the initially obtained ACJ reduction. In fact, although the authors report satisfactory clinical results, subtle secondary displacements were observed at final follow-up in 100% of patients in their series (13/13) [23].

In a study by Natera et al., the senior author (Dr. Sarasquete) added a CC suspension device to the anatomical reconstruction of the CC ligaments with a tendon allograft [7] in order to improve the primary mechanical fixation and thus protect the tendon graft during the integration process to the bone tunnels and reduce the rate of secondary vertical displacements, Likewise, the study group led by the above-mentioned author described the use of two suspension devices with two tunnels in the coracoid, a technique that in the acute setting would provide greater resistance to vertical translation [24]. A summary of the main aspects of the cited biomechanical studies is shown in Table 2.

Synthetic grafts

The use of synthetic ligament reconstructions is an option that could be considered for the treatment of chronic ACJ instability. The synthetic grafts most commonly used are the Ligament Advanced Reinforcement System (LARS®; Surgical Implants and Devices, Arc-sur-Tille, France), the Dacron® graft and the Ligastic® [25, 26]. Several authors reported satisfactory clinical results with the LARS® [34], and unsatisfactory results with the Dacron® [25] and the Ligastic® [26]. With regard to the Dacron® vascular prostheses, Fraschini et al. reported a complication rate of 43.3% (13/30 patients), in which 23.3% (7/30 patients) had a graft tear [25]. Regarding the LARS®, the rate of graft tears described by the authors was 3.3% (1/30 patients) [25].

Regarding the Ligastic®, Mares et al. described a rate of clavicular osteolysis of 22% (6/27 patients) [26]. In fact, these authors reported in their study that they are currently rejecting the use of this type of implant, and advising against its use. However, further studies are needed to clarify the role of synthetic grafts in the management of chronic ACJ injuries.

Muccioli et al. compared the outcomes of ACJ reconstruction with the LARS® in professional athletes with non-professional athletes at a 2-year minimum follow-up. They found that all clinical (Oxford and Constant) scores, as well as patient satisfaction, improved significantly from preoperative to follow-up intervals, with no differences between groups, and only 2% of failures (re-dislocations)

Table 2 Summary of the main aspects of the cited biomechanical studies

Study	Purpose	Treatment methods	Results	Conclusion
Lee et al. [3]	To compare biomechanical properties of native CC ligaments versus tendon graft reconstructions versus other methods	11 human cadaveric shoulders were tested to failure to compare the biomechanical properties of the native CC ligaments, CA ligament transfer, Mersilene suture repair, Mersilene tape repair, and tendon graft reconstructions with gracilis, semitendinosus, and long toe extensor	Reconstructions with semitendinosus, gracilis, or long toe extensor tendon grafts had superior initial biomechanical properties compared with CA ligament transfer; failure strengths were as strong as those of the native CC ligaments	Tendon graft reconstruction may be an alternative to CA ligament transfer and may provide a permanent biologic reconstruction with superior initial biomechanical properties
Michlitsch et al. [16]	To compare the biomechanical characteristics of a modified Weaver–Dunn reconstruction and an ACJ reconstruction with free-tissue graft for reconstruction of both CC and AC ligaments	6 pairs of cadaveric shoulders had a modified Weaver–Dunn reconstruction on 1 side and the contralateral side had a graft reconstruction of CC and AC ligaments. Load-to-failure was performed	AP and superior-inferior (SI) translation of the ACJ reconstruction was significantly less than that of the modified Weaver–Dunn under all loading conditions	ACJ reconstruction with free-tissue graft for both CC and AC ligaments demonstrates initial stability significantly better than a modified Weaver–Dunn and similar to that of intact specimens
Grutter et al. [17]	To compare the modified Weaver–Dunn procedure, the anatomical AC reconstruction using palmaris longus graft, and anatomical AC reconstruction using flexor carpi radialis graft	The native ACJ in 6 fresh-frozen cadaveric upper extremities was stressed to failure under tension in the coronal plane. Each repair was stressed to failure	Load to failure for native ACJ complex was 815 N, modified Weaver–Dunn 483 N, anatomical AC reconstruction with palmaris longus 326 N, and anatomical AC reconstruction with flexor carpi radialis 774 N	Anatomical AC reconstruction with a flexor carpi radialis tendon graft re-creates the tensile strength of the native ACJ complex and is superior to a modified Weaver–Dunn repair
Dawson et al. [20]	To compare the stability of the ACJ and biomechanical characteristics of the ACJ capsule and CC ligaments	AP and SI ACJ translations were quantified in 6 cadaver matched pairs. Either the ACJ capsule or CC ligaments were transected, and measurements were repeated. The biomechanics of the remaining ACJ capsule or CC ligaments were compared	Significant increases in AP translation with the cut ACJ capsule, and significant increases in SI translation with the cut CC ligaments	The ACJ capsule contributes significantly to the ACJ stability, especially in the AP plane
Deshmukh et al. [30]	To determine biomechanical basis for augmenting the Weaver–Dunn with supplemental fixation	Native ACJ motion was measured. AC and CC ligaments were cut, and 1 of 6 reconstructions was performed: Weaver–Dunn, suture cerclage, and 4 different suture anchors. ACJ motion was reassessed, cyclic loading test was performed, and failure load was recorded	Weaver–Dunn reconstructions failed at a lower load. Reconstruction using augmentative fixation allowed less AC motion than Weaver–Dunn reconstruction, but more motion than the native ligaments	Although none of the augmentative methods tested restored ACJ stability to normal, all proved superior to the Weaver–Dunn reconstruction alone.
Abat et al. [33]	To evaluate the vertical biomechanical behavior of two techniques for the anatomical repair of the CC ligaments	18 human cadaveric shoulders. 3 groups were formed–group I, control; group II, double tunnel in clavicle and 1 in coracoid (with two CC suspension devices); group III, repair in 'V' configuration with two tunnels in clavicle and one in coracoid (with one CC suspension device). The force required for failure was analyzed	Comparison of the three groups did not find any significant difference despite the loss of resistance presented by group III	Anatomical repair of CC ligaments with a double system (double tunnel in the clavicle and in the coracoid) permits vertical translation that is more like that of the ACJ

[27]. On the other hand, Fauci et al. compared the clinical and radiographic outcomes of ACJ stabilization performed in patients with chronic ACJ dislocation using a biological allograft or a synthetic ligament, and reported that the biological' group achieved significantly better clinical scores than the 'synthetic' group, at both 1- and 4-year follow-up. The authors concluded that the biological graft afforded better clinical and radiographic outcomes than the synthetic ligament in patients with chronic ACJ instability [28].

Dynamic stabilization of the ACJ

An osteotomy is made to the coracoid process, which is later transferred to the inferior aspect of the clavicle with the attached conjoined tendon [29]. The bone block is fixed to the clavicle by means of a screw with a spike washer. In this way, the conjoined tendon is converted to a depressor of the clavicle. This concept does not directly address the pathomechanics of an ACJ injury in which, rather than a

superior displacement of the clavicle, it is the scapula that descends [1]. Despite this issue, the technique has been used in both the acute and chronic settings with satisfactory results [30].

Distal third clavicle excision

Excision of the distal third of the clavicle (Mumford procedure) may represent a solution to a painful chronic ACJ injury (grade I–III) [31]. Osteoarthritic changes have been described to be mostly restricted to type I and type II injuries, since the greater separation of the bone ends in higher-grade injuries may prevent the development of this complication [31]. However, degenerative changes in the articular disc and lateral end of the clavicle may be found during surgery and might be a source of pain in high-grade injuries. This technique must involve the resection of only 5 mm of the distal third of the clavicle, since (in cases of ACJ injuries grade I–II) the trapezoid ligament is only 2.5 cm medial to the distal end of the clavicle [4]; more generous resections could affect the clavicular insertion of the trapezoid ligament.

Authors preferred technique

This technique has been previously described [7].

We perform an arthroscopy-assisted reconstruction in order to be able to diagnose and treat possible associated glenohumeral injuries (Fig. 2). We propose anatomical reconstruction of the CC ligaments using a semitendinosus tendon allograft (Fig. 3a, b). In Fig. 3c, the radiological aspect of a right shoulder in which this technique was performed can be appreciated. In a contact player, we prefer to use a tendon autograft, which may be the ipsilateral palmaris longus.

The technique implies one tunnel at the coracoid, and two tunnels at the clavicle. These tunnels aim to emulate the anatomical locations of the CC ligaments. We also add a CC suspension device in order to guarantee primary stability of the reconstruction.

A subacromial approach to the base of the coracoid is performed in association with a Mumford procedure. A transverse skin incision over the clavicle is performed. The conoid native insertion is 4.5 cm medial to the distal end of the clavicle and the trapezoid native insertion is 2.5 cm and subtly anterior when compared to the conoid [4].

A cross section of the deltotrapezial fascia is performed, and the AC drilling guide is placed at the base of the coracoid with the sliding tube at the superior aspect of the clavicle, 4.5 cm medial to its distal end (conoid native origin) (Fig. 4a). A K-wire is passed followed by the cannulated drill. The K-wire is removed and the cannulated drill is maintained in the same position (Fig. 4b). Subsequently, the same procedure should be performed for the clavicular tunnel of the trapezoid ligament. Shuttle sutures are passed through the cannulated drills (Fig. 4c). Two metal-core sutures are tied to the distal end of the shuttle suture that passes through the coracoid. A superior perspective of the clavicle shows both shuttle sutures emerging from the tunnels (Fig. 4d).

One of the metal-core sutures passing through the conoid tunnel is temporarily tied to one of the ends of the tendon graft. The other end of the graft is temporarily tied to the shuttle suture, which is coming out of the trapezoid clavicle and exits through the anterior portal.

The graft is passed by means of pulling cranially on the metal-core suture that comes out of the conoid tunnel. Subsequently, the shuttle suture which is coming out of the trapezoid clavicle tunnel is pulled in a superior direction; the graft is directed laterally and superiorly, conforming to the anatomical 'V' configuration of the reconstruction (Fig. 4e).

One of the ends of the shuttle metal-core suture is still free in the conoid tunnel. This suture is now tied to the CC suspension device, and pulled out in a cranial direction so the device passes in a retrograde direction (Fig. 4f).

The graft is fixed in the clavicular portion of the tunnels with bio-tenodesis interferential screws (Fig. 5a). The washer should be threaded with the sliding sutures, in order to be able to bring it down until it is applied over the clavicle (Fig. 5b). The assistants must reduce the ACJ by pushing the elbow upwards and the clavicle downwards at the same time. The CC suspension device is now locked (Fig. 5c). Both limbs of the graft are crossed over each other and sutured to themselves (Fig. 5d). The remaining graft is sectioned and removed. The deltotrapezial fascia is carefully reconstructed.

The described technique provides the advantages of minimally invasive surgery, avoids the biomechanical disadvantages related to rigid metal hardware procedures, offers greater biomechanical resistance thus minimizing the risk of secondary displacements related to non-anatomical techniques, and combines primary mechanical stabilization and definitive biological stabilization represented by the graft, once integrated to the bone (Fig. 6a, b).

The results obtained with this technique have been published previously [32]. Ten patients with a mean age of 41 years underwent surgery after failure of conservative measures. The clinical outcomes showed a significant improvement from the visit prior to surgery to the last follow-up in all patients, and no secondary vertical instability was registered in any of the cases [32].

Fixation method of the tendinous allograft in the coracoid process

It has been reported that suture subcoracoid loops tend to dislocate anteriorly due to the ascending slope that is represented by the most caudal portion of the base of the

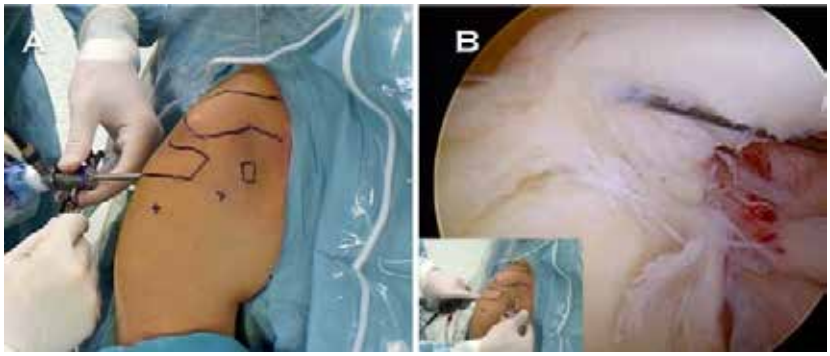


Fig. 2 **a** Anterolateral perspective of a right shoulder positioned in the operating room, with a history of a chronic grade V ACJ injury. **b** Biceps-labrum complex viewed from the posterior portal. Notice the degenerative aspect of the biceps insertion, which indicates an associated glenohumeral injury

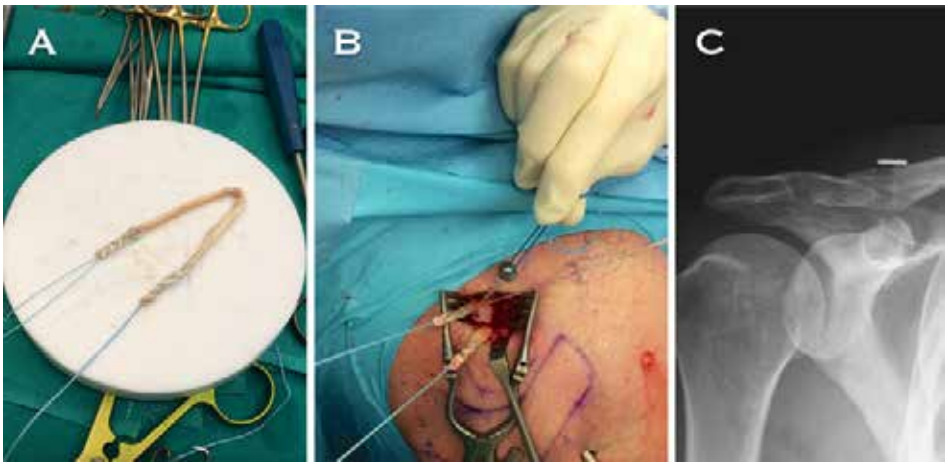


Fig. 3 **a** Semitendinous allograft after being sutured with a metal-core suture in both of its limbs. **b** Both limbs of the graft coming out of the clavicle once fixed in both tunnels with bio-tenodesis interference screws. The ZipTight is tied by threading the sliding suture in the washer. **c** AP X-ray of a right shoulder in which an anatomical reconstruction of CC ligaments with tendon allograft was performed in the chronic setting. Observe the trapezoid tunnel in the clavicle, lateral to the conoid tunnel in the clavicle, through which also passes the suspension device

coracoid [33]. It has also been shown that the use of sub-coracoid suture loops can involve a shear deleterious effect on the bone [34].

Other authors propose techniques that do not involve making tunnels at the coracoid, but pass the graft around the caudal portion of the bone. We think that by taking into consideration the fact that there is no contact between the cancellous bone and the collagen of the tendon graft [22], integration of the graft might not be developed.

Postoperative management

Regardless of the chosen technique, due to the fact that biological augmentation should be employed in the chronic setting, there should be a protection period of the reconstruction in order to guarantee integration of the graft to the bone tunnels [7].

The shoulder should be maintained in a sling for 46 weeks. Patients should be allowed from the beginning to fully and actively move the elbow, wrist, and hand and should be

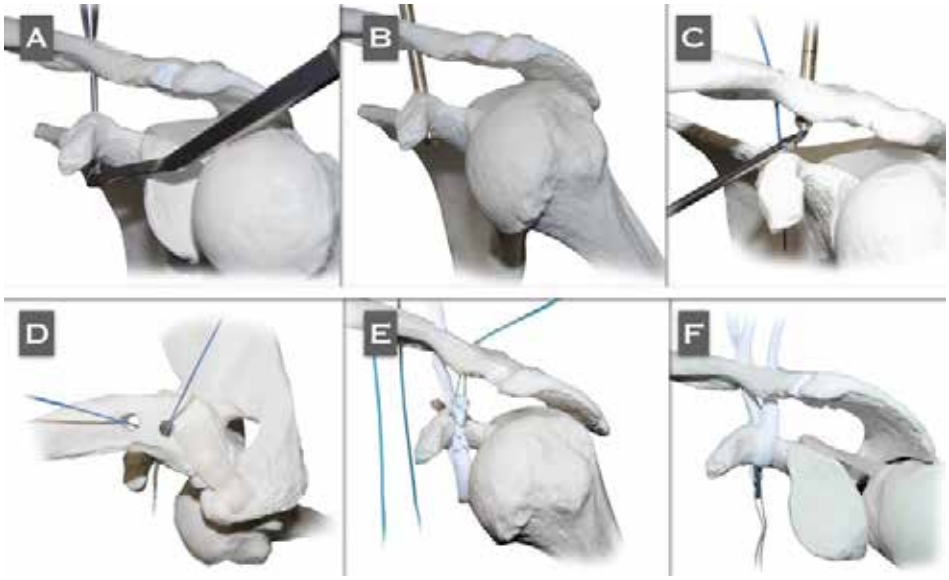


Fig. 4 Reproduced with permission and copyright© of Arthroscopy Techniques, Elsevier. **a** The AC drilling guide is placed at the coracoid base with the sliding tube of the guide in the superior aspect of the clavicle, 4.5 cm medial to its lateral border (conoid native origin). A 2.4-mm K-wire is passed through the AC guide. **b** A cannulated 4.5- to 6-mm (depending on the graft diameter) drill is passed over the K-wire and comes out from the inferior aspect of the coracoid. **c** A shuttle 1-mm PDS suture is passed through the cannulated drill located in the trapezoid tunnel. The PDS is recovered with a grasper from the anterior portal. **d** Superior perspective of the clavicle in which both shuttle sutures are emerging from the tunnels. **e** The PDS that arises from the trapezoid tunnel in the clavicle is pulled out in a cranial direction to recover the limb of the graft that is going to surround the base of the coracoid at its lateral aspect, coming from its tunnel and then being directed laterally and superiorly, configuring the anatomical 'V' shape of the graft. **f** Once the graft has passed through both clavicle tunnels, the ZipTight is tied to the distal limb of the shuttle FiberWire that is still free in the conoid tunnel

allowed to passively move the shoulder into no more than 90° of elevation in the plane of the scapula. The exercise program should be started after the sixth week. Pendulum exercises must begin in the fourth week, and active range of motion is allowed from the sixth week onwards. Exercises to regain strength are initiated once the patient achieves full, pain-free passive and active range of motion. These exercises are primarily directed toward scapular stabilization. Return to work without restrictions is allowed at 12–16 weeks after surgery, and contact sports, as well as tasks requiring major efforts should be avoided for 4–6 months after surgery. The achievement of a full recovery and the return to maximum strength and function can take from 9−12 months.

Complications

The profile of complications that can be expected after surgery for ACJ instability depends on whether the reconstruction is performed in the acute or chronic setting, on the type of fixation used, and on whether the reconstruction is performed using arthroscopy-assisted or open surgery. The rate of complications according to different studies is shown in Table 3.

With regard to infection rates, a systematic review of the literature reports that the overall rate of superficial infections is approximately 3.8% for arthroscopic procedures [35], in contrast to a rate of up to 5% for procedures performed by open surgery [35], and up to 8% in those procedures in which a tendon graft was used [36, 37].

The failure rate after fixation in the chronic setting using only a tendon graft, has been reported to be approximately ≥50% [35, 38], while the failure rate after management in the acute setting has been reported to be approximately 26.8% [35].

It has been reported that these differences may be due to the fact that the tendon graft tends to lengthen over time, and it may also emulate a 'windshield' effect at the level of the clavicular tunnels, a situation that eventually ends with widening of the tunnels [39].

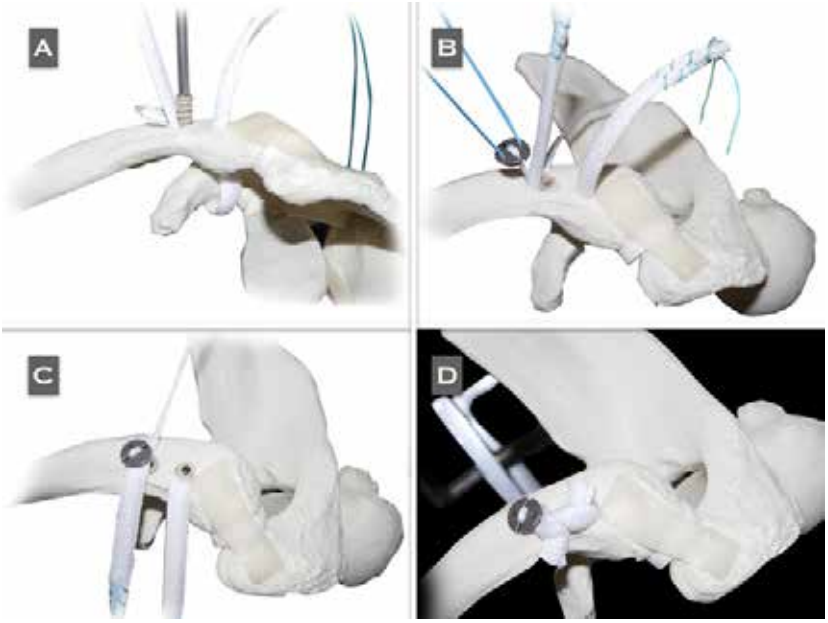


Fig. 5 **a** Before the ZipTight is tensioned, the graft should be fixed in the clavicular portion of the conoid tunnel with a 4.5- to 5.5-mm (same diameter of the tunnel) bio-tenodesis interference screw. Reproduced with permission and copyright© of Arthroscopy Techniques, Elsevier. **b** Both limbs of the graft coming out of the clavicle when fixed in both tunnels with bio-tenodesis interference screws. The ZipTight is tied by threading the sliding suture in the washer. To avoid any harm to the sutures of the ZipTight with the screw, the graft should be placed in an intermediate position between the screw and the sutures. **c** The ZipTight has been tied by pulling alternatively on both limbs of the blue traction sutures in a cranial direction to make the washer go down until it touches the clavicle and self-locks, providing mechanical stabilization of the reconstruction. **d** Both limbs of the graft are crossed over each other and sutured to themselves. The remnant of the graft is sectioned and removed

Regarding the incidence of fractures of the coracoid process, it has been reported that the overall rate (both mono-tunnel and double-tunnel techniques) is approximately 5.3% [35].

Non-surgical management of chronic ACJ instability

Gumina et al. reported that the prevalence of scapular dyskinesis (Fig. 7) in patients with chronic ACJ instability (Rockwood grade III) can be up to 70.6% [40], and that the prevalence of SICK scapula [41] (Scapular malposition, Inferior medial border prominence, Coracoid pain and malposition, and dyskinesis of scapular movement) can be up to 58.3% [40]. This group of patients might develop persistent shoulder pain that could make them unable to return to their previous daily life activities [42]. The occurrence of modifications in the scapular orientation leads to cinematic alterations of the muscles, thus perturbing the shoulder girdle biomechanics. Likewise, it has been shown that the prevalence of scapular dyskinesis in those patients managed surgically is lower when compared to patients managed non-surgically [2, 40].

Patients with this syndrome may refer shoulder pain at the ACJ and at the coracoid, posterior shoulder pain sometimes irradiated to the cervical paraspinal region and to the lateral aspect of the arm, or even radicular symptoms.

Carbone et al. proposed a rehabilitation protocol for patients with scapular dyskinesis [43]. The protocol consists of 12 exercises aimed to strength the scapular muscles. These authors described a series of 24 patients with a history of chronic ACJ instability (grade III) in which 100% (24/24) had scapular dyskinesis and 58.33% (14/24) had SICK scapula [43]. Twelve months after having

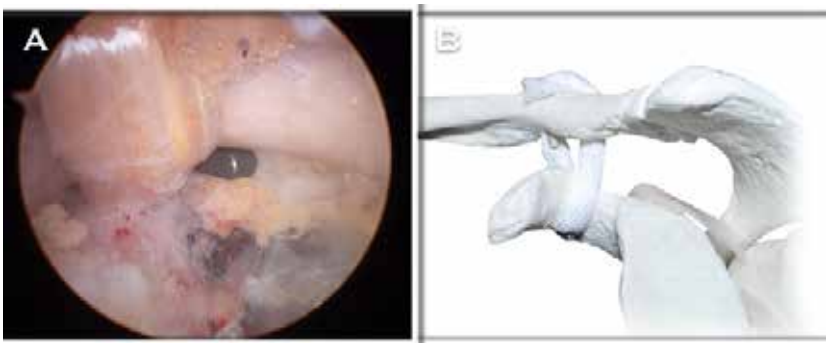


Fig. 6 **a** Final arthroscopic view from the lateral portal. The graft is coming out of the coracoid tunnel, ascending toward the trapezoid tunnel in the clavicle. The flip of the ZipTight is supported in the inferior aspect of the coracoid. **b** Final anatomical 'V' configuration of the CC reconstruction, with the flip of the ZipTight supported in the inferior aspect of the coracoid and both limbs of the graft are crossed over each other and sutured to themselves. Reproduced with permission and copyright© of Arthroscopy Techniques, Elsevier

Table 3 Rate of complications according to different studies

Study	*n*	Technique	Mean follow-up (months)	Rate of complications	Type of complications
Tauber et al. [18]	24	12 patients, modified Weaver–Dunn 12 patients, autogenous semitendinosus tendon graft	37	12.5% (3/24)	Semitendinous group, 1 mild loss of reduction. 1 mild hyperesthesia of the saphenous nerve. Weaver–Dunn group, 1 superficial wound infection
Boileau et al. [25]	10	All-arthroscopic Weaver–Dunn–Chuinard procedure with double-button fixation	12.8	20% (2/10)	1 Superficial infection of the superior portal. 1 lateral migration of the subcoracoid EndoButton
Carofino et al. [31]	22 reconstructions in 21 patients. 16 were available for follow-up	Open anatomical CC ligament reconstruction	21	18.75% (3/16)	1 Persistent ACJ pain. 1 chronic infection, requiring removal of the allograft and latissimus flap coverage. 1 loss of reduction
Yoo et al. [32]	13	Arthroscopically assisted anatomical CC reconstruction with tendon graft	17	23% (3/13)	3 Loss of reduction. In all patients, mild displacement
Fraschini et al. [34]	60 managed surgically and 30 managed conservatively	30 CC reconstructions with DACRON®, 30 CC reconstructions with LARS®	15	43% (13/30) in the DACRON® group and 3.3% (1/30) in the LARS® group	DACRON® group: 7 recurrences due to neoligament rupture, 4 aseptic separations, 1 clavicle fracture and 1 coracoid fracture. LARS® group: 1 neoligament rupture
Cook et al. [43]	10	Arthroscopic CC ligament reconstruction with GraftRope (Arthrex) plus tendon allograft	9.7	80% (8/10)	8 Loss of reduction, 4 revision surgeries

accomplished the rehabilitation protocol, 21.73% (5/23) of the patients still had scapular dyskinesis and 17.4% (4/23) still had SICK scapula. They concluded that scapular dyskinesis and SICK scapula secondary to chronic ACJ instability might show improvement within 6 weeks of starting this rehabilitation protocol.

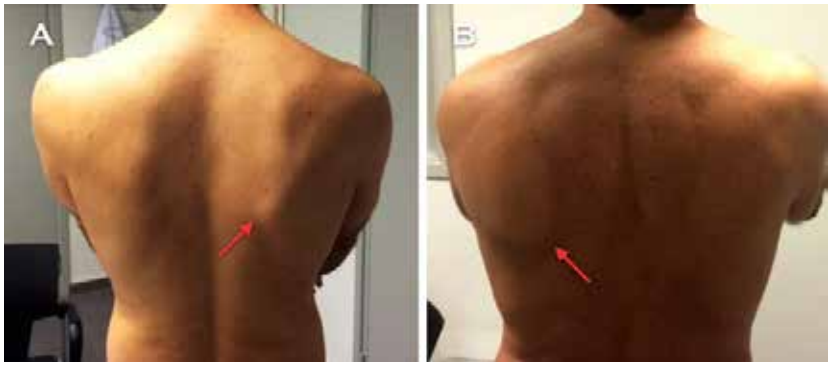


Fig. 7 **a** and **b** Posterior perspective of two patients performing shoulder forward flexion. Notice that the inferomedial border of the right scapula (*red arrows*) shows a prominence. These two patients had a history of chronic unstable ACJ injuries that were conservatively treated

Discussion

Arthroscopy-assisted surgery versus open surgery

With regard to the advantages that arthroscopy-assisted surgery may offer over open surgery in cases of chronic ACJ instability, it is important to mention that associated glenohumeral lesions can be diagnosed and treated [7]. Some authors have reported that the incidence of lesions associated with unstable ACJ injuries can be up to 30% [44]. In the management of chronic ACJ instability, it is important to guarantee that there is no interposition of the deltotrapezial fascia between the clavicle and the acromion, a situation that can only be accomplished by means of making a mini-approach just above the ACJ. Once anatomical reduction of the ACJ has been reached, the deltotrapezial fascia should be carefully reconstructed in order to ensure adequate vertical and horizontal stability [7].

Anatomical versus non-anatomical reconstructions

Anatomical AC and CC ligament reconstruction techniques have become increasingly popular. Several clinical and biomechanical studies have shown their superiority in reproducing the strength and stiffness of the native ACJ complex when compared to other reconstructive techniques [20, 36, 45]. Biomechanical studies of ACJ reconstructions with free-tissue grafts for both the CC and the AC ligamentous complex have shown that these techniques provide ACJ stability similar to that of the native ACJ [45]. Likewise, it is currently clear that by taking into consideration the biomechanics and the resistance of the reconstruction that anatomical procedures are superior techniques when compared to the classical Weaver–Dunn technique [45].

Lafosse et al. describe an arthroscopic technique indicated for cases of chronic ACJ instability, in which they propose CA ligament transfer in order to reproduce the function of the torn CC ligaments [8]. It has been reported that transposition of the CA ligament of the Weaver–Dunn technique offers a lower resistance to vertical translation than anatomical CC reconstructions with tendon grafts [20].

LaPrade et al. described an open non-anatomical technique in which they propose the use of a semitendinosus allograft, which passes through a tunnel in the clavicle and another in the coracoid [9]. This technique entails a biomechanical disadvantage that does not take into account the anatomical location of the CC ligaments [9]. The authors recognize that in some patients, an elongation of the graft may be developed, a situation that may result in persistent ACJ instability in the vertical plane [9].

In a prospective, comparative, clinical study, Tauber et al. showed that anatomical ligament reconstruction of the conoid and trapezoid ligaments with tendon grafts results in superior outcomes compared to the modified Weaver−Dunn technique [36].

Anteroposterior (AP) stabilization

The shoulder community has shown an increasing interest in anatomical CC ligament reconstruction, because these concepts aim to recreate the force vectors of both the conoid and trapezoid ligaments, thus restoring both horizontal and vertical instability. Despite the recent development of numerous reconstructive techniques, residual AP post-surgical instability remains a matter of concern [46].

Likewise, the importance of simultaneous reconstruction of the AC ligaments has been widely studied and demonstrated [47]. It has been reported that patients who underwent surgery for unstable ACJ injury, and show remaining AP post-surgical instability, may have significantly inferior clinical results [48]. Likewise, it has been also reported that persistent AP post-surgical instability is the only factor that may adversely affect the clinical outcomes [48]. For this reason, reconstructive strategies must give the same importance to AC reconstruction as to CC reconstruction [49].

Arthroscopic approach to the coracoid process

Some authors propose a direct skin incision over the tip of the coracoid, blunt dissection and identification of its base, in order to place the drilling guide [50]. These techniques are performed in a 'blind' manner, and therefore lack the precision that direct visualization may provide. To guarantee a proper view of the lower portion of the base of the coracoid, several arthroscopic techniques that facilitate the process of tunnel-making and implant-positioning have been described [7–9]. Glenohumeral access involves the need to release the superior and middle glenohumeral ligaments, in order to gain access to the coracoid process [51]. On the other hand, subacromial access to the coracoid has the advantage over glenohumeral access, as it does not involve the potential deleterious effect that may result from the release of the superior and middle glenohumeral ligaments [7].

Overview

Considering all the procedures described in this review, patients with shoulder symptoms resulting from chronic ACJ instability may benefit from surgical treatment. The procedures considered for the management of chronic ACJ instability should take into account the biological aspects; for this reason the use of either a tendon graft, ligament or osteotendinous transposition should always be considered. Likewise, the fundamental role that primary mechanical fixation may play should to be taken into account, in order to protect the integration period of biological augmentation to the bone.

Compliance with ethical standards

Conflict of interest Dr. Juan Sarasquete receives royalties from Biomet® Sports Medicine.

Patient consent For the purposes of this study, there was no need for informed consent from any individual participant.

Ethical approval No ethics committee approval, nor patients consent are needed for review article, since no human nor animal subject are involved.

Funding For the purposes of this study, there was no need for funding.

References

1. Mazzocca AD, Arciero RA, Bicos J (2007) Evaluation and treatment of acromioclavicular joint injuries. Am J Sports Med 35:316–329. doi:10.1177/0363546506298022
2. Murena L, Canton G, Vulcano E, Cherubino P (2013) Scapular dyskinesis and SICK scapula syndrome following surgical treatment of type III acute acromioclavicular dislocations. Knee Surg Sports Traumatol Arthrosc 21:1146–1150
3. Lee SJ, Nicholas SJ, Akizuki KH, McHugh MP, Kremenic IJ, Ben- Avi S (2003) Reconstruction of the coracoclavicular ligaments with tendon grafts: a comparative biomechanical study. Am J Sports Med 31:648–654
4. Rios CG, Arciero RA, Mazzocca AD (2007) Anatomy of the clavicle and coracoid process for reconstruction of the coracoclavicular ligaments. Am J Sports Med 35:811–817
5. Gstettner C, Tauber M, Hitzl W, Resch H (2008) Rockwood type III acromioclavicular dislocation: surgical versus conservative treatment. J Shoulder Elbow Surg 17:220–225
6. Weinstein DM, McCann PD, McIlveen SJ, Flatow EL, Bigliani LU (1995) Surgical treatment of complete acromioclavicular dislocations. Am J Sports Med 23:324–331
7. Natera L, Sarasquete Reiriz J, Abat F (2014) Anatomic reconstruction of chronic coracoclavicular ligament tears: arthroscopic-assisted approach with nonrigid mechanical fixation and graft augmentation. Arthrosc Tech 15;3(5):e583-8. doi:10.1016/j.eats.2014.06.014. eCollection 2014 Oct
8. Lafosse L, Baier GP, Leuzinger J (2005) Arthroscopic treatment of acute and chronic acromioclavicular joint dislocation. Arthroscopy 21:1017
9. LaPrade RF, Hilger B (2005) Coracoclavicular ligament reconstruction using a semitendinosus graft for failed acromioclavicular separation surgery. Arthroscopy 21:1277.e1-1277.e5
10. Beitzel K, Mazzocca AD, Bak K, Itoi E, Kibler WB, Mirzayan R, Imhoff AB, Calvo E, Arce G, Shea K, Upper Extremity Committee of ISAKOS (2014) ISAKOS upper extremity committee consensus statement on the need for diversification of the Rockwood classification for acromioclavicular joint injuries. Arthroscopy 30(2):271–278. doi:10.1016/j.arthro.2013.11.005
11. Rolf O, Hann von Weyhern A, Ewers A, Boehm TD, Gohlke F (2008) Acromioclavicular dislocation Rockwood III–V: results of early versus delayed surgical treatment. Arch Orthop Trauma Surg 128:1153–1157
12. Mignani G, Rotini R, Olmi R, Marchiodi L, Veronesi CA (2002) The surgical treatment of Rockwood grade III acromio-clavicular dislocations. Chir Organi Mov 87:153–161

13. Dumontier C, Sautet A, Man M, Apoil A (1995) Acromioclavicular dislocations: treatment by coracoacromial ligamentoplasty. J Shoulder Elbow Surg 4:130–134
14. von Heideken J, Boström Windhamre H, Une-Larsson V, Ekelund A (2013) Acute surgical treatment of acromioclavicular dislocation type V with a hook plate: superiority to late reconstruction. J Shoulder Elbow Surg 22:9–17
15. Boileau P, Old J, Gastaud O, Brassart N, Roussanne Y (2010) All-arthroscopic Weaver–Dunn–Chuinard procedure with double-button fixation for chronic acromioclavicular joint dislocation. Arthroscopy 26(2):149–160. doi:10.1016/j.arthro.2009.08.008
16. Weaver JK, Dunn HK (1972) Treatment of acromioclavicular injuries, especially complete acromioclavicular separation. J Bone Joint Surg Am 54-A:1187–1194
17. Boström Windhamre HA, von Heideken JP, Une-Larsson VE, Ekelund AL (2010) Surgical treatment of chronic acromioclavicular dislocations: a comparative study of Weaver-Dunn augmented with PDS-braid or hook plate. J Shoulder Elbow Surg 19:1040–1048
18. Shin SJ, Yun YH, Yoo JD (2009) Coracoclavicular ligament reconstruction for acromioclavicular dislocation using 2 suture anchors and coracoacromial ligament transfer. Am J Sports Med 37:346–351
19. Liu HH, Chou YJ, Chen CH, Chia WT, Wong CY (2010) Surgical treatment of acute acromioclavicular joint injuries using a modified Weaver-Dunn procedure and clavicular hook plate. Orthopedics 11;33(8). doi:10.3928/01477447-20100625-10
20. Grutter PW, Petersen SA (2005) Anatomical acromioclavicular ligament reconstruction: a biomechanical comparison of reconstructive techniques of the acromioclavicular joint. Am J Sports Med 33:1723–1728. doi:10.1177/0363546505275646
21. Deshmukh AV, Wilson DR, Zilberfarb JL, Perlmutter GS (2004) Stability of acromioclavicular joint reconstruction: biomechanical testing of various surgical techniques in a cadaveric model. Am J Sports Med 32:1492–1498. doi:10.1177/0363546504263699
22. Carofino BC, Mazzocca AD (2010) The anatomic coracoclavicular ligament reconstruction: surgical technique and indications. J Shoulder Elbow Surg 19:37–46. doi:10.1016/j.jse.2010.01.004
23. Yoo YS, Seo YJ, Noh KC, Patro BP, Kim DY (2011) Arthroscopically assisted anatomical coracoclavicular ligament reconstruction using tendon graft. Int Orthop 35(7):1025–1030. doi:10.1007/s00264-010-1124-3
24. Abat F, Sarasquete J, Natera LG, Calvo Á, Pérez-España M, Zurita N, Ferrer J, Del Real JC, Paz-Jimenez E, Forriol F (2015) Biomechanical analysis of acromioclavicular joint dislocation repair using coracoclavicular suspension devices in two different configurations. J Orthop Traumatol 16(3):215–219. doi:10.1007/s10195-015-0346-y
25. Fraschini G, Ciampi P, Scotti C, Ballis R, Peretti GM (2010) Surgical treatment of chronic acromioclavicular dislocation: comparison between two surgical procedures for anatomic reconstruction. Injury 41:1103–1106
26. Mares O, Luneau S, Staquet V, Beltrand E, Bousquet PJ, Maynou C (2010) Acute grade III and IV acromioclavicular dislocations: outcomes and pitfalls of reconstruction procedures using a synthetic ligament. Orthop Traumatol Surg Res 96:721–726
27. Marcheggiani Muccioli GM, Manning C, Wright P, Grassi A, Zaffagnini S, Funk L. (2014) Acromioclavicular joint reconstruction with the LARS ligament in professional versus non-professional athletes. Knee Surg Sports Traumatol Arthrosc. doi:10.1007/s00167-014-3231-y (Epub ahead of print)
28. Fauci F, Merolla G, Paladini P, Campi F, Porcellini G (2013) Surgical treatment of chronic acromioclavicular dislocation with biologic graft vs synthetic ligament: a prospective randomized comparative study. J Orthop Traumatol 14(4):283–290
29. Berson BL, Gilbert MS, Green S (1978) Acromioclavicular dislocations: treatment by transfer of the conjoined tendon and distal end of the coracoid process to the clavicle. Clin Orthop Relat Res 135:157e64
30. Bailey RW, Metten CF, O'Connor GA, Titus PD, Baril JD, Moosman DA (1976) A dynamic method of repair for acute and chronic acromioclavicular disruption. Am J Sports Med 4:58e71
31. Snyder SJ, Banas MP, Karzel RP (1995) The arthroscopic Mumford procedure: an analysis of results. Arthroscopy 11(2):157–164
32. Natera-Cisneros L, Santiago-Boccolini H, Sarasquete-Reiriz J (2015) Treatment of chronic acromioclavicular joint instability. Acta Ortop Mex 29(3):164–171
33. Jerosch J, Filler T, Peuker E, Greig M, Siewering U (1999) Which stabilization technique corrects anatomy best in patients with AC-separation? An experimental study. Knee Surg Sports Traumatol Arthrosc 7:365–372
34. Guttmann D, Paksima NE, Zuckerman JD (2000) Complications of treatment of complete acromioclavicular joint dislocations. Instr Course Lect 49:407–413
35. Woodmass JM, Esposito JG, Ono Y, Nelson AA, Boorman RS, Thornton GM, Lo IK (2015) Complications following arthroscopic fixation of acromioclavicular separations: a systematic review of the literature. Open Access J Sports Med 6:97–107. doi:10.2147/OAJSM.S73211
36. Tauber M, Gordon K, Koller H, Fox M, Resch H (2009) Semitendinosus tendon graft versus a modified Weaver–Dunn procedure for acromioclavicular joint reconstruction in chronic cases: a prospective comparative study. Am J Sports Med 37:181–190. doi:10.1177/0363546508323255
37. Modi CS, Beazley J, Zywiel MG, Lawrence TM, Veillette CJ (2013) Controversies relating to the management of acromioclavicular joint dislocations. Bone Joint J 95-B(12):1595–1602
38. Milewski MD, Tompkins M, Giugale JM, Carson EW, Miller MD, Diduch DR (2012) Complications related to anatomic reconstruction of the coracoclavicular ligaments. Am J Sports Med 40(7):1628–1634
39. Cook JB, Shaha JS, Rowles DJ, Bottoni CR, Shaha SH, Tokish JM (2012) Early failures with single clavicular transosseous coracoclavicular ligament reconstruction. J Shoulder Elbow Surg 21(12):1746–1752
40. Gumina S, Carbone S, Postacchini F (2009) Scapular dyskinesis and SICK scapula syndrome in patients with chronic type III acromioclavicular dislocation. Arthroscopy 25(1):40–45. doi:10.1016/j.arthro.2008.08.019
41. Burkhart SS, Morgan CD, Kibler W (2003) The disabled throwing shoulder: spectrum of pathology. Part III: the SICK scapula, scapular dyskinesis, the kinetic chain, and rehabilitation. Arthroscopy 19:641–661
42. Beitzel K, Cote MP, Apostolakos J, Solovyova O, Judson CH, Ziegler CG, Edgar CM, Imhoff AB, Arciero RA, Mazzocca AD (2013) Current concepts in the treatment of acromioclavicular joint dislocations. Arthroscopy 29:387–397. doi:10.1016/j.arthro.2012.11.023
43. Carbone S, Postacchini R, Gumina S (2015) Scapular dyskinesis and SICK syndrome in patients with a chronic type III acromioclavicular dislocation. Results of rehabilitation. Knee Surg Sports Traumatol Arthrosc 23(5):1473–1480. doi:10.1007/s00167-014-2844-5
44. Pauly S, Kraus N, Greiner S, Scheibel M (2013) Prevalence and pattern of glenohumeral injuries among acute high-grade acromioclavicular joint instabilities. J Shoulder Elbow Surg 22:760–766. doi:10.1016/j.jse.2012.08.016

45. Michlitsch MG, Adamson GJ, Pink M, Estess A, Shankwiler JA, Lee TQ (2010) Biomechanical comparison of a modified Weaver-Dunn and a free-tissue graft reconstruction of the acromioclavicular joint complex. Am J Sports Med 38:1196–1203. doi:10.1177/0363546509361160
46. Wellmann M, da Silva G, Lichtenberg S, Magosch P, Habermeyer P (2013) Instability pattern of acromioclavicular joint dislocations type Rockwood III: relevance of horizontal instability. Orthopade 42:271–277. doi:10.1007/s00132-013-2085-1
47. Dawson PA, Adamson GJ, Pink MM, Kornswiet M, Lin S, Shankwiler JA, Lee TQ (2009) Relative contribution of acromioclavicular joint capsule and coracoclavicular ligaments to acromioclavicular stability. J Shoulder Elbow Surg 18:237–244. doi:10.1016/j.jse.2008.08.003
48. Scheibel M, Dröschel S, Gerhardt C, Kraus N (2011) Arthroscopically assisted stabilization of acute high-grade acromioclavicular joint separations. Am J Sports Med 39(7):1507–1516
49. Beitzel K, Mazzocca AD (2014) Open anatomic reconstruction of chronic acromioclavicular instability. Oper Orthop Traumatol 26(3):237–244. doi:10.1007/s00064-013-0277-9 **(Epub 2014 Jun 14)**
50. Wellmann M, Zantop T, Petersen W (2007) Minimally invasive coracoclavicular ligament augmentation with a flip button/polydioxanone repair for treatment of total acromioclavicular joint dislocation. Arthroscopy 23:1132.e1-5
51. Baumgarten KM, Altchek DW, Cordasco FA (2006) Arthroscopically assisted acromioclavicular joint reconstruction. Arthroscopy 22:228.e1–228.e6

9

BIBLIOGRAFÍA

9 Bibliografía

1. Mazzocca AD, Arciero RA, Bicos J. Evaluation and treatment of acromioclavicular joint injuries. *Am J Sports Med*. 2007;35(2):316-329. doi:10.1177/0363546506298022.

2. Murena L, Canton G, Vulcano E, Cherubino P. Scapular dyskinesis and SICK scapula syndrome following surgical treatment of type III acute acromioclavicular dislocations. *Knee Surg Sports Traumatol Arthrosc.* 2013;21(5):1146-1150. doi:10.1007/s00167-012-1959-9.

3. Phadke A, Bakti N, Bawale R, Singh B. Current concepts in management of ACJ injuries. *J Clin Orthop Trauma*. 2019;10(3):480-485. doi:10.1016/j.jcot.2019.03.020.

4. Frank RM, Cotter EJ, Leroux TS, Romeo AA. Acromioclavicular Joint Injuries: Evidence-based Treatment. *J Am Acad Orthop Surg*. 2019. doi:10.5435/JAAOS-D-17-00105 [Epub ahead of print].

5. Johansen JA, Grutter PW, McFarland EG, Petersen SA. Acromioclavicular joint injuries: indications for treatment and treatment options. *J shoulder Elb Surg*. 2011;20:70-82. doi:10.1016/j.jse.2010.10.030.

6. Rosenorn M, Pedersen EB. A comparison between conservative and operative treatment of acute acromioclavicular dislocation. *Acta Orthop*. 1974;45:50-59. doi:10.3109/17453677408989121.

7. Cardone D, Brown JN, Roberts SNJ, Saies AD, Hayes MG. Grade III acromioclavicular joint injury in Australian Rules Football. *J Sci Med Sport*. 2002;5(2):143-148.

8. Larsen E, Hede A. Treatment of acute acromioclavicular dislocation. Three different methods of treatment prospectively studied. *Acta Orthop Belg*. 1987;53(4):480-484.

9. Press J, Zuckerman JD, Gallagher M, Cuomo F. Treatment of grade III acromioclavicular separations. Operative versus nonoperative management. *Bull Hosp Jt Dis*. 1997;56(2):77-83.

10. Larsen E, Bjerg-Nielsen A, Christensen P. Conservative or surgical treatment of acromioclavicular dislocation. A prospective, controlled, randomized study. *J Bone Joint Surg Am*. 1986;68(4):552-555.

11. Bannister GC, Wallace WA, Stableforth PG, Hutson MA. The management of acute acromioclavicular dislocation. A randomised prospective controlled trial. *J Bone Joint Surg Br*. 1989;71(5):848-850.

12. Natera Cisneros L, Sarasquete Reiriz J, Abat F, Besalduch M, Monllau JC, Videla S. Acute unstable acromioclavicular joint injuries: quality of life comparison between patients managed operatively with a coracoclavicular suspension device arthroscopically placed versus patients managed non-operatively. *Eur Orthop Traumatol*. 2015;6(4):343-355. doi:10.1007/s12570-015-0326-y.

13. Galpin RD, Hawkins RJ, Grainger RW. A comparative analysis of operative versus nonoperative treatment of grade III acromioclavicular separations. *Clin Orthop Relat Res*. 1985;(193):150-155.

14. Jacobs B, Wade PA. Acromioclavicular-joint injury. An end-result study. *J Bone Joint Surg Am*. 1966;48(3):475-486.

15. Calvo E, López-Franco M, Arribas IM. Clinical and radiologic outcomes of surgical and conservative treatment of type III acromioclavicular joint injury. *J shoulder Elb Surg*. 2006;15(3):300-305. doi:10.1016/j.jse.2005.10.006.

16. MacDonald PB, Alexander MJ, Frejuk J, Johnson GE. Comprehensive functional analysis of shoulders following complete acromioclavicular separation. *Am J Sports Med*. 1988;16(5):475-480. doi:10.1177/036354658801600508.

17. Taft TN, Wilson FC, Oglesby JW. Dislocation of the acromioclavicular joint. An end-result study. *J Bone Joint Surg Am*. 1987;69(7):1045-1051.

18. Gstettner C, Tauber M, Hitzl W, Resch H. Rockwood type III acromioclavicular dislocation: Surgical versus conservative treatment. *J Shoulder Elb Surg*. 2008;17(2):220-225. doi:10.1016/j.

jse.2007.07.017.

19. Walsh WM, Peterson DA, Shelton G, Neumann RD. Shoulder strength following acromioclavicular injury. *Am J Sports Med*. 1985;13(3):153-158. doi:10.1177/036354658501300302.

20. Bakalim G, Wilppula E. Surgical or conservative treatment of total dislocation of the acromioclavicular joint. *Acta Chir Scand*. 1975;141(1):43-47.

21. Jensen G, Katthagen JC, Alvarado LE, Lill H, Voigt C. Has the arthroscopically assisted reduction of acute AC joint separations with the double tight-rope technique advantages over the clavicular hook plate fixation? *Knee Surg Sports Traumatol Arthrosc*. 2014;22(2):422-430. doi:10.1007/s00167-012-2270-5.

22. Arrigoni P, Brady PC, Zottarelli L, *et al*. Associated lesions requiring additional surgical treatment in grade 3 acromioclavicular joint dislocations. *Arthroscopy*. 2014;30(1):6-10. doi:10.1016/j.arthro.2013.10.006.

23. Salzmann GM, Walz L, Buchmann S, Glabgly P, Venjakob A, Imhoff AB. Arthroscopically assisted 2-bundle anatomical reduction of acute acromioclavicular joint separations. *Am J Sports Med*. 2010;38(6):1179-1187. doi:10.1177/0363546509355645.

24. Lee SJ, Nicholas SJ, Akizuki KH, McHugh MP, Kremenic IJ, Ben-Avi S. Reconstruction of the Coracoclavicular Ligaments with Tendon Grafts: a comparative biomechanical study. *Am J Sports Med*. 2003;31(5):648-654. doi:10.1177/03635465030310050301.

25. Rios CG, Arciero RA, Mazzocca AD. Anatomy of the Clavicle and Coracoid Process for Reconstruction of the Coracoclavicular Ligaments. *Am J Sports Med*. 2007;35(5):811-817. doi:10.1177/0363546506297536.

26. Walz L, Salzmann GM, Fabbro T, Eichhorn S, Imhoff AB. The anatomic reconstruction of acromioclavicular joint dislocations using 2 TightRope devices: a biomechanical study. *Am J Sports Med*. 2008;36(12):2398-2406. doi:10.1177/0363546508322524.

27. Lafosse L, Baier GP, Leuzinger J. Arthroscopic Treatment of Acute and Chronic Acromioclavicular Joint Dislocation. *Arthrosc J Arthrosc Relat Surg*. 2005;21(8):1017.e1-1017.e8. doi:10.1016/j.arthro.2005.05.034.

28. Weinstein DM, McCann PD, McIlveen SJ, Flatow EL, Bigliani LU. Surgical Treatment of Complete Acromioclavicular Dislocations. *Am J Sports Med*. 1995;23(3):324-331. doi:10.1177/036354659502300313.

29. Natera L, Reiriz JS, Abat F. Anatomic reconstruction of chronic coracoclavicular ligament tears: Arthroscopic-assisted approach with nonrigid mechanical fixation and graft augmentation. *Arthrosc Tech*. 2014;3(5). doi:10.1016/j.eats.2014.06.014.

30. LaPrade RF, Hilger B. Coracoclavicular ligament reconstruction using a semitendinosus graft for failed acromioclavicular separation surgery. *Arthroscopy*. 2005;21(10):1277. doi:10.1016/j.arthro.2005.07.020.

31. Beitzel K, Obopilwe E, Apostolakos J, *et al*. Rotational and translational stability of different methods for direct acromioclavicular ligament repair in anatomic acromioclavicular joint reconstruction. *Am J Sports Med*. 2014;42(9):2141-2148. doi:10.1177/0363546514538947.

32. Saier T, Venjakob AJ, Minzlaff P, *et al*. Value of additional acromioclavicular cerclage for horizontal stability in complete acromioclavicular separation: a biomechanical study. *Knee Surg Sports Traumatol Arthrosc*. 2015;23(5):1498-1505. doi:10.1007/s00167-014-2895-7.

33. Dawson PA, Adamson GJ, Pink MM, *et al*. Relative contribution of acromioclavicular joint capsule and coracoclavicular ligaments to acromioclavicular stability. *J shoulder Elb Surg*. 2009;18(2):237-244. doi:10.1016/j.jse.2008.08.003.

34. Scheibel M, Dröschel S, Gerhardt C, Kraus N. Arthroscopically Assisted Stabilization of Acute High-Grade Acromioclavicular Joint Separations. *Am J Sports Med*. 2011;39(7):1507-1516. doi:10.1177/0363546511399379.

35. Rockwood Jr CA, Williams Jr GR YD. Disorders of the acromioclavicular joint. In: Rockwood Jr CA, Matsen 3rd FA, eds. In: The Shoulder. Philadelphia: WB Saunders. In: ; 1998:483-553.

36. Bontempo NA, Mazzocca AD. Biomechanics and treatment of acromioclavicular and sternoclavicular joint injuries. *Br J Sports Med*. 2010;44(5):361-369. doi:10.1136/bjsm.2009.059295.

37. Tiurina T V. [Age-related characteristics of the human acromioclavicular joint]. *Arkh Anat Gistol Embriol*. 1985;89(11):75-81.

38. Renfree KJ, Wright TW. Anatomy and biomechanics of the acromioclavicular and sternoclavicular joints. *Clin Sports Med*. 2003;22(2):219-237.

39. DePalma AF. Surgical anatomy of acromioclavicular and sternoclavicular joints. *Surg Clin North Am*. 1963;43:1541-1550.

40. Salter EG, Nasca RJ, Shelley BS. Anatomical observations on the acromioclavicular joint and supporting ligaments. *Am J Sports Med*. 1987;15(3):199-206. doi:10.1177/036354658701500301.

41. Tillmann B, Peterson W. Clinical Anatomy. In: Fu FH, Ticker JB, Imhoff AB, editors. Analysis of shoulder surgery. Stanford (CT): Appleton and Lange; 1998:1–29.

42. Heers G, Götz J, Schubert T, *et al*. MR imaging of the intraarticular disk of the acromioclavicular joint: a comparison with anatomical, histological and in-vivo findings. *Skeletal Radiol*. 2007;36(1):23-28. doi:10.1007/s00256-006-0181-6.

43. DePalma AF, Callery G, Bennett GA. Variational anatomy and degenerative lesions of the shoulder joint. *Instr Course Lcet*. 1949;6:255-281.

44. Blotter RH, Bruckner JD. Gouty arthropathy of the acromioclavicular joint. *Am J Orthop (Belle Mead NJ)*. 1995;24(11):859-860.

45. Cooper AM, Hayward C, Williams BD. Calcium pyrophosphate deposition disease--involvement of the acromioclavicular joint with pseudocyst formation. *Br J Rheumatol*. 1993;32(3):248-250.

46. Lehtinen JT, Lehto MU, Kaarela K, Kautiainen HJ, Belt EA, Kauppi MJ. Radiographic joint space in rheumatoid acromioclavicular joints: a 15 year prospective follow-up study in 74 patients. *Rheumatology (Oxford)*. 1999;38(11):1104-1107.

47. Zimmermann B, Erickson AD, Mikolich DJ. Septic acromioclavicular arthritis and osteomyelitis in a patient with acquired immunodeficiency syndrome. *Arthritis Rheum*. 1989;32(9):1175-1178.

48. Klassen J, Morrey BF, Ann KN. Surgical anatomy and the function of the acromioclavicular and coracoclavicular ligaments. *Oper Tech Sports Med* 1997;5(2):60–4.

49. Shaffer BS. Painful conditions of the acromioclavicular joint. *J Am Acad Orthop Surg*. 7(3):176-188.

50. Saccomanno MF, DE Ieso C, Milano G. Acromioclavicular joint instability: anatomy, biomechanics and evaluation. *Joints*. 2(2):87-92.

51. Nuber, Bowen. Acromioclavicular Joint Injuries and Distal Clavicle Fractures. *J Am Acad Orthop Surg*. 1997;5(1):11-18.

52. Fukuda K, Craig E V, An KN, Cofield RH, Chao EY. Biomechanical study of the ligamentous system of the acromioclavicular joint. *J Bone Joint Surg Am*. 1986;68(3):434-440.

53. Stine IA, Vangsness CT. Analysis of the capsule and ligament insertions about the acromioclavicular joint: a cadaveric study. *Arthroscopy*. 2009;25(9):968-974. doi:10.1016/j.arthro.2009.04.072.

54. Bosworth BM. Complete acromioclavicular dislocation. *N Engl J Med*. 1949;241(6):221-225. doi:10.1056/NEJM194908112410601.

55. Bonsell S, Pearsall AW, Heitman RJ, Helms CA, Major NM, Speer KP. The relationship of age, gender, and degenerative changes observed on radiographs of the shoulder in asymptomatic individuals. *J Bone Joint Surg Br*. 2000;82(8):1135-1139.

56. Harris RI, Vu DH, Sonnabend DH, Goldberg JA, Walsh WR. Anatomic variance of the coracoclavicular ligaments. *J Shoulder Elb Surg*. 2001;10(6):585-588. doi:10.1067/mse.2001.118480.

57. Cho BP, Kang HS. Articular Facets of the Coracoclavicular Joint in Koreans. *Cells Tissues Organs*. 1998;163(1):56-62. doi:10.1159/000046446.

58. Boehm TD, Kirschner S, Fischer A, Gohlke F. The relation of the coracoclavicular ligament insertion to the acromioclavicular jointA cadaver study of relevance to lateral clavicle resection. *Acta Orthop Scand*. 2003;74(6):718-721. doi:10.1080/00016470310018261.

59. Renfree KJ, Riley MK, Wheeler D, Hentz JG, Wright TW. Ligamentous anatomy of the distal clavicle. *J shoulder Elb Surg*. 12(4):355-359. doi:10.1016/mse.2003.S1058274603000296.

60. Salzmann GM, Paul J, Sandmann GH, Imhoff AB, Schöttle PB. The Coracoidal Insertion of the Coracoclavicular Ligaments. *Am J Sports Med*. 2008;36(12):2392-2397. doi:10.1177/0363546508322887.

61. Debski RE, Parsons IM, Woo SL, Fu FH. Effect of capsular injury on acromioclavicular joint mechanics. *J Bone Joint Surg Am*. 2001;83-A(9):1344-1351.

62. Branch TP, Burdette HL, Shahriari AS, Carter FM, Hutton WC. The Role of the Acromioclavicular Ligaments and the Effect of Distal Clavicle Resection. *Am J Sports Med*. 1996;24(3):293-297. doi:10.1177/036354659602400308.

63. Costic RS, Vangura A, Fenwick JA, Rodosky MW, Debski RE. Viscoelastic behavior and structural properties of the coracoclavicular ligaments. *Scand J Med Sci Sports*. 2003;13(5):305-310.

64. Mazzocca AD, Spang JT, Rodriguez RR, *et al*. Biomechanical and Radiographic Analysis of Partial Coracoclavicular Ligament Injuries. *Am J Sports Med*. 2008;36(7):1397-1402. doi:10.1177/0363546508315200.

65. Debski RE, Parsons IM, Fenwick J, Vangura A. Ligament mechanics during three degree-of-freedom motion at the acromioclavicular joint. *Ann Biomed Eng*. 2000;28(6):612-618.

66. Yoo YS, Tsai AG, Ranawat AS, *et al*. A Biomechanical Analysis of the Native Coracoclavicular Ligaments and Their Influence on a New Reconstruction Using a Coracoid Tunnel and Free Tendon Graft. *Arthrosc J Arthrosc Relat Surg*. 2010;26(9):1153-1161. doi:10.1016/j.arthro.2009.12.031.

67. Beim GM, Warner JJP. Clinical and radiographic evaluation of the acromioclavicular joint. *Oper Tech Sports Med* 1997;5(2):65–71.

68. *Wulker N. Applied Biomechanics. In: Fu FH, Ticker JB, Imhoff AB, Editors. Atlas of Shoulder Surgery. Stanford (CT): Appleton and Lange*;1998:30–52.

69. Beitzel K, Mazzocca AD, Bak K, *et al*. ISAKOS upper extremity committee consensus statement on the need for diversification of the Rockwood classification for acromioclavicular joint injuries. *Arthroscopy*. 2014;30(2):271-278. doi:10.1016/j.arthro.2013.11.005.

70. Bradley JP, Tibone JE. Open treatment of complete acromioclavicular dislocations. Oper Tech Sports Med 1997;5(2):88–92.

71. Rolf O, Hann von Weyhern A, Ewers A, Boehm TD, Gohlke F. Acromioclavicular dislocation Rockwood III-V: results of early versus delayed surgical treatment. *Arch Orthop Trauma Surg*. 2008;128(10):1153-1157. doi:10.1007/s00402-007-0524-3.

72. von Heideken J, Boström Windhamre H, Une-Larsson V, Ekelund A. Acute surgical treatment of acromioclavicular dislocation type V with a hook plate: superiority to late reconstruction. *J shoulder Elb Surg*. 2013;22(1):9-17. doi:10.1016/j.jse.2012.03.003.

73. Mignani G, Rotini R, Olmi R, Marchiodi L, Veronesi CA. The surgical treatment of Rockwood grade III acromioclavicular dislocations. *Chir Organi Mov*. 87(3):153-161.

74. Dumontier C, Sautet A, Man M, Apoil A. Acromioclavicular dislocations: treatment by coracoacromial ligamentoplasty. *J shoulder Elb Surg*. 4(2):130-134.

75. Natera Cisneros L, Sarasquete Reiriz J. Unstable acromioclavicular joint injuries: Is there really a difference between surgical management in the acute or chronic setting? *J Orthop*. 2017;14(1). doi:10.1016/j.jor.2016.10.011.

76. Cisneros LN, Reiriz JS. Management of acute unstable acromioclavicular joint injuries. *Eur J Orthop Surg Traumatol*. 2016;26(8):817-830. doi:10.1007/s00590-016-1836-1.

77. Cisneros LN, Reiriz JS. Management of chronic unstable acromioclavicular joint injuries. *J Orthop Traumatol*. 2017;18(4):305-318. doi:10.1007/s10195-017-0452-0.

78. Sim E, Schwarz N, Höcker K, Berzlanovich A. Repair of complete acromioclavicular separations using the acromioclavicular-hook plate. *Clin Orthop Relat Res*. 1995;(314):134-142.

79. Gille J, Heinrichs G, Unger A, *et al*. Arthroscopic-assisted hook plate fixation for acromioclavicular joint dislocation. *Int Orthop*. 2013;37(1):77-82. doi:10.1007/s00264-012-1691-6.

80. Warth RJ, Martetschläger F, Gaskill TR, Millett PJ. Acromioclavicular joint separations. Curr Rev Musculoskelet Med. 2013;6(1):71-78. doi:10.1007/s12178-012-9144-9.

81. Rolla PR, Surace MF, Murena L. Arthroscopic treatment of acute acromioclavicular joint dislocation. *Arthrosc J Arthrosc Relat Surg*. 2004;20(6):662-668. doi:10.1016/j.arthro.2004.03.012.

82. Phemister PB. The treatment of dislocation of the acromioclavicular joint by open reduction and threaded wire fixation. J Bone Joint Surg 1942;24:166-8.

83. Shin S-J, Kim N-K. Complications after arthroscopic coracoclavicular reconstruction using a single adjustable-loop-length suspensory fixation device in acute acromioclavicular joint dislocation. *Arthroscopy*. 2015;31(5):816-824. doi:10.1016/j.arthro.2014.11.013.

84. Patzer T, Clauss C, Kühne CA, *et al*. [Arthroscopically assisted reduction of acute acromioclavicular joint separations: comparison of clinical and radiological results of single versus double TightRopeTM technique]. *Unfallchirurg*. 2013;116(5):442-450. doi:10.1007/s00113-011-2135-2.

85. Cisneros LN, Reiriz JS. Management of unstable distal third clavicle fractures: clinical and radiological outcomes of the arthroscopy-assisted conoid ligament reconstruction and fracture cerclage with sutures. *Eur J Orthop Surg Traumatol*. 2017;27(3):373-380. doi:10.1007/s00590-017-1925-9.

86. Cisneros LN, Reiriz JS. Arthroscopic-Assisted Management of Unstable Distal-Third Clavicle Fractures: Conoid Ligament Reconstruction and Fracture Cerclage With Sutures. *Arthrosc Tech*. 2015;4(6):e655-e661. doi:10.1016/j.eats.2015.07.010.

87. Venjakob AJ, Salzmann GM, Gabel F, *et al*. Arthroscopically assisted 2-bundle anatomic reduction of acute acromioclavicular joint separations: 58-month findings. *Am J Sports Med*. 2013;41(3):615-621. doi:10.1177/0363546512473438.

88. Abat F, Sarasquete J, Natera LG, *et al*. Biomechanical analysis of acromioclavicular joint dislocation repair using coracoclavicular suspension devices in two different configurations. *J Orthop Traumatol*. 2015;16(3). doi:10.1007/s10195-015-0346-y.

89. Shoji H, Roth C, Chuinard R. Bone block transfer of coracoacromial ligament in acromioclavicular injury. *Clin Orthop Relat Res*. 1986;(208):272-277.

90. Weaver JK, Dunn HK. Treatment of acromioclavicular injuries, especially complete acromioclavicular separation. *J Bone Joint Surg Am*. 1972;54(6):1187-1194.

91. Boström Windhamre HA, von Heideken JP, Une-Larsson VE, Ekelund AL. Surgical treatment of chronic acromioclavicular dislocations: A comparative study of Weaver-Dunn augmented with PDS-braid or hook plate. *J Shoulder Elb Surg*. 2010;19(7):1040-1048. doi:10.1016/j.jse.2010.02.006.

92. Shin S-J, Yun Y-H, Yoo JD. Coracoclavicular ligament reconstruction for acromioclavicular dislocation using 2 suture anchors and coracoacromial ligament transfer. *Am J Sports Med*. 2009;37(2):346-351. doi:10.1177/0363546508324968.

93. Liu H-H, Chou Y-J, Chen C-H, Chia W-T, Wong C-Y. Surgical Treatment of Acute Acromioclavicular Joint Injuries Using a Modified Weaver-Dunn Procedure and Clavicular Hook Plate. *Orthopedics*. 2010;33(8). doi:10.3928/01477447-20100625-10.

94. Deshmukh A V, Wilson DR, Zilberfarb JL, Perlmutter GS. Stability of acromioclavicular joint reconstruction: biomechanical testing of various surgical techniques in a cadaveric model. *Am J Sports Med*. 2004;32(6):1492-1498. doi:10.1177/0363546504263699.

95. Carofino BC, Mazzocca AD. The anatomic coracoclavicular ligament reconstruction: Surgical technique and indications. *J Shoulder Elb Surg*. 2010;19(2):37-46. doi:10.1016/j.jse.2010.01.004.

96. Yoo Y-S, Seo Y-J, Noh K-C, Patro BP, Kim D-Y. Arthroscopically assisted anatomical coracoclavicular ligament reconstruction using tendon graft. *Int Orthop*. 2011;35(7):1025-1030. doi:10.1007/s00264-010-1124-3.

97. Fraschini G, Ciampi P, Scotti C, Ballis R, Peretti GM. Surgical treatment of chronic acromioclavicular dislocation: comparison between two surgical procedures for anatomic reconstruction. *Injury*. 2010;41(11):1103-1106. doi:10.1016/j.injury.2010.09.023.

98. Mares O, Luneau S, Staquet V, Beltrand E, Bousquet P-J, Maynou C. Acute grade III and IV acromioclavicular dislocations: outcomes and pitfalls of reconstruction procedures using a synthetic ligament. Orthop Traumatol Surg Res. 2010;96(7):721-726. doi:10.1016/j.otsr.2010.06.004.

99. Berson BL, Gilbert MS, Green S. Acromioclavicular dislocations: treatment by transfer of the conjoined tendon and distal end of the coracoid process to the clavicle. *Clin Orthop Relat Res*. 1978;(135):157-164.

100. Bailey RW, Metten CF, O'Connor GA, Titus PD, Baril JD, Moosman DA. A dynamic method of repair for acute and chronic acromioclavicular disruption. *Am J Sports Med*. 1976;4(2):58-71. doi:10.1177/036354657600400203.

101. Snyder SJ, Banas MP, Karzel RP. The arthroscopic Mumford procedure: an analysis of results. *Arthroscopy*. 1995;11(2):157-164.

102. Pauly S, Kraus N, Greiner S, Scheibel M. Prevalence and pattern of glenohumeral injuries among acute high-grade acromioclavicular joint instabilities. *J shoulder Elb Surg*. 2013;22(6):760-766. doi:10.1016/j.jse.2012.08.016.

103. Michlitsch MG, Adamson GJ, Pink M, Estess A, Shankwiler JA, Lee TQ. Biomechanical comparison of a modified Weaver-Dunn and a free-tissue graft reconstruction of the acromioclavicular joint complex. *Am J Sports Med*. 2010;38(6):1196-1203. doi:10.1177/0363546509361160.

104. Grutter PW, Petersen SA. Anatomical acromioclavicular ligament reconstruction: a biomechanical comparison of reconstructive techniques of the acromioclavicular joint. *Am J Sports Med*. 2005;33(11):1723-1728. doi:10.1177/0363546505275646.

105. Tauber M, Gordon K, Koller H, Fox M, Resch H. Semitendinosus tendon graft versus a modified Weaver-Dunn procedure for acromioclavicular joint reconstruction in chronic cases: a prospective comparative study. *Am J Sports Med*. 2009;37(1):181-190. doi:10.1177/0363546508323255.

106. Soslowsky LJ, An CH, Johnston SP, Carpenter JE. Geometric and mechanical properties of the coracoacromial ligament and their relationship to rotator cuff disease. *Clin Orthop Relat Res*. 1994;(304):10-17.

107. Cisneros LN, Sarasquete Reiriz J, Besalduch M, *et al*. Horizontal and Vertical Stabilization of Acute Unstable Acromioclavicular Joint Injuries Arthroscopy-Assisted. *Arthrosc Tech*. 2015;4(6):e721-9. doi:10.1016/j.eats.2015.07.014.

108. Natera L, Sarasquete Reiriz J, Abat F. Anatomic reconstruction of chronic coracoclavicular ligament tears: arthroscopic-assisted approach with nonrigid mechanical fixation and graft augmentation. *Arthrosc Tech*. 2014;3(5):e583-8. doi:10.1016/j.eats.2014.06.014.

109. Wellmann M, da Silva G, Lichtenberg S, Magosch P, Habermeyer P. Instability pattern of acromioclavicular joint dislocations type Rockwood III: relevance of horizontal instability. *Orthopade*. 2013;42(4):271-277. doi:10.1007/s00132-013-2085-1.

110. Beitzel K, Mazzocca AD. Open anatomic reconstruction of chronic acromioclavicular instability. *Oper Orthop Traumatol*. 2014;26(3):237-244. doi:10.1007/s00064-013-0277-9.

111. Cisneros LN, Reiriz JS. Prevalence of remaining horizontal instability in high-grade acromioclavicular joint injuries surgically managed. *Eur J Orthop Surg Traumatol*. 2017;27(3):323-333. doi:10.1007/s00590-016-1898-0.

112. Wellmann M, Zantop T, Petersen W. Minimally invasive coracoclavicular ligament augmentation with a flip button/polydioxanone repair for treatment of total acromioclavicular joint dislocation. *Arthroscopy*. 2007;23(10):1132.e1-5. doi:10.1016/j.arthro.2006.12.015.

113. Baumgarten KM, Altchek DW, Cordasco FA. Arthroscopically assisted acromioclavicular joint reconstruction. *Arthroscopy*. 2006;22(2):228.e1-228.e6. doi:10.1016/j.arthro.2005.12.026.

114. Jerosch J, Filler T, Peuker E, Greig M, Siewering U. Which stabilization technique corrects anatomy best in patients with AC-separation? An experimental study. *Knee Surg Sports Traumatol Arthrosc*. 1999;7(6):365-372. doi:10.1007/s001670050182.

115. Guttmann D, Paksima NE, Zuckerman JD. Complications of treatment of complete acromioclavicular joint dislocations. *Instr Course Lect*. 2000;49:407-413.

116. Woodmass JM, Esposito JG, Ono Y, *et al*. Complications following arthroscopic fixation of acromioclavicular separations: a systematic review of the literature. *Open access J Sport Med*. 2015;6:97-107. doi:10.2147/OAJSM.S73211.

117. Modi CS, Beazley J, Zywiel MG, Lawrence TM, Veillette CJH. Controversies relating to the management of acromioclavicular joint dislocations. *Bone Joint J*. 2013;95-B(12):1595-1602. doi:10.1302/0301-620X.95B12.31802.

118. Milewski MD, Tompkins M, Giugale JM, Carson EW, Miller MD, Diduch DR. Complications related to anatomic reconstruction of the coracoclavicular ligaments. *Am J Sports Med*. 2012;40(7):1628-1634. doi:10.1177/0363546512445273.

119. Cook JB, Shaha JS, Rowles DJ, Bottoni CR, Shaha SH, Tokish JM. Early failures with single clavicular transosseous coracoclavicular ligament reconstruction. *J shoulder Elb Surg*. 2012;21(12):1746-1752. doi:10.1016/j.jse.2012.01.018.

120. Gumina S, Carbone S, Postacchini F. Scapular Dyskinesis and SICK Scapula Syndrome in Patients With Chronic Type III Acromioclavicular Dislocation. *Arthrosc J Arthrosc Relat Surg*. 2009;25(1):40-45. doi:10.1016/j.arthro.2008.08.019.

121. Burkhart SS, Morgan CD, Kibler W Ben. The disabled throwing shoulder: spectrum of pathology Part III: The SICK scapula, scapular dyskinesis, the kinetic chain, and rehabilitation. *Arthroscopy*. 19(6):641-661.

122. Carbone S, Postacchini R, Gumina S. Scapular dyskinesis and SICK syndrome in patients with a chronic type III acromioclavicular dislocation. Results of rehabilitation. *Knee Surg Sports Traumatol Arthrosc*. 2015;23(5):1473-1480. doi:10.1007/s00167-014-2844-5.

123. Beitzel K, Cote MP, Apostolakos J, *et al*. Current Concepts in the Treatment of Acromioclavicular Joint Dislocations. *Arthrosc J Arthrosc Relat Surg*. 2013;29(2):387-397. doi:10.1016/j.arthro.2012.11.023.

124. Uhl TL, Kibler W Ben, Gecewich B, Tripp BL. Evaluation of Clinical Assessment Methods for Scapular Dyskinesis. *Arthrosc J Arthrosc Relat Surg*. 2009;25(11):1240-1248. doi:10.1016/j.arthro.2009.06.007.

125. Kibler WB, Uhl TL, Maddux JWQ, Brooks P V., Zeller B, McMullen J. Qualitative clinical evaluation of scapular dysfunction: A reliability study. *J Shoulder Elb Surg*. 2002;11(6):550-556. doi:10.1067/mse.2002.126766.

126. Natera-Cisneros L, Sarasquete-Reiriz J, Escolà-Benet A, Rodriguez-Miralles J. Acute high-grade acromioclavicular joint injuries treatment: Arthroscopic non-rigid coracoclavicular fixation provides better quality of life outcomes than hook plate ORIF. *Orthop Traumatol Surg Res*. 2016;102(1):31-39. doi:10.1016/j.otsr.2015.10.007.

127. Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. *Clin Orthop Relat Res*. 1987;(214):160-164.

128. Costic RS, Labriola JE, Rodosky MW, Debski RE. Biomechanical rationale for development of anatomical reconstructions of coracoclavicular ligaments after complete acromioclavicular joint dislocations. *Am J Sports Med*. 2004;32(8):1929-1936.

129. Tauber M, Koller H, Hitzl W, Resch H. Dynamic Radiologic Evaluation of Horizontal Instability in Acute Acromioclavicular Joint Dislocations. *Am J Sports Med*. 2010;38(6):1188-1195. doi:10.1177/0363546510361951.

130. Jari R, Costic RS, Rodosky MW, Debski RE. Biomechanical function of surgical procedures for acromioclavicular joint dislocations. *Arthrosc J Arthrosc Relat Surg*. 2004;20(3):237-245. doi:10.1016/j.arthro.2004.01.011.

131. Kim YS, Yoo Y-S, Jang SW, Nair AV, Jin H, Song H-S. In vivo analysis of acromioclavicular joint motion after hook plate fixation using three-dimensional computed tomography. *J shoulder Elb Surg*. 2015;24(7):1106-1111. doi:10.1016/j.jse.2014.12.012.

132. Hoffler CE, Karas SG. Transacromial erosion of a locked subacromial hook plate: case report and review of literature. *J shoulder Elb Surg*. 2010;19(3):e12-5. doi:10.1016/j.jse.2009.10.019.

133. Chiang C-L, Yang S-W, Tsai M-Y, Kuen-Huang Chen C. Acromion osteolysis and fracture after hook plate fixation for acromioclavicular joint dislocation: a case report. *J shoulder Elb Surg*. 2010;19(4):e13-5. doi:10.1016/j.jse.2009.12.005.

134. Bahk MS, Kuhn JE, Galatz LM, Connor PM, Williams GR. Acromioclavicular and sternoclavicular injuries and clavicular, glenoid, and scapular fractures. *Instr Course Lect*. 2010;59:209-226.

135. Nadarajah R, Mahaluxmivala J, Amin A, Goodier DW. Clavicular hook–plate: complications of retaining the implant. *Injury*. 2005;36(5):681-683. doi:10.1016/j.injury.2004.08.010.

136. Allemann F, Halvachizadeh S, Waldburger M, *et al*. Different treatment strategies for acromioclavicular dislocation injuries: a nationwide survey on open/minimally invasive and arthroscopic concepts. *Eur J Med Res*. 2019;24(1):18. doi:10.1186/s40001-019-0376-7.

137. Canadian Orthopaedic Trauma Society. Multicenter Randomized Clinical Trial of Nonoperative Versus Operative Treatment of Acute Acromio-Clavicular Joint Dislocation. *J Orthop Trauma*. 2015;29(11):479-487. doi:10.1097/BOT.0000000000000437.

138. Lin H-Y, Wong P-K, Ho W-P, Chuang T-Y, Liao Y-S, Wong C-C. Clavicular hook plate may induce subacromial shoulder impingement and rotator cuff lesion--dynamic sonographic evaluation. *J Orthop Surg Res*. 2014;9(1):6. doi:10.1186/1749-799X-9-6.

139. Kienast B, Thietje R, Queitsch C, Gille J, Schulz AP, Meiners J. Mid-term results after operative treatment of rockwood grade III-V acromioclavicular joint dislocations with an AC-hook-plate. *Eur J Med Res*. 2011;16(2):52-56.

140. Andreani L, Bonicoli E, Parchi P, Piolanti N, Michele L. Acromio-clavicular repair using two different techniques. *Eur J Orthop Surg Traumatol*. 2014;24(2):237-242. doi:10.1007/s00590-013-1186-1.

141. Cohen G, Boyer P, Pujol N, Hamida Ferjani B, Massin P, Hardy P. Endoscopically assisted reconstruction of acute acromioclavicular joint dislocation using a synthetic ligament. Outcomes at 12 months. *Orthop Traumatol Surg Res*. 2011;97(2):145-151. doi:10.1016/j.otsr.2010.10.004.

142. Boileau P, Gastaud O, Wilson A, Trojani C, Bronsard N. All-Arthroscopic Reconstruction of Severe Chronic Acromioclavicular Joint Dislocations. *Arthroscopy*. 2019;35(5):1324-1335. doi:10.1016/j.arthro.2018.11.058.

143. Lim TK, Oh WK. Intraoperative and Postoperative Complications after Arthroscopic Coracoclavicular Stabilization. *Clin Orthop Surg*. 2019;11(1):103. doi:10.4055/cios.2019.11.1.103.

144. Thangaraju S, Tauber M, Habermeyer P, Martetschläger F. Clavicle and coracoid process periprosthetic fractures as late post-operative complications in arthroscopically assisted acromioclavicular joint stabilization. *Knee Surgery, Sport Traumatol Arthrosc*. 2019. doi:10.1007/s00167-019-05482-7. [Epub ahead of print].

145. Wellmann M, Zantop T, Weimann A, Raschke MJ, Petersen W. Biomechanical evaluation of minimally invasive repairs for complete acromioclavicular joint dislocation. *Am J Sports Med*. 2007;35(6):955-961. doi:10.1177/0363546506298585.

146. Martetschläger F, Buchholz A, Sandmann G, *et al*. Acromioclavicular and coracoclavicular PDS augmentation for complete AC joint dislocation showed insufficient properties in a cadaver model. *Knee Surg Sports Traumatol Arthrosc*. 2013;21(2):438-444. doi:10.1007/s00167-012-2067-6.

147. Natera Cisneros L, Santiago Boccolini H, Sarasquete Reiriz J. Tratamiento de la inestabilidad acromioclavicular crónica mediante reconstrucción coracoclavicular anatómica con aloinjerto tendinoso: resultados preliminares en 10 casos. *Rev Española Artrosc y Cirugía Articul*. 2016;23(2):87-95. doi:10.1016/j.reaca.2016.08.001.

148. Kraus N, Hann C, Minkus M, Maziak N, Scheibel M. Primary versus revision arthroscopically-assisted acromio- and coracoclavicular stabilization of chronic AC-joint instability. *Arch Orthop Trauma Surg*. February 2019. doi:10.1007/s00402-019-03153-3.

149. Yeak RD, Daud H, Nizlan NM. Osteomyelitis post acromioclavicular joint reconstruction. *Chinese J Traumatol*. April 2019. doi:10.1016/j.cjtee.2019.03.004. [Epub ahead of print].

150. Hobusch GM, Fellinger K, Schoster T, Lang S, Windhager R, Sabeti-Aschraf M. Ultrasound of horizontal instability of the acromioclavicular joint. *Wien Klin Wochenschr*. 2019;131(3-4):81-86. doi:10.1007/s00508-018-1433-x.

151. Aliberti GM, Kraeutler MJ, Trojan JD, Mulcahey MK. Horizontal Instability of the Acromioclavicular Joint: A Systematic Review. *Am J Sports Med*. 2019:036354651983101. doi:10.1177/0363546519831013. [Epub ahead of print].

152. Irlenbusch U. Examination techniques of the shoulder—expert's evaluation based on literature analysis. *Obere Extrem*. 2012;7(1):61.

153. Alexander O. Radiography of the acromioclavicular articulation. *Med Radiogr Photogr*. 1954;30(34):39.

154. Lädermann A, Grosclaude M, Lübbeke A, *et al*. Acromioclavicular and coracoclavicular cerclage reconstruction for acute acromioclavicular joint dislocations. *J Shoulder Elb Surg*. 2011;20(3):401-408. doi:10.1016/j.jse.2010.08.007.

155. Gerhardt C, Kraus N, Greiner S, Scheibel M. Arthroscopic stabilization of acute acromioclavicular joint dislocation. *Orthopade*. 2011;40(1):61-69. doi:10.1007/s00132-010-1680-7.

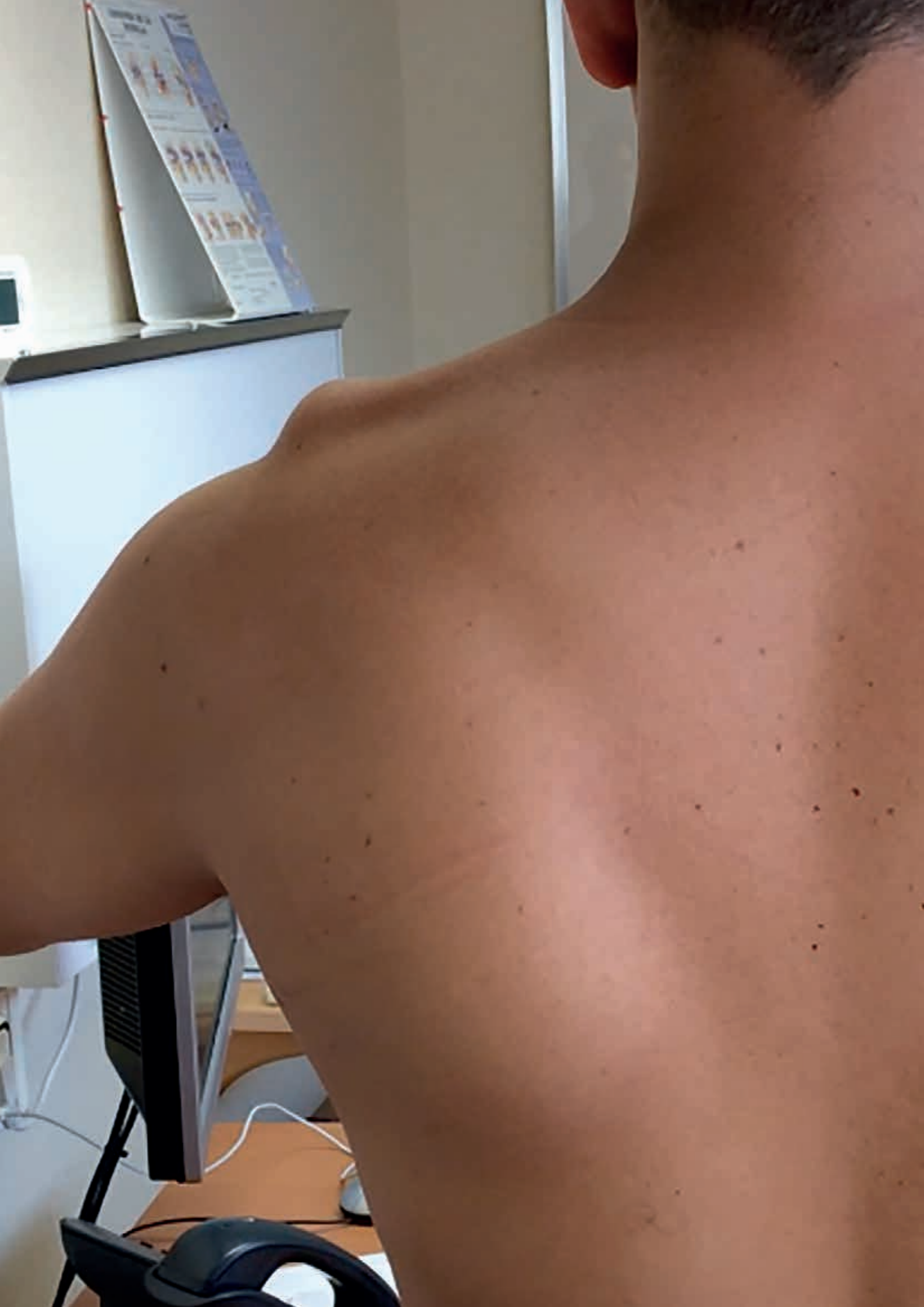
156. Braun S, Imhoff AB, Martetschläger F. Arthroscopically assisted techniques for treatment of acute and chronic acromioclavicular joint injuries. *Unfallchirurg*. 2015;118(5):407-414. doi:10.1007/s00113-015-0004-0.

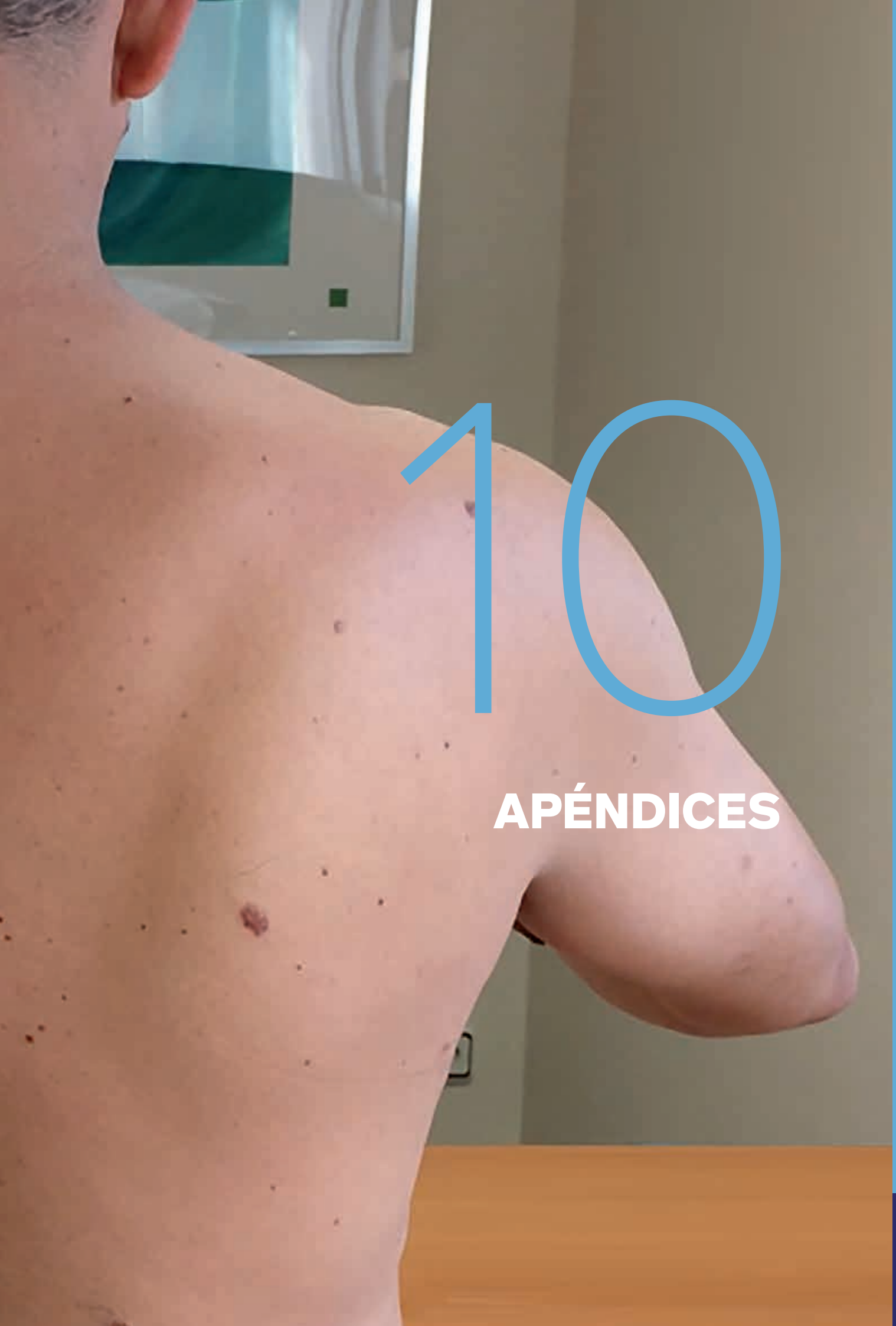
157. Li H, Wang C, Wang J, Wu K, Hang D. Restoration of horizontal stability in complete acromioclavicular joint separations: surgical technique and preliminary results. *Eur J Med Res*. 2013;18(1):42. doi:10.1186/2047-783X-18-42.

158. Beitzel K, Obopilwe E, Apostolakos J, *et al*. Rotational and Translational Stability of Different Methods for Direct Acromioclavicular Ligament Repair in Anatomic Acromioclavicular Joint Reconstruction. *Am J Sports Med*. 2014;42(9):2141-2148. doi:10.1177/0363546514538947.

159. Hislop P, Sakata K, Ackland DC, Gotmaker R, Evans MC. Acromioclavicular Joint Stabilization: A Biomechanical Study of Bidirectional Stability and Strength. *Orthop J Sport Med*. 2019;7(4):232596711983675. doi:10.1177/2325967119836751.

160. Jeong JY, Yoo Y-S, Lee S-J, Im W. Arthroscopic Coracoclavicular Fixation Technique Using Multiple All-Suture Anchors. *Arthrosc Tech*. 2019;8(4):e423-e427. doi:10.1016/j.eats.2018.12.002.





10

APÉNDICES

10 Apéndices

10.1 Comité de ética

10.1.1 Conformidad dirección centro

HOSPITAL DE LA SANTA CREU I SANT PAU

Sant Antoni Mª Claret, 167 - 08025 Barcelona
Tel. 93 291 90 00 - Fax 93 291 94 27
e-mail: santpau.ib@santpau.cat
www.santpau.cat

CONFORMIDAD DE LA DIRECCIÓN DEL CENTRO

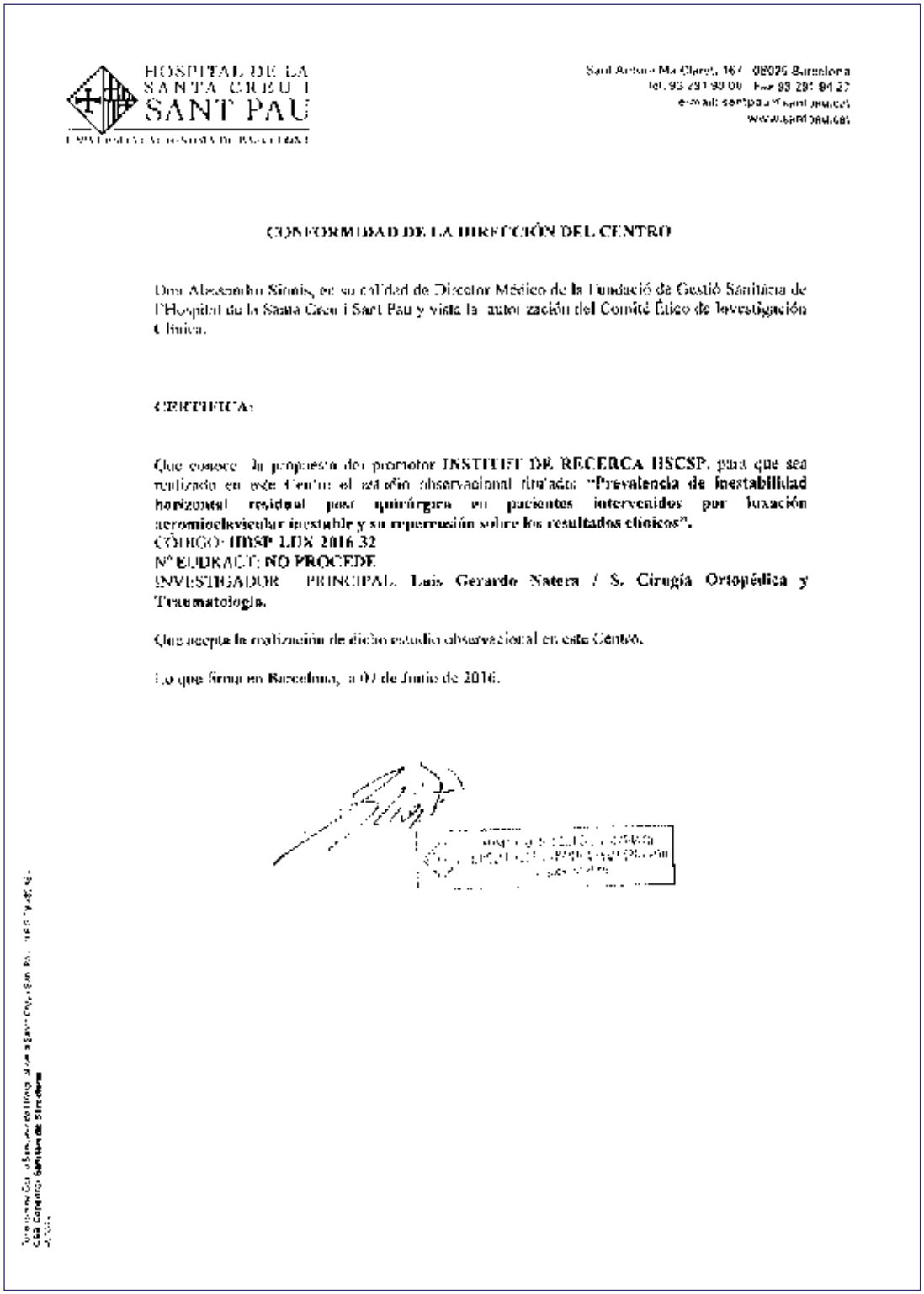
Doña Gemma Craywinckel Martí, en su calidad de Directora Médica de la Fundació de Gestió Sanitària de l'Hospital de la Santa Creu i Sant Pau y vista la autorización del Comité Ético de Investigación Clínica,

CERTIFICA:

Que conoce la propuesta del investigador principal, **Dr. L. Natera** del servicio de **COT** para llevar a cabo el proyecto de investigación titulado **"Rotura de los ligamentos coracoclaviculares: trascendencia clínica y estrategias anatómicas de reparación"** y que acepta la realización de dicho estudio en este Centro.

Lo que firma en Barcelona, a 18 de Febrero de 2014.

10.1.2 Conformidad dirección centro



HOSPITAL DE LA SANTA CREU I SANT PAU

Sant Antoni Ma Claret, 167 · 08025 Barcelona
tel. 93 291 90 00 · fax 93 291 94 23
e-mail: sampau@sant.pau.cat
www.santpau.cat

CONFORMIDAD DE LA DIRECCIÓN DEL CENTRO

Dra Alexandra Simis, en su calidad de Director Médico de la Fundació de Gestió Sanitària de l'Hospital de la Santa Creu i Sant Pau y vista la autorización del Comité Ético de Investigación Clínica.

CERTIFICA:

Que conoce la propuesta del promotor **INSTITUT DE RECERCA HSCSP**, para que sea realizado en este Centro el estudio observacional titulado: **"Prevalencia de inestabilidad horizontal residual post quirúrgica en pacientes intervenidos por luxación acromioclavicular inestable y su repercusión sobre los resultados clínicos".**
CÓDIGO: **IIHSP LDX 2016 32**
Nº EUDRACT: **NO PROCEDE**
INVESTIGADOR PRINCIPAL: **Luis Gerardo Natera / S. Cirugía Ortopédica y Traumatología.**

Que acepta la realización de dicho estudio observacional en este Centro.

Lo que firma en Barcelona, a 07 de Junio de 2016.

10.1.3 Dictamen del comité ético de investigación clínica 1

HOSPITAL DE LA SANTA CREU I SANT PAU
UNIVERSITAT AUTÒNOMA DE BARCELONA

Sant Antoni Ma Claret, 167 · 08025 Barcelona
Tel. 93 291 90 00 - Fax 93 291 94 27
e-mail: santpau@santpau.cat
www.santpau.cat

COMITÉ ÉTICO DE INVESTIGACIÓN CLÍNICA

TÍTULO: Rotura de los ligamentos coracoclaviculares: trascendencia clínica y estrategias anatómicas de reparación	
CÓDIGO CEIC: **09/2014**	CÓDIGO DEL ENSAYO: **IIBSP-ROT-2014-003**
IP: **Dr. L. Natera**	SERVICIO: **COT**

Doña **Milagros Alonso Martínez**, Secretaria del Comité Ético de Investigación Clínica del Hospital de la Santa Cruz y San Pablo,

CERTIFICA:

Que en su reunión de fecha 11 de Febrero de 2014 este Comité ha analizado el proyecto de investigación de referencia y considera que se ajusta a las disposiciones vigentes.

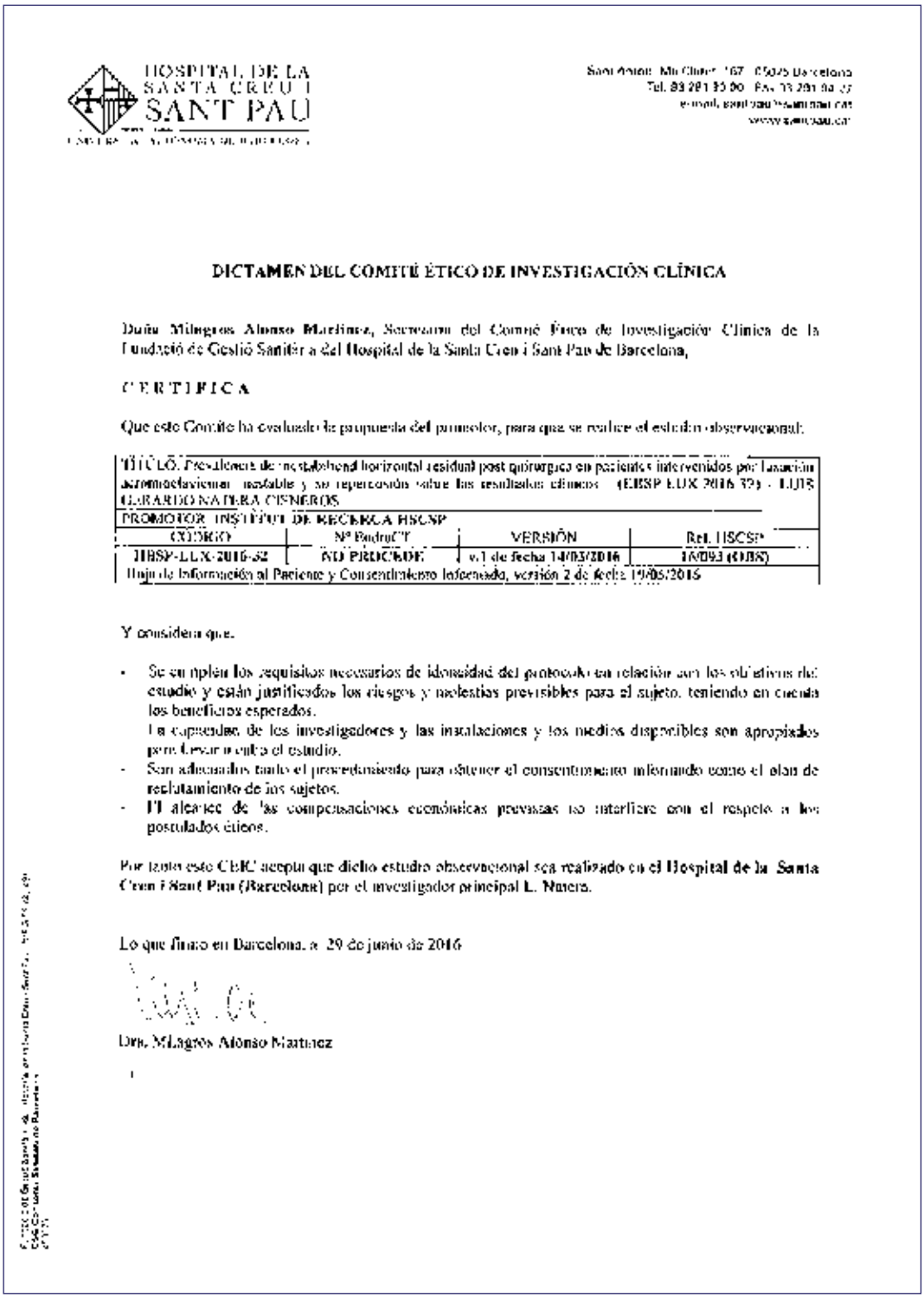
Por ello, ha acordado informar favorablemente sobre su realización.

Y para que así conste, firma el presente en Barcelona, a 17 de Febrero de 2014.

FUNDACIÓ DE GESTIÓ SANITÀRIA DE L'HOSPITAL DE LA SANTA CREU I SANT PAU
COMITÈ ÉTIC D'INVESTIGACIÓ CLÍNICA

Dra. Milagros Alonso Martínez

10.1.4 Dictamen del comité ético de investigación clínica 2



HOSPITAL DE LA SANTA CREU I SANT PAU

Sant Quintí, 89 · 08026 Barcelona
Tel. 93 291 90 00 · Fax 93 291 90 19
e-mail: ceic@santpau.cat
www.santpau.cat

DICTAMEN DEL COMITÉ ÉTICO DE INVESTIGACIÓN CLÍNICA

Doña Milagros Alonso Martínez, Secretaria del Comité Ético de Investigación Clínica de la Fundació de Gestió Sanitària del Hospital de la Santa Creu i Sant Pau de Barcelona,

C E R T I F I C A

Que este Comité ha evaluado la propuesta del promotor, para que se realice el estudio observacional:

TÍTULO: Pseudoartrosis de reconstrucción horizontal residual post quirúrgica en pacientes intervenidos por luxación acromioclavicular inestable y su repercusión sobre los resultados clínicos (HSP-LUX-2016-32) - LUIS GERARDO NATERA CISNEROS			
PROMOTOR: INSTITUT DE RECERCA HSCSP			
CÓDIGO	Nº EudraCT	VERSIÓN	Ref. HSCSP
HSP-LUX-2016-32	NO PROCEDE	v.1 de fecha 14/03/2016	16/093 (OIDS)
Hoja de Información al Paciente y Consentimiento Informado, versión 2 de fecha 19/05/2015			

Y considera que:

- Se cumplen los requisitos necesarios de idoneidad del protocolo en relación con los objetivos del estudio y están justificados los riesgos y molestias previsibles para el sujeto, teniendo en cuenta los beneficios esperados.
  La capacidad de los investigadores y las instalaciones y los medios disponibles son apropiados para llevar a cabo el estudio.
- Son adecuados tanto el procedimiento para obtener el consentimiento informado como el plan de reclutamiento de los sujetos.
- El alcance de las compensaciones económicas previstas no interfiere con el respeto a los postulados éticos.

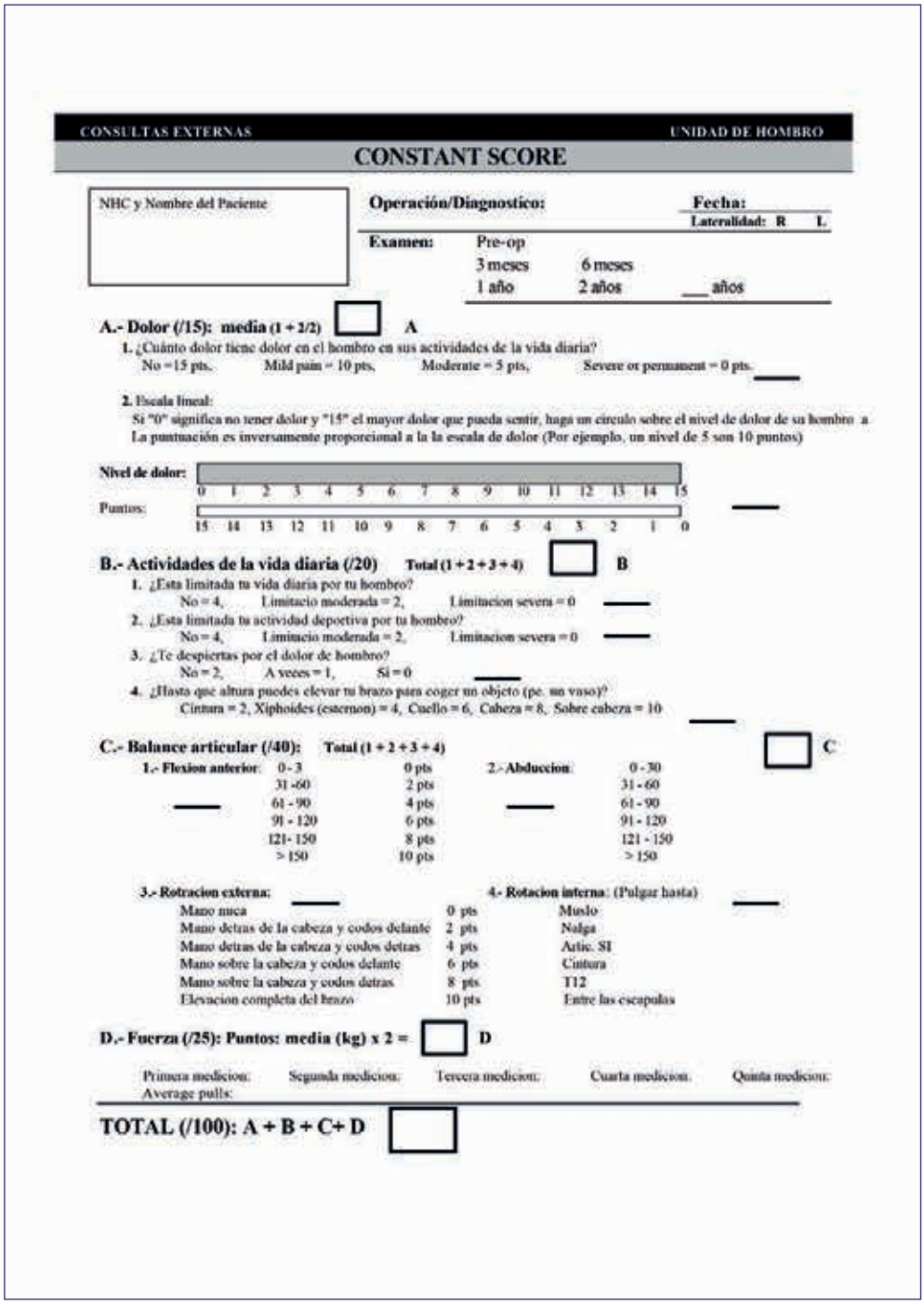
Por tanto este CEIC acepta que dicho estudio observacional sea realizado en el Hospital de la Santa Creu i Sant Pau (Barcelona) por el investigador principal L. Natera.

Lo que firmo en Barcelona, a 29 de junio de 2016

Dra. Milagros Alonso Martínez

10.2 Cuestionarios

10.2.1 Test de Constant



CONSULTAS EXTERNAS — UNIDAD DE HOMBRO

CONSTANT SCORE

NHC y Nombre del Paciente

Operación/Diagnostico: **Fecha:**

Lateralidad: R L

Examen: Pre-op 3 meses 6 meses 1 año 2 años ___ años

A.- Dolor (/15): media (1 + 2/2) ☐ **A**

1. ¿Cuánto dolor tiene dolor en el hombro en sus actividades de la vida diaria?
   No = 15 pts. Mild pain = 10 pts. Moderate = 5 pts. Severe or permanent = 0 pts. ___

2. Escala lineal:
   Si "0" significa no tener dolor y "15" el mayor dolor que pueda sentir, haga un circulo sobre el nivel de dolor de su hombro a
   La puntuación es inversamente proporcional a la la escala de dolor (Por ejemplo, un nivel de 5 son 10 puntos)

Nivel de dolor: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Puntos: 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 ___

B.- Actividades de la vida diaria (/20) **Total (1 + 2 + 3 + 4)** ☐ **B**

1. ¿Esta limitada tu vida diaria por tu hombro?
   No = 4, Limitacio moderada = 2, Limitacion severa = 0 ___
2. ¿Esta limitada tu actividad depoctiva por tu hombro?
   No = 4, Liminacio moderada = 2, Limitacion severa = 0 ___
3. ¿Te despiertas por el dolor de hombro?
   No = 2, A veces = 1, Si = 0 ___
4. ¿Hasta que altura puedes elevar tu brazo para coger un objeto (pe. un vaso)?
   Cintura = 2, Xiphoides (esternon) = 4, Cuello = 6, Cabeza = 8, Sobre cabeza = 10 ___

C.- Balance articular (/40): **Total (1 + 2 + 3 + 4)** ☐ **C**

1.- Flexion anterior			**2.- Abduccion**	
___	0 - 30	0 pts	___	0 - 30
	31 - 60	2 pts		31 - 60
	61 - 90	4 pts		61 - 90
	91 - 120	6 pts		91 - 120
	121 - 150	8 pts		121 - 150
	> 150	10 pts		> 150

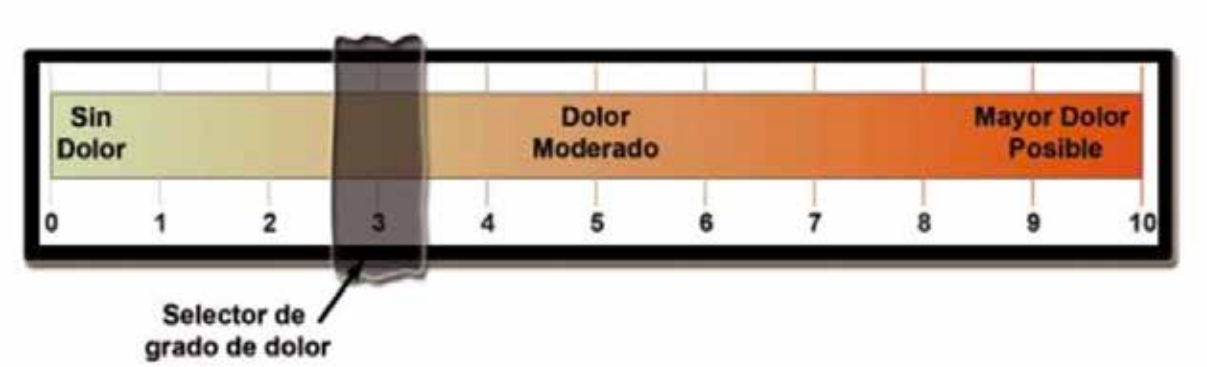
3.- Rotracion externa: ___		**4.- Rotacion interna**: (Pulgar hasta) ___
Mano nuca	0 pts	Muslo
Mano detras de la cabeza y codos delante	2 pts	Nalga
Mano detras de la cabeza y codos detras	4 pts	Artic. SI
Mano sobre la cabeza y codos delante	6 pts	Cintura
Mano sobre la cabeza y codos detras	8 pts	T12
Elevacion completa del brazo	10 pts	Entre las escapulas

D.- Fuerza (/25): Puntos: media (kg) x 2 = ☐ **D**

Primera medicion: Segunda medicion: Tercera medicion: Cuarta medicion: Quinta medicion:
Average pulls:

TOTAL (/100): A + B + C+ D ☐

10.2.2 Escala Visual Analógica (EVA)



10.2.3 Escala de Satisfacción General

En una escala de 0 a 10, donde 0 equivale a insatisfecho y 10 equivale a muy satisfecho, ¿qué tan satisfecho está usted con su hombro? (señale el número correcto)

☹ 0 1 2 3 4 5 6 7 8 9 10 ☺

Insatisfecho Satisfecho

10.2.4 SF36

11549035

Datos para el estudio

Día:	Mes:	Año: (20...)	Número identificador:
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 ☐ 13 ☐ 14 ☐ 15 ☐ 16 ☐ 17 ☐ 18 ☐ 19 ☐ 20 ☐ 21 ☐ 22 ☐ 23 ☐ 24 ☐ 25 ☐ 26 ☐ 27 ☐ 28 ☐ 29 ☐ 30 ☐ 31	☐ Enero ☐ Julio ☐ Febrero ☐ Agosto ☐ Marzo ☐ Septiembre ☐ Abril ☐ Octubre ☐ Mayo ☐ Noviembre ☐ Junio ☐ Diciembre	0 ☐☐ 1 ☐☐ 2 ☐☐ 3 ☐☐ 4 ☐☐ 5 ☐☐ 6 ☐☐ 7 ☐☐ 8 ☐☐ 9 ☐☐	0 ☐☐☐☐☐☐☐☐☐ 1 ☐☐☐☐☐☐☐☐☐ 2 ☐☐☐☐☐☐☐☐☐ 3 ☐☐☐☐☐☐☐☐☐ 4 ☐☐☐☐☐☐☐☐☐ 5 ☐☐☐☐☐☐☐☐☐ 6 ☐☐☐☐☐☐☐☐☐ 7 ☐☐☐☐☐☐☐☐☐ 8 ☐☐☐☐☐☐☐☐☐ 9 ☐☐☐☐☐☐☐☐☐

Cuestionario de Salud
SF-36 (versión 2)

Versión española de SF-36v2™ Health Survey © 1996, 2000
adaptada por J. Alonso y cols 2003.

Institut Municipal d´Investigació Mèdica (IMIM-IMAS)
Unidad de Investigación en Servicios Sanitarios
c/Doctor Aiguader, 80 E-08003 Barcelona
Tel. (+34) 93 225 75 53, Fax (+34) 93 221 40 02
www.imim.es

IMAS
Institut Municipal d'Investigació Mèdica. IMIM

Este instrumento ha superado los estándares de calidad del **Medical Outcome Trust** y de la Red Cooperativa para la Investigación en Resultados de Salud y Servicios Sanitarios (**Red IRYSS**).
El cuestionario y su material de soporte están disponibles en BiblioPRO, la biblioteca virtual de la Red IRYSS (www.rediryss.net).

11549035

Su Salud y Bienestar

Por favor conteste las siguientes preguntas. Algunas preguntas pueden parecerse a otras pero cada una es diferente.

Tómese el tiempo necesario para leer cada pregunta, y marque con una ☒ la casilla que mejor describa su respuesta.

¡Gracias por contestar a estas preguntas!

1. En general, usted diría que su salud es:

☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Excelente	Muy buena	Buena	Regular	Mala

2. ¿Cómo diría usted que es su salud actual, comparada con la de hace un año?:

Mucho mejor ahora que hace un año	Algo mejor ahora que hace un año	Más o menos igual que hace un año	Algo peor ahora que hace un año	Mucho peor ahora que hace un año
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

11549035

3. Las siguientes preguntas se refieren a actividades o cosas que usted podría hacer en un día normal. Su salud actual, ¿le limita para hacer esas actividades o cosas? Si es así, ¿cuánto?

	Sí, me limita mucho	Sí, me limita un poco	No, no me limita nada
a Esfuerzos intensos, tales como correr, levantar objetos pesados, o participar en deportes agotadores.	☐ 1	☐ 2	☐ 3
b Esfuerzos moderados, como mover una mesa, pasar la aspiradora, jugar a los bolos o caminar más de 1 hora.	☐ 1	☐ 2	☐ 3
c Coger o llevar la bolsa de la compra.	☐ 1	☐ 2	☐ 3
d Subir varios pisos por la escalera.	☐ 1	☐ 2	☐ 3
e Subir un sólo piso por la escalera.	☐ 1	☐ 2	☐ 3
f Agacharse o arrodillarse.	☐ 1	☐ 2	☐ 3
g Caminar un kilómetro o más	☐ 1	☐ 2	☐ 3
h Caminar varios centenares de metros.	☐ 1	☐ 2	☐ 3
i Caminar unos 100 metros.	☐ 1	☐ 2	☐ 3
j Bañarse o vestirse por sí mismo.	☐ 1	☐ 2	☐ 3

4. Durante las 4 últimas semanas, ¿con qué frecuencia ha tenido alguno de los siguientes problemas en su trabajo o en sus actividades cotidianas, a causa de su salud física?

	Siempre	Casi siempre	Algunas veces	Sólo alguna vez	Nunca
a ¿Tuvo que reducir el tiempo dedicado al trabajo o a sus actividades cotidianas?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
b ¿Hizo menos de lo que hubiera querido hacer?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
c ¿Tuvo que dejar de hacer algunas tareas en su trabajo o en sus actividades cotidianas?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
d ¿Tuvo dificultad para hacer su trabajo o sus actividades cotidianas (por ejemplo, le costó más de lo normal)?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

11549035

5. Durante las 4 últimas semanas, ¿con qué frecuencia ha tenido alguno de los siguientes problemas en su trabajo o en sus actividades cotidianas, a causa de algún problema emocional (como estar triste, deprimido o nervioso)?

	Siempre	Casi siempre	Algunas veces	Sólo alguna vez	Nunca
a ¿Tuvo que reducir el tiempo dedicado al trabajo o a sus actividades cotidianas por algún problema emocional?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
b ¿Hizo menos de lo que hubiera querido hacer por algún problema emocional?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
c ¿Hizo su trabajo o sus actividades cotidianas menos cuidadosamente que de costumbre, por algún problema emocional?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

6. Durante las 4 últimas semanas, ¿hasta qué punto su salud física o los problemas emocionales han dificultado sus actividades sociales habituales con la familia, los amigos, los vecinos u otras personas?

Nada	Un poco	Regular	Bastante	Mucho
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

7. ¿Tuvo dolor en alguna parte del cuerpo durante las 4 últimas semanas?

No, ninguno	Sí, muy poco	Sí, un poco	Sí, moderado	Sí, mucho	Sí, muchísimo
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6

8. Durante las 4 últimas semanas, ¿hasta qué punto el dolor le ha dificultado su trabajo habitual (incluido el trabajo fuera de casa y las tareas domésticas)?

Nada	Un poco	Regular	Bastante	Mucho
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

SF-36 v2.0
4 / 7

11549035

9. Las preguntas que siguen se refieren a cómo se ha sentido y cómo le han ido las cosas durante las 4 últimas semanas. En cada pregunta responda lo que se parezca más a cómo se ha sentido usted. Durante las últimas 4 semanas ¿con qué frecuencia...

	Siempre	Casi siempre	Algunas veces	Sólo alguna vez	Nunca
a se sintió lleno de vitalidad?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
b estuvo muy nervioso?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
c se sintió tan bajo de moral que nada podía animarle?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
d se sintió calmado y tranquilo?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
e tuvo mucha energía?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
f se sintió desanimado y deprimido?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
g se sintió agotado?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
h se sintió feliz?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
i se sintió cansado?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

10. Durante las 4 últimas semanas, ¿con qué frecuencia la salud física o los problemas emocionales le han dificultado sus actividades sociales (como visitar a los amigos o familiares)?

Siempre	Casi siempre	Algunas veces	Sólo alguna vez	Nunca
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

11. Por favor diga si le parece CIERTA o FALSA cada una de las siguientes frases:

	Totalmente cierta	Bastante cierta	No lo sé	Bastante falsa	Totalmente falsa
a Creo que me pongo enfermo más facilmente que otras personas	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
b Estoy tan sano como cualquiera	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
c Creo que mi salud va a empeorar	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
d Mi salud es excelente	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Gracias por contestar a estas preguntas

SF-36 v2.0
5 / 7

11549035

OBTENCIÓN AUTOMÁTICA DE LAS PUNTUACIONES DEL CUESTIONARIO

Este cuestionario ha sido diseñado con un software de captura automática de las respuestas (TeleForm®), que hace posible obtener rápidamente y sin errores una base de datos con las puntuaciones mediante lectura por escáner.

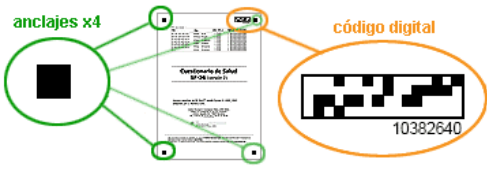
Si desea utilizar este servicio de Obtención de las puntuaciones y entrada de datos póngase en contacto con :

BiblioPRO@imim.es

MUY IMPORTANTE

Si desea utilizar este servicio **no debe realizar modificaciones** del cuestionario (la impresión debe ser clara y absolutamente fiel al documento PDF descargado).

El **código digital** y los **puntos de anclaje** (los cuatro cuadrados negros de las esquinas) deben de estar **bien definidos** para poder escanear satisfactoriamente el cuestionario. Tenga mucho cuidado con los dos cuadrados inferiores, si quedaran recortados por un error de impresión no se podría capturar la información.



Para obtener más información sobre este servicio y sus tarifas consulte la sección de "Puntuaciones" de la página principal de BiblioPRO en **www.rediryss.net**

Esta página NO es necesaria para el estudio ni para la captura de datos.
Aconsejamos no incluir ésta hoja en los cuestionarios del estudio.

SF-36 v2.0
7 / 7

10.2.5 Cuestionario de DASH

DASH

Versión Española

Instrucciones

Este cuestionario le pregunta sobre sus síntomas así como su capacidad para realizar ciertas actividades o tareas.

Por favor conteste cada pregunta basándose en su condición o capacidad durante la última semana. Para ello marque un círculo en el número apropiado.

Si usted no tuvo la oportunidad de realizar alguna de las actividades durante la última semana, por favor intente aproximarse a la respuesta que considere que sea la más exacta.

No importa que mano o brazo usa para realizar la actividad; por favor conteste basándose en la habilidad o capacidad y como puede llevar a cabo dicha tarea o actividad

Por favor puntúe su habilidad o capacidad para realizar las siguientes actividades durante la última semana. Para ello marque con un circulo el número apropiado para cada respuesta.

	Ninguna dificultad	Dificultad leve	Dificultad moderada	Mucha dificultad	Imposible de realizar
1. -Abrir un bote de cristal nuevo	1	2	3	4	5
2.-Escribir	1	2	3	4	5
3.- Girar una llave	1	2	3	4	5
4.- Preparar la comida	1	2	3	4	5
5.-Empujar y abrir una puerta pesada	1	2	3	4	5
6.-Colocar un objeto en una estantería situadas por encima de su cabeza.	1	2	3	4	5
7.-Realizar tareas duras de la casa (p. ej. fregar el piso, limpiar paredes, etc.	1	2	3	4	5
8.-Arreglar el jardín	1	2	3	4	5
9.-Hacer la cama	1	2	3	4	5
10.-Cargar una bolsa del supermercado o un maletín.	1	2	3	4	5
11.-Cargar con un objeto pesado (más de 5 Kilos)	1	2	3	4	5
12.-Cambiar una bombilla del techo o situada más alta que su cabeza.	1	2	3	4	5
13.-Lavarse o secarse el pelo	1	2	3	4	5
14.-Lavarse la espalda	1	2	3	4	5

15.- Ponerse un jersey o un suéter	1	2	3	4	5
16.-Usar un cuchillo para cortar la comida	1	2	3	4	5
17.-Actividades de entretenimiento que requieren poco esfuerzo (p. ej. jugar a las cartas, hacer punto, etc.)	1	2	3	4	5
18.-Actividades de entretenimiento que requieren algo de esfuerzo o impacto para su brazo, hombro o mano (p. ej. golf, martillear, tenis o a la petanca)	1	2	3	4	5
19.-Actividades de entretenimiento en las que se mueva libremente su brazo (p. ej. jugar al platillo "frisbee", badminton, nadar, etc.)	1	2	3	4	5
20.- Conducir o manejar sus necesidades de transporte (ir de un lugar a otro)	1	2	3	4	5
21.- Actividad sexual	1	2	3	4	5
	No, para nada	Un poco	Regular	Bastante	Mucho
22.- Durante la última semana, ¿ su problema en el hombro, brazo o mano ha interferido con sus actividades sociales normales con la familia, sus amigos, vecinos o grupos?	1	2	3	4	5

	No para nada	Un poco	Regular	Bastante limitado	Imposible de realizar
23.- Durante la última semana, ¿ha tenido usted dificultad para realizar su trabajo u otras actividades cotidianas debido a su problema en el brazo, hombro o mano?	1	2	3	4	5

Por favor ponga puntuación a la gravedad o severidad de los siguientes síntomas

	Ninguno	Leve	Moderado	Grave	Muy grave
24.-Dolor en el brazo, hombro o mano.	1	2	3	4	5
25.- Dolor en el brazo, hombro o mano cuando realiza cualquier actividad específica.	1	2	3	4	5
26.-Sensación de calambres (hormigueos y alfilerazos) en su brazo hombro o mano.	1	2	3	4	5
27.-Debilidad o falta de fuerza en el brazo, hombro, o mano.	1	2	3	4	5
28.-Rigidez o falta de movilidad en el brazo, hombro o mano.	1	2	3	4	5

	No	Leve	Moderada	Grave	Dificultad extrema que me impedía dormir
29.- Durante la última semana, ¿cuanta dificultad ha tenido para dormir debido a dolor en el brazo, hombro o mano?.	1	2	3	4	5

	Totalmente falso	Falso	No lo sé	Cierto	Totalmente cierto
30.- Me siento menos capaz, confiado o útil debido a mi problema en el brazo, hombro, o mano	1	2	3	4	5

Módulo de Trabajo (Opcional)

Las siguientes preguntas se refieren al impacto que tiene su problema del brazo, hombro o mano en su capacidad para trabajar (incluyendo las tareas de la casa sí ese es su trabajo principal)

Por favor, indique cuál es su trabajo/ocupación: _____

Yo no trabajo (usted puede pasar por alto esta sección) .

Marque con un círculo el número que describa mejor su capacidad física en la semana pasada. **¿Tuvo usted alguna dificultad...**

	Ninguna dificultad	Dificultad leve	Dificultad moderada	Mucha dificultad	Imposible
1. para usar su técnica habitual para su trabajo?	**1**	**2**	**3**	**4**	**5**
2. para hacer su trabajo habitual debido al dolor del hombro, brazo o mano?	**1**	**2**	**3**	**4**	**5**
3. para realizar su trabajo tan bien como le gustaría?	**1**	**2**	**3**	**4**	**5**
4. para emplear la cantidad habitual de tiempo en su trabajo?	**1**	**2**	**3**	**4**	**5**

Actividades especiales deportes/músicos (Opcional)

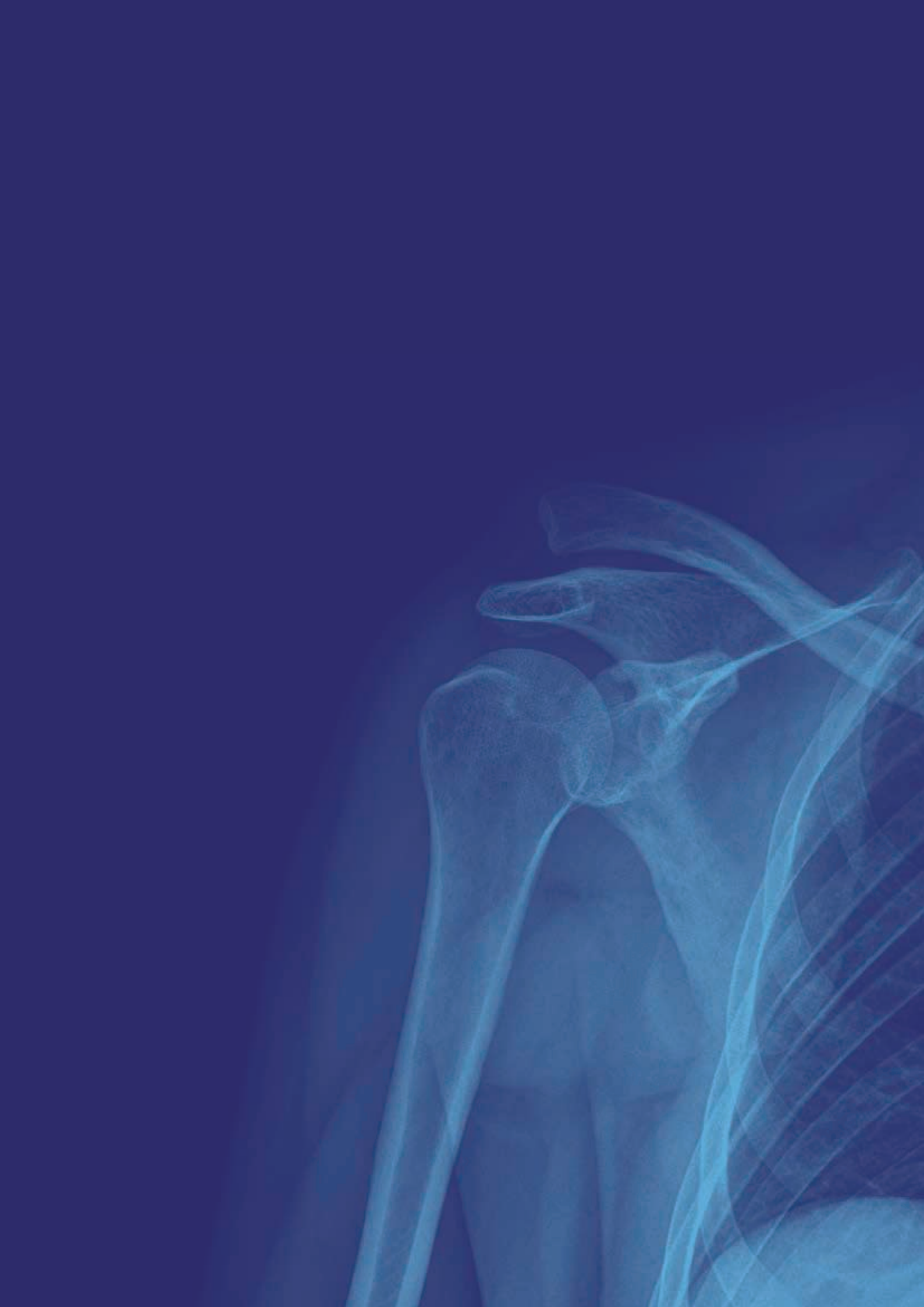
Las preguntas siguientes hacen referencia al impacto que tiene su problema en el brazo, hombro o mano para tocar su instrumento musical, practicar su deporte, o ambos. Si usted practica más de un deporte o toca más de un instrumento (o hace ambas cosas), por favor conteste con respecto a la actividad que sea más importante para usted. Por favor, indique el deporte o instrumento que sea más importante para usted.

¿Tuvo alguna dificultad.:

	Ninguna dificultad	Dificultad leve	Dificultad moderada	Mucha dificultad	Imposible
para usar su técnica habitual al tocar su instrumento o practicar su deporte?	1	2	3	4	5
para tocar su instrumento habitual o practicar su deporte debido a dolor en el brazo, hombro o mano ?	1	2	3	4	5
para tocar su instrumento o practicar su deporte tan bien como le gustaría?	1	2	3	4	5
para emplear la cantidad de tiempo habitual para tocar su instrumento o practicar su deporte?	1	2	3	4	5

Barcelona 2019

UAB
Universitat Autònoma
de Barcelona



UAB
Universitat Autònoma
de Barcelona