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The surgical treatment of acromioclavicular joint injuries

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- Acromioclavicular joint (ACJ) injuries are common, but their incidence is probably underestimated. As the treatment of some sub-types is still debated, we reviewed the available literature to obtain an overview of current management.

- We analysed the literature using the PubMed search engine.

- There is consensus on the treatment of Rockwood type I and type II lesions and for high-grade injuries of types IV, V and VI. The treatment of type III injuries remains controversial, as none of the studies has proven a significant benefit of one procedure when compared with another.

- Several approaches can be considered in reaching a valid solution for treating ACJ lesions. The final outcome is affected by both vertical and horizontal post-operative ACJ stability. Synthetic devices, positioned using early open or arthroscopic procedures, are the main choice for young people.

- Type III injuries should be managed surgically only in cases with high-demand sporting or working activities.

Acromioclavicular (AC) injuries are common, with an unknown real incidence because a relevant percentage of affected patients do not seek medical treatment. A significantly increased risk of developing these types of lesions has been demonstrated[1,2] in athletes participating in contact sports (e.g. horse-riding, soccer, rugby, hockey, and martial arts).

The AC joint is a diarthrodial link stabilised by several ligaments. The AC capsular ligaments provide most of the joint stability in the anteroposterior direction. The coracoclavicular (CC) ligaments, on the contrary, provide vertical stability.

The mechanism most commonly involved in AC and CC ligament injuries is a direct force applied on the superior surface of the acromion; it is usually the consequence of a fall with the arm in an adducted position.[3] Less frequently, an indirect force may be transmitted to the shoulder because of a fall on an outstretched hand or elbow.

Finally, epiphyseal separation with an AC ligament sprain in children and young adults, as well as distal clavicle fractures, can lead to CC dislocation on radiographs; these are called "AC joint pseudo-dislocations".[4]

Classification and diagnosis

Several classifications have been proposed to describe AC joint injuries. According to Tossy et al[5] and Allman,[6] type I lesions show a well-aligned joint with strained ligaments. Type II lesions are characterised by a complete rupture of the AC ligaments and a strain of the CC ligaments resulting in a displacement of the end of the clavicle of <100% of the depth of the AC joint. In Type III lesions both AC and CC ligaments tear with a clavicular displacement >100%.

Rockwood et al[7,8] add in their classification three additional types of injury: type IV lesions, described as a type III lesion associated with a posterior displacement of the clavicle through the trapezius; type V lesions, which include an important AC joint displacement with deltoid and trapezius muscles detachment; and finally type VI lesions, where the clavicle is displaced under the coracoid process.

AC joint injuries should be suspected in any patient who has sustained a shoulder trauma. Physical and radiographic examinations are essential.

Management

The management of AC lesions is based on minimal intervention, either surgical or non-surgical,[9] aiming to restore both vertical and horizontal stability[10] and a stable joint.[11]

There is a general consensus for non-operative treatment of Rockwood type I and type II lesions.[12,13]

Currently, rather than ice and oral analgesic medication, the most accepted conservative treatment is sling immobilisation for a brief period.[13] The patient is encouraged to start range of motion activities within the first week and then strengthening exercises with a specific focus on scapular stabilisation. During this time, heavy lifting and contact sports must be avoided to allow ligament healing.[7]

Surgical treatment, mostly used in chronic injuries, is based on CC fixation[14] and/or ligament repair[15,16] and usually reflects individual patient demands. Surgery can allow high-demand sport players or manual workers a quicker return to activities and limits the duration of painful disability.

Although non-surgical treatment is recommended for type I and type II injuries,[12,13] Mouhsine et al[17] reported chronic AC symptoms in 27% of patients treated conservatively after an average 26 months since the traumatic event. The most concerning sequelae of lower-energy injuries are chronic instability and the late development of AC joint osteoarthritis, which occur in about 50% of patients.[18] When symptomatic, these conditions can be treated by steroid injection or distal clavicle resection, as described by Mumford.[19]

The treatment of Type III injuries is controversial. A meta-analysis by Phillips et al[20] described a satisfactory outcome in more than 85% of patients, whether the management of these lesions was non-surgical or surgical; furthermore, surgery seldom allows a quick return to activity. A recent retrospective study comparing 24 patients treated surgically with a hook-plate and 17 managed conservatively showed, after median follow-up of 34 months, a significantly better functional outcome following operative compared with non-operative management.[21]

Wojtys and Nelson[22] suggest a treatment strategy based on the levels of shoulder strength or endurance, underlying the point that, in case of non-invasive management, a proper and adequate rehabilitation is critical to obtain good results.[22-24]

High-grade injuries (type IV, V and VI) are often treated surgically even though no long-term differences between surgical and non-surgical treatment have been reported.[25]

Surgical treatment should focus on AC joint reduction and fixation, and delto-trapezoidal fascia and CC ligaments repair or reconstruction. A variety of operative techniques have been developed over the years: some of them are focused on ligament healing, other techniques are focused on its reconstruction. The former techniques cannot be applied in cases of chronic lesions, while the latter are specifically indicated for high-grade dislocations and chronic injuries.[26]

Surgical procedures include the use of pin and tension bands, plates and screws, loops, biological or synthetic transfers with different techniques, all aiming to recover and correct AC anatomy.

Historically, the primary AC joint fixation consisted of pin fixation using Kirschner-wires (K-wires) after reduction; this method was abandoned because of the development of severe complications including pin migration, with potential damage to nerves, vessels and spinal canal structures.[27,28] In addition, functional and clinical results were generally poor, requiring a large exposure, and soft tissue damage and osteoarthritis developed in a significant percentage of patients.

Leidel et al[29] described 70 cases of temporary unthreaded K-wire fixations of acute AC joint dislocations of Rockwood type III with the suture of the CC and AC ligaments and delto-trapezoidal fascia. The clinical results after one to two years (short-term), three to five years (mid-term) and six to ten years (long-term) did not differ significantly, with an overall complication rate of 15%, including K-wire migration in 4% and AC joint recurrent dislocation in 11%.

The hook-plate is a commonly used alternative technique. After an open AC joint reduction, the plate is inserted deep to the acromion and superficially to the lateral clavicle to maintain alignment. The screws secure the plate to the clavicle restoring a correct CC distance. Some authors combine this procedure with ligament reconstruction.[30,31] Good functional results have been reported even if a secondary widening of the hook holes has been observed in a high number of subjects, as well as diastasis and re-dislocation of the AC joint.[32] Furthermore, a second surgical procedure to remove the hook plate is recommended because the plate can cause implant failure, joint damage and osteolysis at the inferior surface of the acromion, and/or subacromial impingement.[33]

Kienast et al[33] report good and excellent results in 84% of 225 patients treated for an acute AC joint dislocation types III to V implanting an AC hook plate, with a complication rate of 10.6%. Di Francesco et al[34] reported a re-dislocation rate of 12% in a group of 42 patients treated with the same surgery without CC ligament repair.

Gstettner et al[21] mentioned significantly better results for surgical treatment using the hook-plate after a mean follow-up of three years in a retrospective study comparing non-operative and operative treatments in AC joint dislocations type III.

The use of a Bosworth screw[35] is a percutaneous procedure to obtain CC fixation. The potential disadvantages are incorrect placement, screw breakage and

Table 1. Results of different surgical procedures for acromioclavicular (AC) lesion

Authors	Yr	Patients (n)	Rockwood type	Surgery	Results, n (%)	Complications
Pavlik et al[37]	2001	17	Chronic III	Modified Weaver-Dunn + no lateral clavicle resection + screw	11 (65) excellent subjectively	1 screw loosing and partial loss of reduction
Adam and Farouk[38]	2004	14	Symptomatic III or more	Weaver-Dunn + deltotrapezius imbrication over the top + tension band	8 (57) excellent results	1 loosening of the temporary fixation with clavicle subluxation
Jeon et al[41]	2007	11	Chronic III-V	Artificial ligament made from braided polyester	9 (82) satisfied	1 fracture of the base of the coracoid in the early post-operative period; 2 additional operations (lateral end of the clavicle excision with screw removal; subacromial decompression)
Millett et al[44]	2009	17	Symptomatic III or acute IV-V	Weaver-Dunn with intramedullary tensioning	16 (94) maintain reduction without pain	1 (6%) recurrent dislocation returning to sport 3 mths post-operatively
Boileau et al[45]	2010	10	Chronic III-IV	Modified Weaver-Dunn with 2 titanium buttons and heavy suture	10 (100) pain relief and cosmetic satisfaction, 9 (90) returned to previous sports	1 superficial infection of the superior (clavicular) portal
Kim et al[49]	2012	12	Chronic V	Weaver-Dunn + lateral half conjoined tendon	11 (92) excellent results	8 mild radiographic AC joint arthrosis; 2 heterotopic ossification of the CC space

further surgical procedures needed to remove the device. Rockwood et al[4] recommend combining CC screws with ligament repair in acute cases of AC dislocation because the screw device serves as a temporary fixation to let the ligament heal.[21]

In a recent study, Assaghir[36] reported good to excellent long-term outcomes, after an average follow-up of 74.6 months, in 56 patients undergoing combined extra- and intra-articular ligament repair for AC joint dislocations types III to V under rigid CC protection using a lag screw.

In the early 1970s, Weaver and Dunn[15] first described an open procedure using the native coracoacromial (CA) ligament to re-establish AC joint stability. After the resection of the lateral end of the clavicle, the CA ligament is detached from the deep surface of the acromion with or without a chip of bone and then transferred to the clavicle. A suture loop augmentation between the coracoid and the clavicle can be added to protect the transferred ligament from excessive loads during healing, allowing earlier rehabilitation and improving load to failure and stiffness (modified Weaver-Dunn procedure). Since then, many other surgical techniques have been developed with controversial results (Table 1).

Pavlik et al[37] reported a study in 2001 of 17 patients with chronic AC instability treated with a modified Weaver-Dunn procedure without lateral clavicular end resection and a Bosworth CC screw to protect the graft post-operatively for eight weeks. After a median follow-up of 37 months, 11 patients were subjectively satisfied and nine showed a radiographical anatomical reduction.

Adam and Farouk[38] published a study in 2004 on 14 patients surgically treated for symptomatic complete dislocation of the AC joint. The surgical procedure included a Weaver-Dunn reconstruction, imbrication of the deltotrapezius aponeurosis over the top of the distal clavicle and a

temporary joint stabilisation with a tension band between the clavicle and the acromion. After an average of 20 months, only eight patients obtained excellent results.

In 2001, Wolf and Pennington[39] described for the first time the arthroscopic CC stabilisation using polyethylene wire cerclages, whilst in 2005 Lafosse et al[40] presented the Weaver-Dunn arthroscopic technique with satisfactory reduction and results.

In 2007, Jeon et al[41] published a study in which 11 patients affected by chronic AC disruption were treated with an artificial CC ligament made from braided polyester (the Nottingham 'Surgilig' or 'LockDown' device). The ligament had a loop at each end and was passed around the coracoid process, threaded through itself, then passed around the posterior aspect of the clavicle and finally anchored to it with a bone screw. The authors concluded that it was a useful alternative for the treatment of chronic AC separation, especially in revision reconstruction when the CC ligament was no longer available.

Hosseini et al[42] first described in 2009 an arthroscopic technique for chronic AC joint dislocations with CA ligament transposition and augmentation with the 'TightRope' device (Arthrex, Naples, United States) (Fig. 1). Two titanium buttons are connected by a FiberWire suture (Arthrex) and can be introduced through a drill hole using a special guiding device. After the inferior subcoracoidal button has been flipped, the TightRope is secured tying a knot onto the clavicle. Although technically demanding, the authors concluded that it was a safe method to reconstruct the CC ligaments allowing a sufficient reduction of the clavicle without the need for further implant removal or autologous tendon transplantation. The principle of the TightRope stabilisation can be applied in a mini-open technique as well. The two main advantages of the mini-open technique are first, a good overview on to the
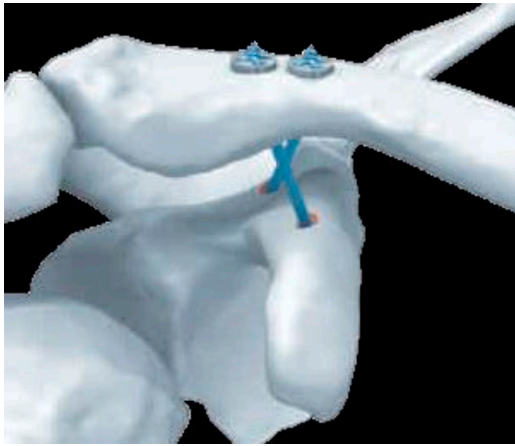
Fig. 1 'TightRope' device (figure reproduced with permission from Arthrex, Naples, USA)

coracoid base and second, the possibility of an adequate reconstruction of the delto-trapezoidal fascia. The MINAR (Minimal INvasive Ac joint Reconstruction) system (Karl Storz, Tuttlingen, Germany) is a different implant working according to the same double-button principle.[43]

Millett et al[44] published, in the same year, a study of 17 patients surgically treated for symptomatic type III AC joint or acute type IV and V injuries. The distal clavicle was resected and stabilised with CC ligament reconstruction using the CA ligament. The CA ligament was passed into the medullary canal and tensioned. At an average follow-up of 29 months, 94% of patients maintained reduction with a complete improvement in pain.

Boileau et al[45] reported, in 2010, a novel technique to repair arthroscopically a symptomatic chronic and complete AC joint dislocation (Rockwood type III or IV). Transferring the CA ligament with a bone block in the distal clavicle and fixing it with two titanium buttons connected by a heavy suture in a four-strand configuration (Double-Button fixation; Smith & Nephew Endoscopy, Andover, Massachusetts), the authors could achieve a good and strong healing.

Recent biomechanical[46] and clinical[12] data prove that anatomical CC ligament reconstruction using autologous semitendinosus tendon is superior to the Weaver–Dunn procedure. Arthroscopic techniques provide an advantage over open techniques in reducing surgical morbidity and surgical site infection. On the other hand, loss of reduction or recurrence are the most frequent complications following arthroscopic reconstructions with reported failure rates of 50% or greater. Similar functional outcomes have been reported in arthroscopic and open techniques.[47,48] Kim et al[49] introduced in 2012 the results of CA ligament and lateral half-conjoined tendon transfer for chronic type V injuries. The results were promising and the half-conjoined tendon transfer represented an

advantage avoiding distant donor site morbidities and the costs of an allograft tendon or a synthetic implant. In their 2013 study, von Heideken et al[50] compared Rockwood type V injuries receiving immediate or delayed treatment. The first group scored better in function, disability, pain and satisfaction, and the main issues were more difficult to achieve with delayed surgery.[51]

Complications following surgical treatment of AC joint dislocations are generally specific for each technique. Hardware failure and migration resulting in injury to the great vessels as well as aseptic foreign body reaction or infection may occur after the use of implants and synthetic sutures.[52] Surgical dissection, clavicle drilling or screws may disturb blood perfusion in bone, leading to significant osteolysis. As a direct consequence, early or late fractures of the coracoid process or clavicle have been observed.[12] In addition, any technique that passes a graft or synthetic material medial to the coracoid process poses a potential risk to the brachial plexus and the axillary artery.[52]

Both the conservative and surgical treatments seem to offer excellent clinical results. The more rapid return to athletic activities following conservative treatment could represent a short-term advantage because these patients can develop persistent pain, discomfort or functional dissatisfaction. Acute lesions of young people with long-term, high-demand sport or recreational activities can therefore be treated surgically.[51,53-54]

Different surgical procedures have been described to treat acute and chronic AC joint dislocations, but there is still no gold standard treatment. Biomechanical considerations could help in the choice of surgery type but there is no evidence that an acute treatment can restore the previous anatomy.

Vertical and horizontal post-operative AC joint stability[10] are the main factors affecting final outcome; in fact, the best results are recorded in patients with completely stable joints.[11] Although the synthetic graft is effective from a biomechanical standpoint, graft shredding, wear and bone remodelling around the screws can compromise mechanical strength over time, particularly in elderly patients and in those with poor clavicle bone thickness or osteoporosis.[11]

From a biological point of view, the surgical treatment of an acute lesion mainly offers a guide for the remnant fibres of the torn ligament to be correctly aligned and heal along the neo-ligament.[53-55] Biological grafts provide joint stability in the axial and the coronal planes through sutures of their lateral stump to the acromion and are a valuable option when treating patients with post-operative recurrent dislocation due to synthetic graft failure.[11,12,46]

AC injuries are common lesions whose management is directly related to the type of damage. Whilst overall the literature is concordant as to the treatment of some

sub-types, the ideal approach to type III lesions is currently under debate. In addition, despite the availability of a large number of techniques, the best surgical management of AC joint lesions has still to be defined.

The authors' final suggestion is to surgically treat young people with high-grade AC dislocations in the early stages using synthetic devices with open or arthroscopic procedures aiming to obtain a stable joint. A mini-open technique permits a good overview on to the base of the coracoid and allows an adequate reconstruction of the delto-trapezoidal fascia. Type III injuries should be surgically managed only in patients with high-demand sport or working activities.

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ICMJE CONFLICT OF INTEREST STATEMENT
None declared.

REFERENCES

1. **Laprade RF, Surowiec RK, Sochanska AN, et al.** Epidemiology, identification, treatment and return to play of musculoskeletal-based ice hockey injuries. *Br J Sports Med* 2014;48:4-10.

2. **Lynch TS, Saltzman MD, Ghodasra JH, et al.** Acromioclavicular joint injuries in the National Football League: epidemiology and management. *Am J Sports Med* 2013;41:2904-2908.

3. **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.

4. **Rockwood CA Jr, Williams GR Jr, Young DC.** Disorders of the acromioclavicular joint. In: Rockwood CA Jr, Matsen FA III, eds. *The Shoulder*. Philadelphia, PA: WB Saunders, 1998:483-553.

5. **Tossy JD, Mead NC, Sigmond HM.** Acromioclavicular separations: useful and practical classification for treatment. *Clin Orthop Relat Res* 1963;28:111-119.

6. **Allman FL Jr.** Fractures and ligamentous injuries of the clavicle and its articulation. *J Bone Joint Surg [Am]* 1967;49-A:774-784.

7. **Rockwood CA, Green DP.** Injuries to the acromioclavicular joint. Fractures in Adults. Second ed. Philadelphia, Pa: JB Lippincott, 1984:860-891.

8. **Rockwood CA Jr, Green DP, Bucholz RW, Heckman JD.** *Fractures in Adults*. Fourth ed. Philadelphia, Pa: Lippincott-Raven, 1996.

9. **Bradley JP, Elkousy H.** Decision making: operative versus nonoperative treatment of acromioclavicular joint injuries. *Clin Sports Med* 2003;22:277-290.

10. **Saccomanno MF, Fodale M, Capasso L, Cazzato G, Milano G.** Reconstruction of the coracoclavicular and acromioclavicular ligaments with semitendinosus tendon graft: a pilot study. *Joints* 2014;2:6-14.

11. **Shin SJ, Yun YH, Yoo JD.** Coracoclavicular ligament reconstruction for acromioclavicular dislocation using 2 suture anchors and coracoacromial ligament transfer. *Am J Sports Med* 2009;37:346-351.

12. **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.

13. **Bontempo NA, Mazzocca AD.** Biomechanics and treatment of acromioclavicular and sternoclavicular joint injuries. *Br J Sports Med* 2010;44:361-369.

14. **Lemos MJ.** The evaluation and treatment of the injured acromioclavicular joint in athletes. *Am J Sports Med* 1998;26:137-144.

15. **Weaver JK, Dunn HK.** Treatment of acromioclavicular injuries, especially complete acromioclavicular separation. *J Bone Joint Surg [Am]* 1972;54-A:1187-1194.

16. **Mazzocca AD, Santangelo SA, Johnson ST, et al.** A biomechanical evaluation of an anatomical coracoclavicular ligament reconstruction. *Am J Sports Med* 2006;34:236-246.

17. **Mouhsine E, Garofalo R, Crevoisier X, Farron A.** Grade I and II acromioclavicular dislocations: results of conservative treatment. *J Shoulder Elbow Surg* 2003;12:599-602.

18. **Bergfeld JA, Andrish JT, Clancy WG.** Evaluation of the acromioclavicular joint following first- and second-degree sprains. *Am J Sports Med* 1978;6:153-159.

19. **Mumford EB.** Acromioclavicular dislocation: A new operative treatment. *J Bone Joint Surg [Am]* 1941;23-A:799-802.

20. **Phillips AM, Smart C, Groom AF.** Acromioclavicular dislocation. Conservative or surgical therapy. *Clin Orthop Relat Res* 1998;353:10-17.

21. **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.

22. **Wojtys EM, Nelson G.** Conservative treatment of Grade III acromioclavicular dislocations. *Clin Orthop Relat Res* 1991;268:112-119.

23. **Glick JM, Milburn LJ, Haggerty JF, Nishimoto D.** Dislocated acromioclavicular joint: follow-up study of 35 unreduced acromioclavicular dislocations. *Am J Sports Med* 1977;5:264-270.

24. **Gurd FB.** The treatment of complete dislocation of the outer end of the clavicle: A hither to undescribed operation. *Ann Surg* 1941;113:1094-1098.

25. **Joukainen A, Kröger H, Niemitukia L, Mäkelä EA, Väätäinen U.** Results of Operative and Nonoperative Treatment of Rockwood Types III and V Acromioclavicular Joint Dislocation: A Prospective, Randomized Trial With an 18- to 20-Year Follow-up. *Orthop J Sports Med* 2014;2:2325967114560130.

26. **Spoliti M, De Cupis M, Via AG, Oliva F.** All arthroscopic stabilization of acute acromioclavicular joint dislocation with fiberwire and endobutton system. *Muscles Ligaments Tendons J* 2014;4:398-403.

27. Norrell H Jr, Llewellyn RC. Migration of a threaded Steinmann pin from an acromioclavicular joint into the spinal canal: A case report. *J Bone Joint Surg [Am]* 1965; 47-A:1024-1026.

28. Sethi GK, Scott SM. Subclavian artery laceration due to migration of a Hagie pin. *Surgery* 1976;80:644-646.

29. Leidel BA, Braunstein V, Kirchhoff C, et al. Consistency of long-term outcome of acute Rockwood grade III acromioclavicular joint separations after K-wire transfixation. *J Trauma* 2009;66:1666-1671.

30. Faraj AA, Ketzer B. The use of a hook-plate in the management of acromioclavicular injuries. Report of ten cases. *Acta Orthop Belg* 2001;67:448-451.

31. 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.

32. Koukakis A, Manouras A, Apostolou CD, et al. Results using the AO hook plate for dislocations of the acromioclavicular joint. *Expert Rev Med Devices* 2008;5:567-572.

33. Kienast B, Thietje R, Queitsch C, et al. Mid-term results after operative treatment of rockwood grade III-V acromioclavicular joint dislocations with an AC-hook-plate. *Eur J Med Res* 2011;16:52-56.

34. Di Francesco A, Zoccali C, Colafarina O, Pizzoferrato R, Flamini S. The use of hook plate in type III and V acromio-clavicular Rockwood dislocations: clinical and radiological midterm results and MRI evaluation in 42 patients. *Injury* 2012;43:147-152.

35. Bosworth BM. Acromioclavicular separation: new method of repair. *Surg Gynecol Obstet* 1941;73:866-871.

36. Assaghir YM. Outcome of exact anatomic repair and coracoclavicular cortical lag screw in acute acromioclavicular dislocations. *J Trauma* 2011;71:E50-E54.

37. Pavlik A, Csépai D, Hidas P. Surgical treatment of chronic acromioclavicular joint dislocation by modified Weaver-Dunn procedure. *Knee Surg Sports Traumatol Arthrosc* 2001;9:307-312.

38. Adam FF, Farouk O. Surgical treatment of chronic complete acromioclavicular dislocation. *Int Orthop* 2004;28:119-122.

39. Wolf EM, Pennington WT. Arthroscopic reconstruction for acromioclavicular joint dislocation. *Arthroscopy* 2001;17:558-563.

40. Lafosse L, Baier GP, Leuzinger J. Arthroscopic treatment of acute and chronic acromioclavicular joint dislocation. *Arthroscopy* 2005;21:1017.

41. Jeon IH, Dewnany G, Hartley R, Neumann L, Wallace WA. Chronic acromioclavicular separation: the medium term results of coracoclavicular ligament reconstruction using braided polyester prosthetic ligament. *Injury* 2007;38:1247-1253.

42. Hosseini H, Friedmann S, Tröger M, Lobenhoffer P, Agneskirchner JD. Arthroscopic reconstruction of chronic AC joint dislocations by transposition of the coracoacromial ligament augmented by the Tight Rope device: a technical note. *Knee Surg Sports Traumatol Arthrosc* 2009;17:92-97.

43. Petersen W, Wellmann M, Rosslenbroich S, Zantop T. Minimally Invasive Acromioclavicular Joint Reconstruction (MINAR). *Oper Orthop Traumatol* 2010;22:52-61.

44. Millett PJ, Braun S, Gobezie R, Pacheco IH. Acromioclavicular joint reconstruction with coracoacromial ligament transfer using the docking technique. *BMC Musculoskelet Disord* 2009;10:6.

45. 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.

46. 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.

47. Clavert P, Meyer A, Boyer P, et al; The SFA. Complication rates and types of failure after arthroscopic acute acromioclavicular dislocation fixation. Prospective multicenter study of 116 cases. *Orthop Traumatol Surg Res* 2015;101:S313-S316.

48. 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.

49. Kim SH, Lee YH, Shin SH, Lee YH, Baek GH. Outcome of conjoined tendon and coracoacromial ligament transfer for the treatment of chronic type V acromioclavicular joint separation. *Injury* 2012;43:213-218.

50. 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;22:9-17.

51. Virtanen KJ, Savolainen V, Tulikoura I, et al. Surgical treatment of chronic acromioclavicular joint dislocation with autogenous tendon grafts. *Springerplus* 2014;3:420.

52. Simovitch R, Sanders B, Ozbaydar M, Lavery K, Warner JJ. Acromioclavicular joint injuries: diagnosis and management. *J Am Acad Orthop Surg* 2009;17:207-219.

53. De Carli A, Lanzetti RM, Ciompi A, et al. Acromioclavicular third degree dislocation: surgical treatment in acute cases. *J Orthop Surg Res* 2015;10:13.

54. Fauci F, Merolla G, Paladini P, Campi F, Porcellini G. Surgical treatment of chronic acromioclavicular dislocation with biologic graft vs synthetic ligament: a prospective randomized comparative study. *J Orthop Traumatol* 2013;14:283-290.

55. Marchie A, Kumar A, Catre M. A modified surgical technique for reconstruction of an acute acromioclavicular joint dislocation. *Int J Shoulder Surg* 2009;3:66-68.