Treatment of Acute Traumatic Acromioclavicular Dislocations

23

Ettore Taverna, Vincenzo Guarrella,
and Riccardo D'Ambrosi

23.1 Etiology

Injuries to the acromioclavicular joint (ACJ) account for approximately 9–12 % of those to the shoulder girdle seen in clinical practice [1]. This is likely to be an underestimate of their true prevalence, since patients with minor sprains may not seek medical attention. Overall, AC dislocations represent 12 % of all dislocations of the shoulder girdle and 8 % of all joint dislocations in the body [2, 3, 7–9]. Most patients were younger than 35 years with a gender distribution of 8:1 in favor of men [3–9]. Sports activities are a common cause of ACJ injuries, especially alpine skiing, ice hockey, football, and rugby (32–40 % of shoulder injuries) [3, 4]. AC joint dislocation is also often diagnosed after road traffic accidents and fall on the side of the body.

23.2 Injury Mechanism

The most frequent injury usually involves a direct blow to the lateral aspect of the shoulder with the arm in an adducted position, leading to downward displacement of the scapula opposed by impaction of the clavicle onto the first rib [5]. The inherent strength and stability of the sternoclavicular joint transfers energy to both the acromioclavicular (AC) and coracoclavicular (CC) ligaments [10] (Fig. 23.1). The force initially injures the acromioclavicular ligaments. The CC ligament is one of the strongest ligaments in the body. As the force perpetuates, further energy is transmitted to the coracoclavicular ligaments, resulting in greater displacement of the clavicle with reference to the acromion. The acromioclavicular capsule ligamentous structures are first to fail with consecutive loading of the CC ligaments. Complete ACJ dislocations are defined as combined AC and CC ligament disruption leaving the deltoid and trapezoid muscle attachments as last restraints against the applied forces. A major injury will lead to further transmission of force and disruption of the deltoid and trapezius muscles, as the lateral end of the clavicle herniates through it [11], leading to high-degree ACJ instabilities.

Indirect mechanisms of ACJ injuries are rare. A fall on to the adducted arm leads to a pushing force of the humeral head upward against the inferior aspect of the acromion. The resulting forces create a wide spectrum of ACJ injuries including inferior displacement of the clavicle beneath the coracoid process (type VI dislocation according to the classification of Rockwood [12]).

Fig. 23.1 Coracoclavicular ligaments: conoid ligament – located medial, coned or *triangular in shape*. Runs from the posterior medial aspect of the coracoid process to the posterior conoid tubercle in the clavicle. Responsible for restraining superior–inferior displacements. Trapezoid ligament – located lateral, *quadrilateral in shape*. Runs from the coracoid process shaft oblique and superior–lateral to the anterior–lateral clavicle trapezoid ridge. Responsible for resisting compressive forces and lateral displacement of the clavicle

E. Taverna • V. Guarrella • R. D'Ambrosi (✉)
U.O. Chirurgia della Spalla II, Istituto Ortopedico Galeazzi,
Via R. Galeazzi 4, Milan 20161, Italy
e-mail: taverna@shoulder.it; vguarrella@hotmail.com; riccardo.dambrosi@hotmail.it

P. Volpi (ed.), *Arthroscopy and Sport Injuries: Applications in High-level Athletes*,
DOI 10.1007/978-3-319-14815-1_23, © Springer International Publishing Switzerland 2016

23.3 Clinical and Diagnostic Examination

A detailed history including the mechanism of injury, location and duration of pain, and associated symptoms is vital to diagnosing an AC joint injury.

An accurate clinical evaluation may be difficult and painful in the acute setting. It is important to examine the patient in a sitting or standing position, allowing the weight of the injured arm to exaggerate any deformity. Pain may be variable in nature, given the AC joints' dual innervation from the suprascapular nerve and the lateral pectoral nerve [13]; however, the diagnosis is often clinched with a visible or palpable defect noted at the AC joint. Tenderness directly at the ACJ is the main symptom with visually evident step formation between the acromion and the distal clavicle end in complete ACJ dislocations. A comparison to the unaffected contralateral ACJ should be drawn due to a sometimes physiological prominent distal clavicle end on both shoulders. A key part of the clinical assessment represents the testing of horizontal instability. Hereby, the distal clavicle is shifted posteriorly with the acromion fixed by the other hand. An increased posterior translation in comparison to the unaffected side indicates a horizontal component of ACJ instability. Discomfort is often exacerbated with range of motion of the shoulder and with loading of the joint with the crossarm adduction test, which is performed by forward elevating the arm to 90° with arm adduction. Assessment of the AC joint for stability after an acute injury may be difficult secondary to guarding; however, for subacute and chronic injuries, this should be attempted. The Paxinos test (thumb pressure at the posterior AC joint) combined with a positive bone scan has been found to predict AC joint pathology with a high degree of confidence. Pain localized to the acromioclavicular joint or "on top" is diagnostic of acromioclavicular joint abnormality, whereas pain or painful clicking described as "inside" the shoulder is considered indicative of labral abnormality. However, the sensitivity of this test for AC pathology is only 41 %, with a specificity of 94 % [14]. A simple shoulder shrug may be helpful in determining if the deltotrapezial fascia has been separated from the clavicle [5]. Reduction of the AC joint can also be tested by stabilizing the clavicle in one hand and with the other hand placing an upward force on the ipsilateral elbow and assessing the joint for visible or palpable incongruity. Additionally, a thorough neurovascular assessment of the upper extremity including the cervical spine should be performed. Suspicion for other associated injuries, such as clavicle, coracoid, and rib fractures, should be raised with higher injury mechanisms [15].

They were initially graded I through III based on radiographic displacement and the degree of ligamentous damage [16, 17]. Rockwood later added types IV through VI to the classification system. The rising type correlates with greater displacement and higher levels of ligamentous injury [5].

Type I: This typically low-energy injury involves a sprain to the AC ligaments only. The CC ligaments are spared by the absorption of the impact by the AC ligaments. With the AC and CC ligaments intact, radiographic imaging appears normal.

Type II: As the energy imparted to the shoulder is increased, the AC joint capsule and ligaments are ruptured, and the distal clavicle is thereby rendered unstable in the horizontal plane. The CC ligaments remain intact, and there may be slight elevation of the clavicle on radiographs; however, the displacement is less than 100 % of the diameter of the distal clavicle, and the radiographic CC distance is increased by less than 20 %.

Type III: This higher-energy injury represents a complete disruption of both the AC and CC ligaments, which leads to complete dislocation of the AC joint. The insertion of the deltotrapezial fascia remains intact. Radiographs demonstrate displacement of the clavicle greater than 100 % of the diameter of the distal clavicle, and the radiographic CC distance is increased by 20–100 % [5].

Type IV: This injury involves a complete rupture of the AC and CC ligaments with posterior displacement of the distal clavicle into the trapezius fascia. It is important in this setting to evaluate the SC joint as concomitant anterior dislocation can occur.

Type V: This higher-energy variant of a type III injury represents a complete disruption of both the AC and CC ligaments, which leads to complete dislocation of the AC joint. The deltotrapezial fascia is stripped from its attachment to the clavicle. Radiographs demonstrate displacement of the clavicle greater than 300 % of the diameter of the distal clavicle, and the radiographic CC distance is increased by 100–300 %.

Type VI: This rare injury involves inferior displacement of the clavicle either subacromial or subcoracoid behind the conjoined tendon. The mechanism involves severe hyperabduction and external rotation of the arm combined with scapular retraction. It results from high-energy trauma, and neurovascular impairment is often present prior to reduction [15].

Confirmation of AC joint injury involves a complete radiographic shoulder series, which is essential in the analysis and classification of these injuries. Anteroposterior, scapular Y, and axillary views are obtained. These radiographs serve to provide information regarding the nearby glenohumeral joint and can rule out coexisting pathology. As standard anteroposterior (a.p.) projection, the Zanca view [18] (Fig. 23.4) has been established with the x-ray beam tilted for 10° in a caudocranial direction completed by a panorama stress view with a weight of 10 kg hanging on both wrists. Different methods have been employed for weight bearing. Detection of an increased AC and/or CC distance is indicative of ACJ dislocation. The normal ACJ

Fig. 23.2 Zanca view is the most accurate view to visualize the AC joint. This view is achieved by tilting the x-ray beam 10–15° cephalad and using one-half of the standard penetrance. Because of the significant variation in AC joint anatomy from one side to another, a bilateral Zanca view is recommended to visualize both AC joints on a single x-ray cassette while maintaining the same orientation of the x-ray beam. By visualizing both AC joints on the same cassette, the CC distance can be compared from side to side, pre- and postoperatively. The two *arrows* show the two acromion-clavicular joints. On the right is possible to observe a healthy clavicle. On the left an acromioclavicular dislocation

width in the frontal plane (Zanca view) measures 1–3 mm and decreases with age. An ACJ width >7 mm in men and 6 mm in women is found to be pathologic (Fig. 23.2). The introduction of Rockwood's classification necessitated a second plane to detect posterior dislocation of the distal clavicle. Routinely, at most radiologic departments, an axillary view with the patient in a sitting, supine, or standing position is performed [19].

Magnetic resonance (MR) imaging represents a sensitive diagnostic tool in evaluation of ACJ disorders. Assessment of the stabilizing soft tissue structures involving the AC ligaments, CC ligaments, and delto-trapezoidal fascia is possible in a reliable manner, and its results can change the clinical grading of dislocation [20, 21].

MR imaging is also useful if surgery is considered to identify accompanying pathologies and again to identify underestimated injuries.

T1-weighted imaging best demonstrates the CC ligaments, and fat-suppressed proton density-weighted or T2-weighted imaging best demonstrates the ligamentous disruption, when surrounded by blood or fluid [20].

In the author's clinical practice, a panorama stress view and axillary dynamic radiological evaluation represent the basic imaging tools, on which a therapeutic decision can be made in almost all cases. MRI is used only in selected cases, where associated glenohumeral soft tissue injuries are assumed.

23.4 Treatment Strategy

The goals of treatment for AC injuries are achieving painless range of motion of the shoulder, obtaining full strength, and exhibiting no limitation in activity. The treatment strategy varies according to the classification of the lesion.

Rockwood Type I

Sprains or partial tears at the ACJ are beyond all doubt treated nonoperatively [3, 5, 7, 17, 22]. Joint stability is maintained and ligament healing will occur in virtually all cases. Conservative therapy in terms of "skilful neglect" seems to be appropriate and sufficient. Occasionally, symptoms may appear between 6 months and 5 years, the 90 % are insignificant, reasonably well tolerated [38] and resolve within 12 months [23].

Rockwood Type II

General treatment recommendations are nonoperative for type II injuries [33, 5, 7, 22–24]. Similar to type I injuries, in most cases, symptoms disappear within 12 months [23]. Reasons for persistent complaints are residual instability, tearing of the intraarticular disk, articular cartilage injuries, residual joint incongruity, osteolysis of the lateral clavicle, and weakness [3, 5]. In case of type II injuries it's possible to observe an increased anteroposterior translation in terms of horizontal stability. This may be a further explanation for persistent symptoms due to mis-/underdiagnosis of the initial injury degree.

Rockwood Type III

Operative treatment of grade III injuries results in a better cosmetic outcome but greater duration of sick leave compared to nonoperative management. No difference regarding strength, pain, throwing ability, and incidence of acromioclavicular joint osteoarthritis has been observed between the treatments. Current treatment recommendations favor surgical treatment in young patients with physically demanding occupations or sporting activities. The current scientific evidence seems to show rather a cosmetic advantage of surgical treatment than a functional one [3, 5, 6].

Rockwood Type IV

There is consensus in the literature that the treatment of type IV injuries should be surgical [3, 5]. The argument to treat even the most inactive patients, was the extremely high pain level, considering only closed reduction as sufficient therapeutic measure [7]. When considering the complete disruption of the AC ligaments and the detachment of the delto-trapezoidal insertion, closed reduction alone is not deemed to be sufficient, requiring surgical stabilization. Surgical treatment should focus on ACJ reduction, AC ligament fixation, and reconstruction of the delto-trapezoidal fascia. Obviously if the CC ligament complex is involved, its pathology has to be addressed as well.

Rockwood Type V

All stabilizing anatomical structures, including the CC and AC ligaments and the delto-trapezoidal fascia, are disrupted. The treatment should be operative [7] with reconstruction of the stabilizing structures including the delto-trapezoidal fascia. Thus, open procedures may be of advantage as compared to arthroscopic techniques, which usually fail to address adequately reconstruction of the delto-trapezoidal fascia.

Rockwood Type VI

This type of ACJ dislocation is quite rare and has been reported only in case reports [3, 15, 24, 25]. The treatment is always operative with reduction of the distal clavicle end and ACJ stabilization. Closed reduction may be difficult due to entrapment of the distal clavicle posterior to the conjoint tendon.

23.4.1 Treatment Modalities

23.4.1.1 Nonoperative Treatment

A common pitfall of these treatment attempts was skin and soft tissue related. Skin breakdown may be a potential complication of using external immobilization straps that apply continuous pressure over the lateral clavicle. A further prerequisite for successful nonoperative treatment is a maximum of compliance of the patient which often lacks in young and active patients.

Recognizing the difficulties to maintain sufficient reduction of the ACJ, several authors have recommended only the use of a simple shoulder sling [6]. In the author's opinion, nonoperative therapy in terms of "skillful neglect" represents a sufficient therapy consisting in immobilization of the respective arm until subsidence of the acute pain, ice application, analgesics according to the patient's needs and accompanying physical therapy to gain free range of motion and full muscle strength. A key pillar of physical rehabilitation programs represents the strengthening of the spino-scapulohumeral function chain. The main focus should be kept on the periscapular muscles, including the rhomboidei, levator scapulae, trapezius, and latissimus dorsi muscles to stabilize the scapula actively due to the lack of passive ligamentous suspension to the clavicle. This musculoskeletal pathology explains the resulting scapular dyskinesis in many patients suffering from chronic ACJ instability. Thus, nonoperative treatment should be symptomatic in the acute phase and functional in the subacute/chronic phase. Usually, freedom from pain and free range of motion should be present 3–4 weeks after the injury.

23.4.1.2 Surgical Treatment

Open Techniques

Bosworth Screw

For several decades, it represented an established method to treat acute ACJ dislocations. Until today, some orthopedic and trauma surgeons use this simple technique, which can be performed percutaneously and grants good to excellent long-term outcomes [3, 5, 6]. Possible malpositioning, screw breakage, damage of the CC repair, and necessity of screw removal represent disadvantages rendering this implant unpopular nowadays [26].

Hook Plate

It is still a widely used implant providing high primary stability but requiring a second surgery for implant removal.

Overall [27, 28], the hook plate provides high rates of successful functional restoration offering a high primary stability. Possible complications (loss of reduction, redislocation, and acromion osteolysis or fracture) have to be taken into consideration, as well as the need for plate removal after 3 months.

Pinning and Tension Banding

Percutaneous pinning and tension banding using two AC transarticular K-wires and a cerclage represent simple and cost-effective procedures [29, 30]. Good results can be achieved in 96 % of cases and reduction can be retained in 80 %. Only 5 % complained intermittent pain with an average visual analog score of 4 at follow-up. The overall complication rate is 15 % including K-wire migration in 4 % and ACJ redislocation in 11 %.

PDS Sling

It is not a universally accepted technique because it requires a large exposure resulting in soft tissue damage and a high rate of redislocation reported by a few authors [31, 32].

Extra-anatomical Procedures

Transfer of the coracoacromial ligament from the acromion into the resected distal clavicle was suggested already in 1917 by Cadenet and reported in 1972 by Weaver and Dunn [33] for both acute and chronic cases. However, the coracoacromial ligament transfer should not be indicated for acute cases when the CC and AC ligaments are likely to heal spontaneously after repair. For chronic cases, biomechanical [34, 35] and clinical [3, 5] data proved anatomic CC ligament reconstruction using autologous semitendinosus tendon to be superior to the Weaver–Dunn procedure.

Arthroscopic Techniques

Following the development of arthroscopic techniques in joint surgery, suitable implants have been searched allowing for a minimally invasive, arthroscopically assisted procedure. In 2001, Wolf and Pennington described for the first time the arthroscopic CC stabilization using polyethylene wire cerclages reporting on 81 % good and excellent results. Rolla et al. [36] described the arthroscopically assisted use of a cannulated Bosworth screw with excellent early results. Elser et al. used suture anchors for arthroscopic CC stabiliza-

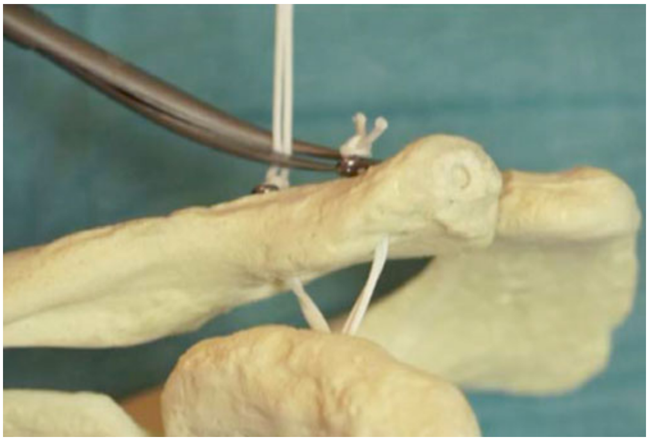

Fig. 23.3 Reduction after dislocation of the clavicle with a TightRope™ technique

Fig. 23.4 Rx: anteroposterior view after TightRope™ reconstruction (right acromioclavicular joint)

tion without image intensifier with good results. The TightRope™ system (Arthrex, Naples, FL, USA) or similar can be used to repair ACJ with excellent results [37]. Arthroscopic techniques allow for contemporaneous treatment of the associated intraarticular lesion and ACJ stabilization (Figs. 23.3 and 23.4).

The principle of the TightRope™ stabilization can be performed in a mini-open technique as well.

23.5 Rehabilitation and Return to Play

The role of the postoperative treatment for ACJ reconstruction is very important. In contrast to ligamentous injuries of other joints, the gravity creates a continuous stress to the CC and AC ligaments preventing ligament stump contact and healing. Therefore, exceptional protection of the ACJ repair has to be guaranteed in the immediate postoperative period which contributes significantly to the success of the surgery and minimizes the risk for redislocation. In the literature, a broad spectrum regarding postoperative rehabilitation protocols has been reported ranging from early unrestricted rehabilitation over early active mobilization to 90° after 2–3 days to only passive motion up to 90° twice a week for 4 weeks with immobilization using a sling. Care should be taken in regard to the model of sling immobilization. It is of crucial importance to provide a sufficient support to the forearm and elbow to neutralize CC gravity distraction forces. In addition, a high compliance of the patient is required to follow the physician's advices of strictly limited postoperative activity.

The postoperative protocol typically involves the use of a sling or shoulder immobilizer for a period of 4–6 weeks to allow the reconstruction to heal. This provides support for the involved upper extremity when in an upright position [38]. Limited supine passive and active assisted range of motion is initiated as early as 7–10 days postoperatively, while strengthening and upright range of motion is typically restricted until 6 weeks.

Shoulder must be immobilized, and no range of motion is allowed for 4–6 weeks, necessary time for biological healing. The sling or shoulder immobilizer can be removed at this time with active range of motion and strengthening of the scapular stabilizers encouraged. Shoulder range of motion is initially limited to 90° of forward elevation, 90° of abduction, 30° of external rotation, and internal rotation to the chest wall. Weight training is initiated at 8–12 weeks, followed by return to noncontact athletic activity at 3–6 months. Peak strength is often obtained by 9 months, whereby patients can return to contact activities. It has been suggested that use of various types of tendon grafts may allow a more accelerated rehabilitation program [39].

References

1. Emery R (1997) Acromioclavicular and sternoclavicular joints. In: Copeland S (ed) Shoulder surgery. WB Saunders, London
2. Riand N, Sadowski C, Hoffmeyer P (1999) Acute acromioclavicular dislocations. Acta Orthop Belg 65(4):393–403
3. Tauber M (2013) Management of acute acromioclavicular joint dislocations: current concepts. Arch Orthop Trauma Surg 133:985–995
4. Webb J, Bannister G (1992) Acromioclavicular disruption in first class rugby players. Br J Sports Med 26(4):247–248
5. Epstein D, Day M, Rokito A (2012) Current concepts in the surgical management of acromioclavicular joint injuries. Bull NYU Hosp Jt Dis 70(1):11–24
6. Babhulkar A, Pawaskar A (2014) Acromioclavicular joint dislocations. Curr Rev Musculoskelet Med 7:33–39

7. Collins DN (2009) Disorders of the acromioclavicular joint. In: Rockwood CA, Matsen FA, Wirth MA, Lippitt SA (eds) The shoulder, 4th edn. Saunders, Philadelphia
8. Flik K, Lyman S, Marx RG (2005) American collegiate men's ice hockey: an analysis of injuries. Am J Sports Med 33(2):183–187
9. Headey J, Brooks JH, Kemp SP (2007) The epidemiology of shoulder injuries in English professional rugby union. Am J Sports Med 35(9):1537–1543
10. Mazzocca AD, Sellards R, Romeo A (2002) Acromioclavicular joint injuries: pediatric and adult. In: DeLee JC, Drez D (eds) Orthopedic sports medicine. WB Saunders, Philadelphia
11. Lemos MJ (1998) The evaluation and treatment of the injured acromioclavicular joint in athletes. Am J Sports Med 1:137–144
12. Rockwood CA (1984) Injuries to the acromioclavicular joint. In: Rockwood CA, Green DP (eds) Fractures in adults, 2nd edn. JB Lippincott, Philadelphia, pp 860–910
13. Gerber C, Galantay RV, Hersche O (1998) The pattern of pain produced by irritation of the acromioclavicular joint and the subacromial space. J Shoulder Elbow Surg 7(4):352–355
14. O'Brien SJ, Pagnani MJ, Fealy S et al (1998) The active compression test: a new and effective test for diagnosing labral tears and acromioclavicular joint abnormality. Am J Sports Med 26(5):610–613
15. Gerber C, Rockwood CA Jr (1987) Subcoracoid dislocation of the lateral end of the clavicle. A report of three cases. J Bone Joint Surg Am 69(6):924–927
16. Tossy JD, Mead NC, Sigmond HM (1963) Acromioclavicular separations: useful and practical classification for treatment. Clin Orthop Relat Res 28:111–119
17. Allman FL Jr (1967) Fractures and ligamentous injuries of the clavicle and its articulation. J Bone Joint Surg Am 49(4):774–784
18. Zanca P (1971) Shoulder pain: involvement of the acromioclavicular joint. (Analysis of 1,000 cases). Am J Roentgenol Radium Ther Nucl Med 112(3):493–506
19. 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
20. Antonio GE, Cho JH, Chung CB, Trudell DJ, Resnick D (2003) Pictorial essay. MR imaging appearance and classification of acromioclavicular joint injury. AJR Am J Roentgenol 180(4): 1103–1110
21. Barnes CJ, Higgins LD, Major NM, Basamania CJ (2004) Magnetic resonance imaging of the coracoclavicular ligaments: its role in defining pathoanatomy at the acromioclavicular joint. J Surg Orthop Adv 13(2):69–75
22. Mouhsine E, Garofalo R, Crevoisier X, Farron A (2003) Grade I and II acromioclavicular dislocations: results of conservative treatment. J Shoulder Elbow Surg 12(6):599–602
23. Shaw MB, McInerney JJ, Dias JJ, Evans PA (2003) Acromioclavicular joint sprains: the post-injury recovery interval. Injury 34(6): 438–442
24. Beitzel K et al (2013) Current concepts in the treatment of acromioclavicular joint dislocations. Arthroscopy 29(2):387–397
25. Torrens C, Mestre C, Perez P, Marin M (1998) Subcoracoid dislocation of the distal end of the clavicle. A case report. Clin Orthop Relat Res 348:121–123
26. Assaghir YM (2011) Outcome of exact anatomic repair and coracoclavicular cortical lag screw in acute acromioclavicular dislocations. J Trauma 71(3):E50–E54
27. Gstettner C, Tauber M, Hitzl W, Resch H (2008) Rockwood type III acromioclavicular dislocation: surgical versus conservative treatment. J Shoulder Elbow Surg 17(2):220–225
28. Salem KH, Schmelz A (2009) Treatment of Tossy III acromioclavicular joint injuries using hook plates and ligament suture. J Orthop Trauma 23(8):565–569
29. 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
30. Kazda S, Pasa L, Pokorny V (2011) Clinical outcomes of surgical management of acromioclavicular dislocation with and without ligament suturing. Rozhl Chir 90(10):561–564
31. Eschler A, Gradl G, Gierer P, Mittlmeier T, Beck M (2012) Hook plate fixation for acromioclavicular joint separations restores coracoclavicular distance more accurately than PDS augmentation, however presents with a high rate of acromial osteolysis. Arch Orthop Trauma Surg 132(1):33–39
32. Greiner S, Braunsdorf J, Perka C, Herrmann S, Scheffler S (2009) Mid to long-term results of open acromioclavicular-joint reconstruction using polydioxansulfate cerclage augmentation. Arch Orthop Trauma Surg 129(6):735–740
33. Weaver JK, Dunn HK (1972) Treatment of acromioclavicular injuries, especially complete acromioclavicular separation. J Bone Joint Surg Am 54(6):1187–1194
34. 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
35. 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
36. Rolla PR, Surace MF, Murena L (2004) Arthroscopic treatment of acute acromioclavicular joint dislocation. Arthroscopy 20(6):662–668
37. Scheibel M, Droschel S, Gerhardt C, Kraus N (2011) Arthroscopically assisted stabilization of acute high-grade acromioclavicular joint separations. Am J Sports Med 39(7):1507–1516
38. White B, Epstein D, Sanders S, Rokito A (2008) Acute acromioclavicular injuries in adults. Orthopedics 31(12)
39. Lee SJ, Nicholas SJ, Akizuki KH et al (2003) Reconstruction of the coracoclavicular ligaments with tendon grafts: a comparative biomechanical study. Am J Sports Med 31(5):648–655