



Acromioclavicular Joint Dislocation Failed Fixation

4

Paul Cowling

History of Previous Primary Failed Treatment

This is the case of a 46-year-old fit and well male who sustained multiple injuries from a climbing accident out of area. He was taken by air ambulance to the local trauma centre and his injuries included a left femoral fracture, which received an immediate intramedullary nail, multiple left-sided rib fractures with bilateral pneumothoraces, a minor head injury, a thoracic spine injury requiring fixation 5 days after the accident, as well as this left shoulder acromioclavicular (ACJ) Grade V injury. Following resuscitation, he had his femur and thoracic spine stabilised within the first 48 hours. The ACJ injury had been ade-

quately visualised on plain radiographs at the time of initial injury (Fig. 4.1), and quite reasonably had been left until 14 days following the accident until surgical intervention. At that point, an open ACJ ligament reconstruction had been performed using a suture button type fixation passed around the coracoid (Fig. 4.2). Subsequently, 17 days after the accident he was repatriated to our centre for further management. Following a short hospital stay, he was discharged home 23 days following the accident.

However, over the course of the next 10 weeks, whilst he was attempting to mobilise with the aid of crutches for her femoral fracture, it was noticed that his left shoulder gradually became deformed over the superior aspect (Fig. 4.3).

P. Cowling (✉)
Department of Trauma and Orthopaedic Surgery,
Leeds Teaching Hospitals NHS Trust, Leeds, UK
e-mail: paulcowling@nhs.net

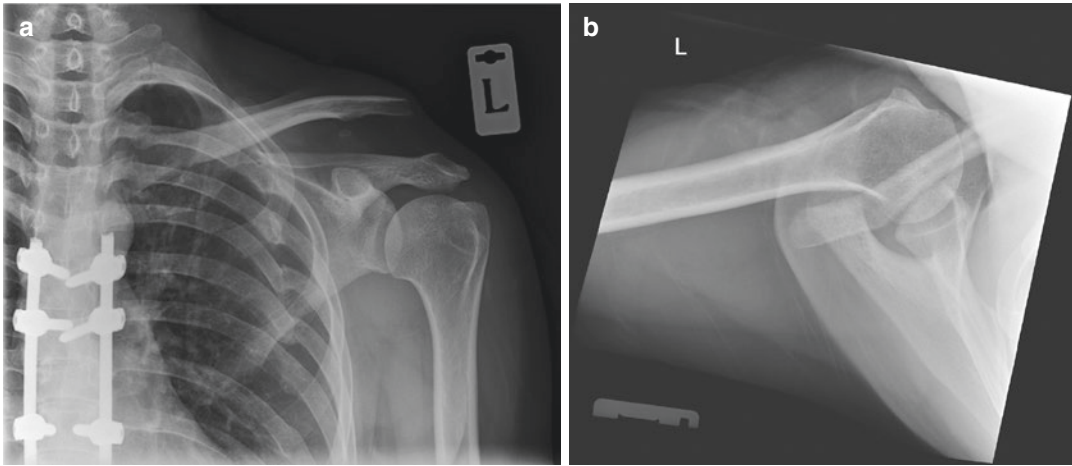


Fig. 4.1 (a) Anteroposterior (AP) and (b) axial radiographs of initial left acromioclavicular injury



Fig. 4.2 Initial AP shoulder post-operative image demonstrating acceptable reduction and fixation of the ACJ



Fig. 4.3 Plain AP left shoulder radiograph performed at 8 weeks following initial fixation, demonstrating loss of reduction of the ACJ

Evaluation of the Aetiology of Failure of Fixation

This case demonstrates failure of reconstruction over a time period of the initial 2–3 months. Consideration of the reason for failure is vitally important with these injuries, to determine the means of correction.

In this specific case, it was presumed that a suture fixation technique was performed around the coracoid, with a cortical button placed on the superior clavicle. The original position certainly seemed acceptable, and the patient described no issues in the initial phase of her rehabilitation. However, a gradual loss of position was noted by the patient, with recognition of a deformity over the ACJ with a high-riding clavicle (Fig. 4.3). Symptoms of crepitus on movement were also noted.

It was, therefore, felt that the failure in this case had been mechanical in nature, due to the patient requiring loading on the shoulder to help mobilise with crutches following his femoral fixation from the initial accident. He was still using crutches and/or a stick several weeks following the intramedullary fixation of the femur as there had been a delayed union of the femur, and it was felt this prolonged period of upper limb weight-bearing had contributed to the failure of fixation as there was no adequate time to allow ligament healing.

Clinical Examination

The clinical examination of the ACJ following surgery involves full exposure of both shoulders to compare either side. Generally, the examination progressed through the common ‘look’ ‘feel’ ‘move’ stepwise process.

The focus of any clinical examination following stabilisation of an ACJ dislocation would be on the mode of failure suspected. In the case of infection, scrutiny of the scar for any erythema, subcutaneous collection or wound breakdown is important. In this case, the scar was well healed with no signs of erythema or infection, but the

deformity that had appeared was concerning the patient.

It is then necessary to observe the ACJ itself: in this case, no acute change of position was noted, but a gradual alteration leading to an obvious prominence of the distal clavicle.

Palpation over the distal clavicle, acromion and coracoid (if possible) can determine any areas of pain, abnormal anatomy or the palpation of metalwork or other surgical implant used in the initial fixation. Tenderness over the distal clavicle or acromion may point towards inflammation, osteolysis or damage caused by fixation failure, e.g. pull-out of sutures or graft. This patient did have pain over the distal 1/3 of the clavicle, and generalised tenderness throughout the region of the ACJ as well as where the CC ligaments would be situated. As the ACJ now sits in an obviously dislocated position (Fig. 4.4), it is important to note whether the distal clavicle can be reduced: this may point towards structures damaged, such as the deltopectoral fascia. In this case, pressure over the distal clavicle, as well as



Fig. 4.4 Red arrow shows left shoulder dislocated ACJ

elevation of the arm/scapula revealed pain, demonstrated the ability to fully reduce the distal clavicle, as well as pain.

Recording of the range of movement of the arm, particularly the posture of the ACJ during movement, as well as any pain or other symptoms during motion is important. In this case, the patient demonstrated a reduction in range in abduction and flexion, which was met with intermittent crepitus over the superior aspect of the shoulder. Cross body adduction highlighted the deformity. It was difficult to assess the amount of movement in an anteroposterior direction, but it seemed more mobile than one would expect.

Finally, careful examination and documentation of the neurovascular status of the upper limb is a requirement: in the patient's case, he was fully intact.

Diagnostic-Biochemical and Radiological Investigations

In order to ascertain the nature of the failure, plain film images are required to investigate for the most frequent mechanisms of fixation failure, particularly mechanical failure and loss of reduction of the ACJ. In this case, it had become obvious that a loss of reduction had occurred on plain radiographs by 10 weeks following fixation (Fig. 4.3).

Traditionally, to image the ACJ, a standard antero-posterior clavicle view as well as a 30-degree caudal view is important. This will allow assessment of the acromioclavicular and coracoclavicular distance to determine if reduction has been lost following the previous surgery. Generally, if there is >8 mm acromioclavicular distance, and >13 mm coracoclavicular distance, there is a loss of ACJ alignment. An axillary view would allow assessment of any displacement of the clavicle posteriorly in keeping with a Rockwood IV injury. However, a Zanca view allows focussed evaluation of the ACJ and distal clavicle. This is an antero-posterior view focussing upon the distal clavicle and ACJ performed with a 10-degree cephalic tilt.

Initially, the patient elected not to proceed with further surgical intervention to the failed ACJ fixation, citing the fact that she was still struggling to mobilise on her healing left femoral fracture, so felt he would like to be more confident with this, and past the point of requiring walking aids before any form of operative intervention on his shoulder.

The patient then returned 4 weeks later, at 14 weeks following the initial fixation. At this point, he was walking freely and the femur had healed. Further radiographs were performed, unfortunately demonstrating worsening migration of the ACJ, as well as lysis around the cortical button and suture tunnel through the distal clavicle (Fig. 4.5).

With this lysis now visible, further tests were felt necessary to investigate infection as a cause for failure. Blood tests investigating infection included a white cell count ($8.9 \times 10^9/L$), C-reactive protein (76 mg/L). A computed tomography (CT) of the ACJ depicted the lysis and loss of reduction in more detail and was able to more accurately demonstrate the position of the initial fixation and suture passage through the distal clavicle (Fig. 4.6).



Fig. 4.5 Plain radiograph performed at 12 weeks following initial fixation, demonstrating worsening of the displacement along with significant lysis in the distal clavicle around the cortical button

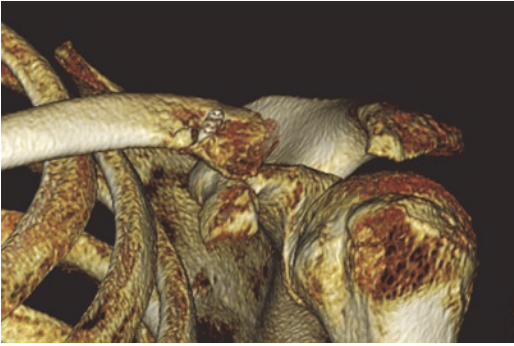


Fig. 4.6 Three-dimensional reconstruction CT images of the ACJ, demonstrating bone lysis around the cortical button and displacement of the ACJ

Preoperative Planning

From the results of the patient's investigations, it was felt that infection could have contributed to the failure of the ACJ fixation. In our institution, in such cases of infected fixation, a multidisciplinary approach is taken. Therefore, in a meeting with surgeons, microbiologists and radiologists, a surgical plan was put into place. A discussion occurred with the patient about the outcomes of the investigations, and he agreed that now was time for surgical intervention to be considered. It was felt that further delay may lead to fracture of the distal clavicle through the area of lysis, and therefore making operative intervention much more challenging.

It was decided to embark upon a two-stage process of surgical intervention. In the first stage, debridement of the ACJ would occur, removal of all surgical implants including cortical button and suture material, x5 deep tissue samples for microbiology, and curettage of the lysis of the distal clavicle. Then depending upon the microbiological sampling, a course of antibiotics would be provided to the patient for a period of 6–8 weeks, before proceeding with the second stage of fixation.

It was felt necessary to await the outcome following first-stage debridement to decide the definitive fixation technique, as it may be that due to necessary extensive debridement, several options may be required.

Revision Surgery

First-Stage Revision Surgery

The patient was positioned in a beach-chair position, with draping to allow access to the anterior and posterior areas of the ACJ. An arm support is used to be able to position the arm where required, and aid the reduction of the ACJ. The initial longitudinal incision just inferior to the distal clavicle was used to access the ACJ, with the skin edges excised. Though the author's preferred approach to the distal clavicle and ACJ is a 'sabre' type transverse incision, it was felt at only 3 months since the initial procedure that performing as new incision could compromise wound healing.

A 'deltoid turndown approach' is utilised: this is at the medial raphe between deltoid and pectoralis major, with a triangular detachment performed. This not only allows for spacious approach to the coracoid, but also for strong closure following fixation, which has been demonstrated to add further stability to the repair.

The ACJ was found dislocated, and the distal clavicle mobile. The cortical button itself was easily removed, but the attached suture passing through the clavicle and around the coracoid was more difficult to retrieve. This required dissection down to the superior aspect of the coracoid in the infra-clavicular tissue around the CC ligaments. It was found that the suture had failed within the tunnel or around the suture button, as no suture material was found within or around the button, and was all infraclavicular and still around the coracoid. Eventually all material was removed.

The lytic area of the distal clavicle was then debrided using a 3.5 mm drill and a curette. Furthermore, the distal end of the clavicle (approximately the last 5 mm) was excised using an oscillating saw in order to aid eventual reduction and fixation. Five deep tissue samples, including bone from the distal clavicle, bone from the lytic region and tissue from the infraclavicular area were sent for microbiological culture and sensitivity testing. Further debridement of the surrounding tissues, including the superior

and inferior surface of the clavicle was then undertaken, along with rigorous lavage of the surgical site. Closure of the wound with monofilament sutures was performed.

A broad-spectrum antibiotic in the form of teicoplanin was commenced following surgery. Unfortunately, after prolonged cultures, a *Cutibacterium* isolate was seen in three of the five deep tissue specimens, sensitive to clindamycin. The antibiotic regime was subsequently changed to clindamycin 450 mg 6 hourly for 6 weeks. This type of organism is most commonly found as an infective agent in upper limb surgery, and often doesn't mount a huge systemic or even local response, such as in this patient's case: the wound was dry and pristine prior to revision surgery with no obvious systemic features of infection.

Inflammatory markers were monitored throughout the patient's treatment following the first stage, along with monitoring for symptoms of diarrhoea, a side effect of this regimen, which might necessitate alternative antibiotic treatment. Imaging was also performed, noting the lytic region remodelling following debridement and antibiotic treatment (Fig. 4.7).

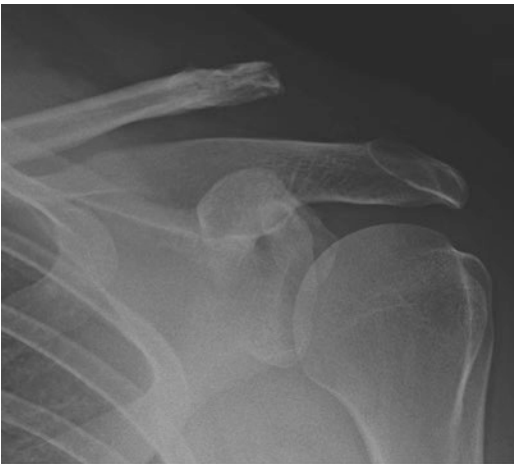


Fig. 4.7 Plain radiograph demonstrating the appearance of the ACJ following the first-stage procedure of debridement and removal of surgical implant

Second-Stage Revision Surgery

This was performed when the patient was 2 weeks following the conclusion of the 6 weeks of antibiotic management. Inflammatory markers had revealed a normal white cell count ($6.8 \times 10^9/L$) and CRP of 15 mg/L. The scar had healed well with no erythema.

The same surgical set up and approach was performed. Because it was felt that the distal clavicle lytic region around the previous suture fixation had remodelled sufficiently, a combined fixation approach was considered, using a hook plate augmented with a synthetic graft (Ligament Augmentation and Reconstruction System (LARS™) ligament, Corin, Cirencester, UK). This graft is made from polyethylene terephthalate, chosen for its good biocompatibility and biomechanical characteristics [1].

This technique was chosen as there was still concern that though the lysis had improved, there was still weakness in the distal clavicle: 'spreading the load' through this region with the fixation was deemed necessary. Furthermore, a combination of fixation would allow a 'belt and braces' to the fixation, hopefully providing rigidity in the stabilisation.

Further tissue specimens were taken for microbiology to guide any post-operative antibiotic therapy: however, the surgical site appeared pristine, and eventually proved negative for any further bacterial growth. The first part of this approach was to reduce the distal clavicle back down into the ACJ. This was performed more easily with the debridement of the distal end of the clavicle. Elevation of the arm, with downward pressure on the clavicle allowed reduction and temporary fixation using a transfixing 1.6 mm Kirschner-wire from the acromion into the distal clavicle. The LARS™ ligament was then passed around the coracoid using a side specific suture passer placed from medial to lateral close to the coracoid to prevent neurovascular injury. The drill holes for the interference screw fixation are ordinarily at the isometric points

where the conoid and trapezoid ligaments would usually be found: in this case, care was taken to provide satisfactory distance between the new drill holes and the previously used drill hole from the initial failed fixation. Luckily, as depicted on the pre-operative CT scan, the placement of the new drill holes was not too far from the intended position.

With tension on the synthetic ligament, the interference screws were tightened, ensuring good hold and stable reduction of the ACJ. The free ends of the synthetic ligament were then tied anteroinferior to the distal clavicle so as to not irritate the skin overlying the distal clavicle. The temporary reduction K-wires could now be removed as the synthetic ligament was holding the reduction.

This construct was able to hold the ACJ in a reduced position, and the stability could be assessed on the operating table. However, due to the concern of previously noted lysis through the distal clavicle, a hook plate was used to augment the repair. The difficulty with using a hook plate in addition to the synthetic ligament was positioning of the plate over the interference screws and ligament ends. As can be noted in Fig. 4.8, the plate is not flush with the distal clavicle but held well enough with three screws into the clavicle, avoiding the synthetic ligament. The hook, having been anteroinferior to the acromion, pro-



Fig. 4.8 Images following the second-stage revision using a combination of hook plate fixation, LARS™ ligament and autologous hamstring graft

vided additional support in the anteroposterior stability of the reconstructed ACJ.

The deltotrapezial fascia was closed meticulously to gain further stability around the ACJ, with wound closure performed with an absorbable suture.

Due to concern regarding the possible erosion of the acromion reported with use of a hook plate, initially the patient was restricted in post-operative activities with the physiotherapy team: full active internal and external rotation was allowed with the elbow by the side, but abduction and forward flexion was restricted to a maximum of 90 °.

The hook plate remained in situ for 3 months, before removal was performed. The ACJ has remained stable, and the patient returned to full range of motion and function in the shoulder by 6 months following the second-stage procedure.

Summary: Lessons Learned

Historically, certain methods of ACJ reconstruction have been linked to specific means of failure. However, as this case has hopefully demonstrated, infection should also never be excluded, and investigations may be required to ensure the correct diagnosis.

Early fixation methods of ACJ dislocation included the use of percutaneous insertion of a screw through the clavicle into the coracoid, with the aim of reducing the space between the coracoid and the clavicle via compression: this became eponymously known as ‘Bosworth Screw’ fixation [2]. Despite being widely accepted as the method of fixation at the time, it proved technically challenging, with studies demonstrating failure by the screw missing the coracoid, as well as late screw failure, and subluxation after screw removal [3]. It was proven that as there is movement between the coracoid and clavicle of approximately 5 °, fatigue and ultimately failure of screw fixation would eventually be inevitable with this method of treatment [4]. This necessitated a second procedure for screw removal, so essentially, patients undergoing this technique of fixation were consenting for two operations.

This was the same finding with hook plate fixation: This plate is fixed with several screws to the distal clavicle, with the 'hook' component of the plate then placed resting on the under surface of the acromion in the subacromial space, thus reducing a dislocated ACJ. However, there is high incidence of acromial erosion, necessitating a second operation for removal [5]. However, this method does provide good results with ACJ reconstruction. As we found in this case, a hook plate is also an excellent option for revision of failed fixation.

In 1972, Weaver and Dunn described a procedure involving excision of the distal clavicle, and transferring the coraco-acromial (CA) ligament, often with a small amount of acromial bone still attached to the proximal end, fixing the bone into the cut end of the distal clavicle [6]. A subsequent modification was added by Copeland to stabilise the clavicle on the acromion with an additional augmentation, often a suture, around the coracoid and over the clavicle [7]. However, it has been found that when this augmentation was performed with GORE-TEX loop or Dacron graft, an inflammatory reaction could occur, providing symptoms of persistent anterolateral shoulder pain and osteolysis of the distal clavicle [8, 9]. Other methods of failure of the Weaver-Dunn technique include failure of the CA ligament transfer to heal, leading to recurrent instability, and tunnel widening of the passage through the distal clavicle of the drill holes for suture fixation [10].

Additional more historical fixation methods involved reduction in the displaced ACJ, and fixation with two Kirschner wires passed from the acromion into the distal clavicle. This practice has largely fallen out of favour due to numerous reports of wires migrating to the lungs, spinal canal, subclavian artery and aorta [11]. It also appears within the literature that most neurovascular injuries took place due to migration of Kirschner wires or pins in early methods of ACJ stabilisation [11].

Since the Weaver-Dunn technique came to prominence, other so-called 'anatomical' reconstructions have since been described. The aim of these procedures is to reconstruct the CC

ligaments. Initial versions of this procedure used autologous graft, such as semitendinosus tendon, gracilis or toe extensor graft [12]. There are a number of specific techniques described, ranging from passing the graft around the coracoid and over the clavicle; fixing the graft into the base of the coracoid with a biotenodesis screw, then doubling it over and passing it through drill holes in the distal clavicle and using interference screws to tension and hold the graft; or passage of a doubled over graft into the coracoid via drill hole, and then through the distal clavicle and the acromion in an attempt to recreate the anatomy of the CC ligaments [13]. This is the design of the LARS™ ligament we used for the revision surgery, but it can be utilised just as well as the sole fixation in the primary repair.

Though the outcomes of these procedures are generally very good, failure of these anatomic reconstructions has been described in several ways: Lee et al. described midsubstance tears of the graft and fractures at the coracoid base [12]; Miller et al. described fracture of the distal clavicle, fracture through a more medial clavicle bone tunnel [14].

A number of recent techniques described now involve suture fixation involving either screw fixation or a cortical button, with the aim of recreating the CC ligaments. This use of synthetic material to pass either around or through the coracoid and then around or through the clavicle to reduce and stabilise an ACJ dislocation has gained popularity as the synthetic ligament reconstruction has been shown to have good tensile strength, promotes tissue ingrowth and avoids sacrifice of the native coracoacromial ligament for reconstruction [15]. Such reconstructions have produced excellent outcomes, with few complications [16, 17], but in the few failures noted in the literature, the most commonly reported is suture breakage or the suture button migrating through the coracoid [13]. In the case of our patient, the primary failure was with suture breakage at the clavicle side rather than the coracoid, coupled with infection.

Arthroscopic ACJ stabilisations or arthroscopically assisted stabilisations have also increased in recent years. The arthroscopic portion of the

procedure is described as allowing for accurate placement of the drill hole through the coracoid base for button placement. It has also been stated that performing a diagnostic arthroscopy of the glenohumeral joint at the time of ACJ stabilisation may allow for other procedures to be performed: it has been shown that high-grade ACJ dislocations can be associated with traumatic concomitant glenohumeral joint pathology in up to 15% of cases [18]. Various specific techniques have been described, but with such a new and evolving surgical technique, description of outcomes and failures in the literature are limited. That said, some of the published studies noted early failure caused by cutting of the suture loop through the cortex of the clavicle, with eccentric drilling through the anterior cortex thought to be one of the important causes. Partial loss of reduction was seen with clavicular osteolysis associated with the clavicular button [19]. A review of complications following arthroscopic fixation of ACJ separations found residual shoulder/ACJ pain or hardware irritation occurred at a rate of 26.7%. The rate of coracoid/clavicle fracture was 5.3% and occurred most commonly with techniques utilising bony tunnels. Loss of AC joint reduction occurred in 26.8% of patients [20].

In conclusion, many types of ACJ dislocation do not require surgical intervention at the time of initial injury. However, when surgery is indicated, failure of fixation is rare. In some cases, despite this failure, re-operation may not be mandatory. In cases where surgical intervention in the presence of fixation failure is required, the technique required will depend upon the mode of failure. The most common salvage procedure is the use of either a synthetic graft or an autologous tendon graft to recreate the CC ligaments, to which a hook plate may be used as an augment if there is concern about bone stock or the hold of any graft.

References

1. Trieb K, Blahovec H, Brand G, et al. In vivo and in vitro cellular ingrowth into a new generation of artificial ligaments. *Eur Surg Res.* 2004;24:148–51.
2. Bosworth BM. Complete acromioclavicular dislocation. *N Engl J Med.* 1949;241:221–5.
3. Tsou P. Percutaneous cannulated screw coracoclavicular fixation for acute acromioclavicular dislocations. *Clin Orthop.* 1989;243:112–21.
4. Rockwood CA Jr. Injuries to the acromioclavicular joint. In: Rockwood Jr CA, Groom DP, editors. *Fractures in adults.* 2nd ed. Philadelphia PA: JB Lippincott; 1984. p. 860–910.
5. Sim E, Schwarz N, Hocker K, et al. Repair of complete acromioclavicular separations using the acromioclavicular-hook plate. *Clin Orthop.* 1995;314:134–42.
6. Weaver JK, Dunn HK. Treatment of acromioclavicular injuries, especially complete acromioclavicular separations. *JBJS.* 1972;54-A:1187.
7. Copeland S. *Operative shoulder surgery.* New York: Churchill Livingstone; 1995.
8. Jones HP, Lemos MJ, Schepesis AA. Salvage of failed acromioclavicular joint reconstruction using autogenous semitendinosus tendon from the knee. *Am J Sports Med.* 2001;29:234–7.
9. Jones HP, Lemus MJ, Schepesis AA. Salvage of failed acromioclavicular joint reconstruction using autogenous semitendinosus tendon from the knee. Surgical technique and case report. *Am J Sports Med.* 2001;29(2):234–7.
10. Tauber M, Eppel M, Resch H. Acromioclavicular reconstruction using autogenous semitendinosus tendon graft: results of revision surgery in chronic cases. *J Shoulder Elb Surg.* 2007;16:429–33.
11. Lemos MJ, Tolo ET. Complications of the treatment of the acromioclavicular and sternoclavicular joint injuries, including instability. *Clin Sports Med.* 2003;22:371–85.
12. Lee SJ, Nicholas SJ, Akizuki KH, et al. Reconstruction of the coracoclavicular ligaments with tendon grafts. *Am J Sports Med.* 2003;31:648–54.
13. Geaney LE, Miller MD, Ticker JB, et al. Management of the failed AC joint reconstruction: causation and treatment. *Sports Med Arthrosc Rev.* 2010;18:167–72.
14. Turman KA, Miller CD, Miller MD. Clavicular fracture following anatomic coracoclavicular ligament reconstruction with tendon graft: a report of 3 cases. *J Bone Joint Surg Am.* 2010;96(2):1526–32.
15. Jeon I-H, et al. Chronic acromioclavicular separation: the medium term results of coracoclavicular ligament reconstruction using braided polyester prosthetic ligament. *Injury.* 2007;38(11):1247–53.
16. Wright J, et al. Stabilisation for the disrupted acromioclavicular joint using a braided polyester prosthetic ligament. *J Orthop Surg (Hong Kong).* 2015;23(2):223–8.
17. Younis F, et al. Operative versus non-operative treatment of grade III acromioclavicular joint dislocations and the use of SurgiLig: a retrospective review. *Ortop Traumatol Rehabil.* 2017;19(6):523–30.
18. Pauly S, et al. Prevalence of concomitant intraarticular lesions in patients treated operatively for high-

- grade acromioclavicular joint separations. *Knee Surg Sports Traumatol Arthrosc.* 2009;17(5):513–5.
19. Zhang L-F, et al. Arthroscopic fixation of acute acromioclavicular joint disruption with TightRope™: outcome and complications after minimum 2 (2e5) years follow-up. *J Orthop Surg.* 2017;25(2):230949901668449.
20. 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;10(6):97–107.