

Acromioclavicular joint injury

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Acromioclavicular joint injury is common among young active individuals. Stability of this complex structure composes of muscles (deltoid and trapezius), ligaments (acromioclavicular and coracoclavicular) and joint capsule. Clinical and radiographic examinations are crucial for the diagnosis of this injury. Non operative treatment is indicated for type I and II injury. Surgical treatment is, however, indicated for type IV, V and VI injury. Treatment for type III injury is still controversy. Methods of treatment fall into 3 categories, namely: fixation of the acromioclavicular joint, fixation of the coracoclavicular joint and ligament reconstruction. The trend of treatment goes to minimal invasive anatomic acromioclavicular joint reconstruction.

Keywords: Acromioclavicular, AC, Coracoclavicular, CC.

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การบาดเจ็บของข้ออะโครมิโอคลาวิคิวลาพบได้บ่อยในกลุ่มประชากรที่อายุน้อย ความมั่นคงของโครงสร้างนี้มาจากกล้ามเนื้อโดยรอบ (กล้ามเนื้อเดลตอยด์และทราพีเชียส) เส้นเอ็น (อะโครมิโอคลาวิคิวลาและโคราโคคลาวิคิวลา) และแคปซูลที่หุ้มข้ออะโครมิโอคลาวิคิวลา อาการแสดงทางคลินิกและภาพถ่ายทางรังสีวิทยามีความสำคัญในการวินิจฉัยการบาดเจ็บชนิดนี้ การรักษาโดยไม่ผ่าตัดมีข้อบ่งชี้ในการบาดเจ็บระดับที่ 1 และ 2 การรักษาโดยการผ่าตัดมีข้อบ่งชี้ในการบาดเจ็บระดับที่ 3,4,5 และ 6 โดยการรักษาการบาดเจ็บในระดับที่ 3 ยังมีความไม่ชัดเจน การรักษาแบ่งออกได้เป็น 3 กลุ่มคือการยืดตึงข้ออะโครมิโอคลาวิคิวลา การยืดตึงข้อโคราโคคลาวิคิวลา และการสร้างเสริมเส้นเอ็นแนวโน้มในการรักษาในปัจจุบันเป็นไปในลักษณะที่เป็นการสร้างเสริมเส้นเอ็นแบบแผลเล็กบาดเจ็บน้อย.

คำสำคัญ: ข้ออะโครมิโอคลา, กระดูกไหปลาร้า, กระดูกสะบัก.

Injury to the acromioclavicular (AC) joint represents approximately 40 - 50% of the shoulder injuries.⁽¹⁾ Treatment options between conservative and surgery are still controversy.⁽²⁾ Recently, minimal invasive surgical treatment tends to earn more popularity.

Anatomy and biomechanics

The AC joint is a diarthrodial joint located between the distal end of the clavicle and medial border of the acromion process of the scapular. Inclination of this joint is almost vertical or incline downward and medially with the clavicle overriding the acromion by the angle of 50 degrees. Articular surface of clavicle overrides the articular surface of the acromion by approximately 50%. Fibrocartilagenous intra-articular disc is divided in 2 types: complete and partial (meniscoid). The disc degenerates and reaches non-functional state at the fourth decade. Nerve supply to the AC joint derives from the axillary, suprascapular and lateral pectoral nerves.

The dynamic stabilizers to the AC joint compose of the anterior portion of deltoid muscle and the upper portion of trapezius muscle. In the presence of disruption of the AC and the coracoclavicular (CC) ligament, the importance of these structures increases.

The AC joint is surrounded by a thin capsule, reinforced by the superior, inferior, anterior and posterior AC ligaments. These structures predominantly control the horizontal motion of the clavicle. The posterosuperior capsule prevents posterior translation of the clavicle.⁽³⁾ Distal clavicle resection up to 1 cm renders the stability of the AC

joint by increasing posterior translation up to 32%.

The CC ligament is a very strong ligament which runs from the outer inferior surface of the clavicle to the base of the coracoid process. The CC ligament has 2 components, namely: the conoid and trapezoid ligaments. The average distance between the clavicle and the coracoid process (CC interspace) is 1.3 cm and the average distance from the lateral end of the clavicle to the most lateral extent to the trapezoid ligament is 1.53 cm.

The clavicle rotates about 40 - 50 degrees along the longitudinal axis during full abduction but actual motion of the clavicle is only 5-8 degrees in relation to the acromion because of the downward rotation of the scapula. This mechanism is called synchronous scapuloclavicular rotation. The CC ligament is responsible for dictating scapulothoracic motion. The primary function of the CC ligament is the prime suspension to the upper extremity.

Mechanism of injury

Injury to the AC joint can be divided into 2 categories, namely: direct and indirect mechanisms. The direct mechanism occurs when the patient falls on the shoulder with the arm at the side in adducted position. This mechanism is probably the most common cause of AC joint injury. The force drives the acromion downward and medialward. If no fracture occurs, the force initially sprains the AC ligament then may progress to tear the AC and CC ligaments and finally tear the deltoid and trapezius muscles.

Indirect force, which is less common, generated by a fall on outstretch arm with superior direct force. The force is transmitted to the AC joint rather than CC ligament.

Classification

AC joint injury is classified according to the extent of the injury to the AC and CC ligaments by the magnitude of force. Injury to the AC joint is graded according to Allman ⁽⁴⁾ and Tossy et al. ⁽⁵⁾ who

differentiated the injury into 3 types depend on the integrity of the AC and CC ligaments. Rockwood ⁽⁶⁾ added type IV, V and VI AC joint injury to the original classification scheme.

Type I injury: Sprain of the AC ligament; intact AC and CC ligaments, (Figure 1) intact deltoid and trapezius muscles; no visible deformity, not tender over CC Interspace; minimal swelling and tender over AC joint.

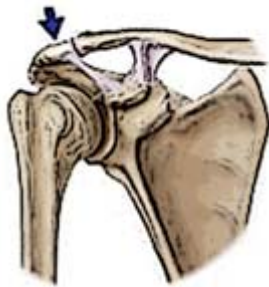


Figure 1. Type I injury.

Type II injury: Disrupt AC ligament (widening both AC and CC interspace), (Figure 2) Sprain of the CC ligament, intact deltoid and trapezius muscles

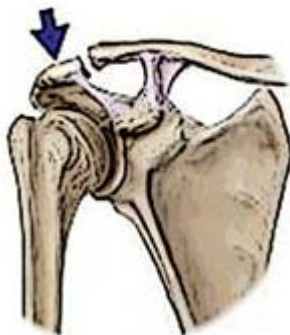


Figure 2. Type II injury.

Type III injury: Disrupt both AC and CC ligaments, (Figure 3) Deltoid and trapezius muscles usually detached, Dislocate AC joint and increase CC distance (25 - 100% of normal shoulder)



Figure 3. Type III injury.

Type III variants: Fracture coracoid process, physeal injury Pseudodislocation (intact periosteal sleeve)

Type IV: Disrupt both AC and CC ligaments

(Figure 4) Deltoid and trapezius muscles usually detached,
Clavicle is displaced posteriorly into or through trapezius muscle,
CC interspace may appear intact

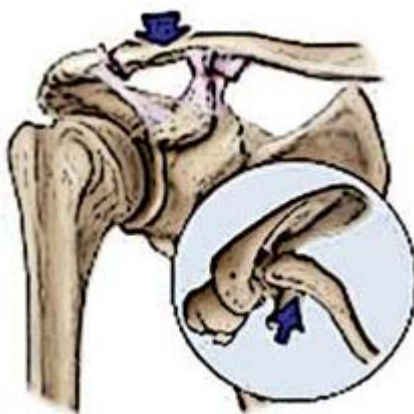


Figure 4. Type IV injury.

Type V: Disrupt both AC and CC ligaments,

(Figure 5) Deltoid and trapezius muscles usually detached,
AC joint grossly dislocated superiorly,
Markly increased CC distance (100 - 300% of normal shoulder)



Figure 5. Type V injury.

Type VI: Disrupt AC and CC ligament
 (Figure 6) Deltoid and trapezius muscles usually detached,
 Clavicle is displaced inferior to the acromion or coracoid processes
 As a result of hyperabduction and external rotation



Figure 6. Type 6 injury.

Diagnosis

During physical examination, the patient should be in a standing or a sitting position without supporting to the injured arm. The weight of the arm can make the deformity more apparent. Findings on physical examination are related to the severity of the injury. Local swelling, deformity, contusion, and ecchymosis maybe seen. Pain with arm motion as

well as pain over the AC joint and CC interspace should be noted. Pain is often accentuated by abduction and cross body adduction. Active compression test (O'Brien) is positive when pain can be located on the top of the shoulder while the patient is asked to resist forward elevation (with arm position in forward flexion to 90 degrees, adduction to 10 degrees and internal rotation)

In the subacute phase (3 - 12 weeks after injury), vertical and horizontal stability of the AC joint should be tested. By stabilizing the clavicle and placing an upward force under the ipsilateral elbow, AC joint will be reduced. Then grasp the clavicle with index and thumb and attempt to translate the clavicle anteriorly and posteriorly to assess horizontal stability. Sternoclavicular joint should always be examined for associated anterior dislocation. Also the neurological status of the affected extremity should be evaluated to rule out brachial plexus injury.

Radiographic evaluation

Standard radiographs are essential to diagnose and classify AC joint injury. Routine radiographs for the AC joint require one third to one half of the x-ray penetration needed for routine glenohumeral radiographs. Routine radiographs

include true anteroposterior and axillary lateral views. Additionally, Zanca view (10° - 15° cephalic tilt, AP standing view) is useful when small fracture or loose body is suspected on the routine view. Comparative radiographs of the uninjured shoulder maybe needed to determine the normal CC distance and the relative normal position of the normal clavicle. Stress radiograph is used to test the integrity of the CC ligament and should be performed when AC dislocation is suspected (differentiate between type II and type III injuries).

Coracoid fracture should always be suspected when faced with AC dislocation in the presence of normal CC distance. Axillary radiograph can demonstrate coracoids fracture. If coracoid fracture is suspected on the axillary view, Stryker notch view will almost always demonstrate this pathology.



Figure 7. Demonstrates difference between normal true AP (A) and stressed (B) radiograph. Note significant increased CC distance on the stressed radiograph.

Treatment

Nonsurgical treatment

Most authors suggested that nonsurgical treatment is recommended for type I and type II injury. Many methods of reduction and immobilization such as sling, plaster cast, adhesive tape strapping, brace, harnesses and traction techniques are proposed. Urist⁽⁷⁾ summarized more than 35 forms of non-operative management. A period of immobilization is required to alleviate the stress to the AC and CC ligaments. Type I injury can be treated using a simple sling for 7 - 10 days or until the pain subsides. Type II requires longer time of immobilization (usually 10 - 14 days). Once the pain has subsided, gradual rehabilitation program is started beginning with passive or active assisted range of motion exercise. After full-painless motion is achieved, isometric strengthening program is begun. Contact sport should be avoided for 2-3 months to prevent further injury to the shoulder.

The most controversial issue is the treatment of type III injury. Several studies have demonstrated long-term disability and pain with non-operative treatment. Bannister *et al.*⁽²⁾ conducted a randomized, prospective, controlled trial comparing surgical treatment of AC joint injury type III and type V using CC screws versus sling immobilization. Following the same rehabilitation program, patient with AC joint displacement of less than 2 cm has better outcome with nonsurgical treatment. In severe AC joint injury (AC displacement more than 2 cm), 20% have good result with non-operative treatment while 70% in the surgical group have good to excellent results. In contrast, meta-analysis by Phillips⁽⁸⁾ demonstrated that the results of operative and non-operative groups of type III injury were similar in the aspect of patient

return to work, strength and range of motion but higher complication rate was found in the operative group. The key to success of non-operative treatment is an appropriate rehabilitation program.^(9, 10) The active rehabilitation program focuses on regaining the strength of the shoulder girdle muscle including deltoid, trapezius, sternocleidomastoid, periscapular stabilizer and rotator cuff muscles.

After injury, the shoulder is immobilized with arm sling for 2 weeks. Cold compression can be applied to reduce pain and swelling. Active and passive range of motion exercise is initiated after the pain has resolved. In this phase, forward flexion should not exceed 90 degrees and lifting weight more than 5 lbs. should be prohibited. At 8 weeks, full active motion and initial resistive exercise should be started. Patient can return to work and full sport activity at 12 weeks.

Surgical treatment

Relative indication for surgery in acute type III AC joint injury (less than 3 weeks after injury) is young adult with high demand sport or labor worker. In chronic (more than 3 months after injury) type III AC joint injury, pain and instability may indicate surgical intervention.

Acute injuries of type IV, V and VI dislocation require surgical intervention. Still, there is no consensus which technique is the best. Surgical interventions are categorized into 3 groups: fixation of the AC joint, fixation between coracoid process and clavicle and ligament reconstruction. Nowadays, most surgeons use a combination of procedures to achieve the maximal stability in order to reduce pain and gain maximum strength of the shoulder.

Fixation of the AC joint

Historically, the first instrument used to stabilize the AC joint is smooth or threaded pin. Lizaaur⁽¹¹⁾ advocated the use of 1.8 mm Kirshner-wire (k-wire) to stabilize the joint and emphasize the repair of deltoid and trapezius muscles. Several studies reported good long- term result using non-threaded K-wire across the AC joint.⁽¹²⁾ Sage and Salvatore⁽¹³⁾ recommended AC ligament repair to enhance the stability of the AC joint. This technique is losing popularity because of its major catastrophic complication of pin migration which was reported to migrate to the great vessel, spinal canal, lung and heart.^(14, 15) Hook plate is an alternative technique of fixation of the AC joint. After reduction, the lateral end of the plate is inserted under the acromion and levered down the clavicle to its anatomic position. Bicortical screws are used to secure the plate to the clavicle. Plate removal is recommended at 8 weeks. Recent work of Salem and Schmelz reported a good clinical outcome with this technique.⁽¹⁶⁾ Ladermann et. al. reported good intermediate result of AC and CC cerclage reconstruction with nonabsorbable sutures.⁽¹⁷⁾

Fixation between coracoid and clavicle

Various methods of CC joint stabilization have been reported including screws, suture, synthetic or metallic loop.⁽¹⁷⁾ In 1941, Bosworth advocated lag screw fixation between the coracoid and the clavicle without repairing the AC and CC ligaments. Esenyel *et al.*⁽¹⁸⁾ modified original Bosworth technique by combining screw fixation with the repair of the CC ligament. In chronic injury, several surgeons combine screw fixation with ligament reconstruction and report satisfactory results.^(19, 20)

A recent technique uses metallic button with heavy non-absorbable suture (Tightrope and Graftrope: Arthrex, Endobutton: Smith & Nephew) passing under the coracoid and secure to the superior border of the clavicle with the second button.⁽²¹⁻²⁸⁾ Biomechanical study comparing Tightrope versus Mesh tape demonstrated that Tightrope has superior mechanical property in controlling the horizontal and vertical stability.⁽²⁵⁾ Walz et al.⁽²⁶⁾ demonstrated that Tightrope is a stable and functional reconstruction with equal or even higher force compared to the native ligament. This technique can be used in conjunction with ligament reconstruction.

Synthetic loop placed between the coracoid and the clavicle gains more popularity nowadays. This technique can be used in combination with CC ligament reconstruction.^(21, 29) Main advantage of this technique is that it does not require implant removal like plate or screws. However, several cases of aseptic reaction and clavicle osteolysis have been reported.^(30, 31)

Ligament reconstruction

This technique of using coracoacromial (CA) ligament to reestablished AC joint stability originally was described by Weaver and Dunn.⁽³²⁾ The CA ligament is detached from the deep surface of the acromion with or without bone and transferred to the distal clavicle. This construct may be augmented with loop of suture or synthetic material to allow protection of the healing ligament.⁽³³⁻³⁶⁾ Major modification of this technique is to resect the distal clavicle to avoid late degeneration of the AC joint which might cause pain. Recently, all-arthroscopic technique was proposed for CA ligament transfer.^(22, 37)

Semitendinosus graft is used to reconstruct the CC ligament by making a loop under the coracoid or through the coracoid tunnel and fix with interference screw. ⁽³⁸⁻⁴⁰⁾ Modifications of this technique vary from graft selection, fixation method and graft route. ^(41, 42) Biomechanical study by Kristen ⁽⁴³⁾ demonstrated that anatomic semitendinosus allograft reconstruction gave higher biomechanical property than other reconstruction modalities (Graftrope, nonanatomic allograft, modify Weaver- Dunn technique, anatomic suture). Several biomechanical studies demonstrated significant superior outcomes of semitendinosus tendon graft compared to the modified Weaver-Dunn procedure. ^(34, 35) Cleverger *et al.* demonstrated no significant difference in biomechanical strength of adjunct CA ligament transfer in patients who underwent AC joint reconstruction with hamstring graft. ⁽³⁶⁾

Distal clavicle resection

According to Gurd ⁽¹⁰⁾ excision of the distal end of the clavicle is suitable for chronic symptomatic AC joint injury. The amount of resection varies from 1-2.5 cm. This procedure must be performed in patient who have intact CC ligament or performed in combination with CC ligament reconstruction. When this procedure is performed in patients with horizontal and vertical instability the result is compromised.

Complications

Complications can occur in both surgical and nonsurgical treatments of AC joint injury. Common complications associated with nonsurgical treatment include persistent instability and development of late arthrosis of the AC joint.

Complications following surgical treatment are related to the technique chosen. Wire breakage and migration to the major vessels and lung have been reported. Foreign body reaction and infection might occur after the use of synthetic material. Fracture of the coracoid process and the clavicle is related to the procedure which has been chosen. The brachial plexus and axillary artery can be endangered when the graft or synthetic material is passed medial to the coracoid. Recurrent instability has been reported in every technique.

Rehabilitation

After CC fixation with screw or suture, the shoulder should be immobilized with an arm sling for 2 weeks. Active and passive range of motion exercise is initiated at week 2 - 4 but forward flexion more than 90 degrees should be avoided. After 4 weeks, full active and passive motion is encouraged and limited light resistance exercise is continued for 8 weeks. After full motion and strength are achieved, patient can return to pre-injury activities and sports.

After AC joint reconstruction with tendon graft (autograft or allograft), the patient should be placed in an arm sling for 2 weeks. Pendulum exercise should start at the 2nd week and light activity of daily living at 4th week. Active and passive motion exercise is started at 8th week. Light resistance exercise can be started at 3 months after surgery. Once full motion and strength have been achieved, normal labor work is permitted.

References

1. Kaplan LD, Flanigan DC, Norwig J, Jost P, Bradley J. Prevalence and variance of

- shoulder injuries in elite collegiate football players. *Am J Sports Med* 2005 Aug; 33(8): 1142-6
2. 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 Nov; 71(5): 848-50
 3. Klimkiewicz JJ, Williams GR, Sher JS, Karduna A, Des Jardins J, Iannotti JP. The acromioclavicular capsule as a restraint to posterior translation of the clavicle: a biomechanical analysis. *J Shoulder Elbow Surg* 1999 Mar - Apr; 8(2): 119-24
 4. Allman FL, Jr. Fractures and ligamentous injuries of the clavicle and its articulation. *J Bone Joint Surg Am* 1967 Jun; 49(4): 774-84
 5. Tossy JD, Mead NC, Sigmond HM. Acromioclavicular separations: useful and practical classification for treatment. *Clin Orthop Relat Res* 1963; 28: 111-9
 6. Williams GR, Nguyen VD, Rockwood CA Jr. Classification and radiographic analysis of acromioclavicular dislocations. *Appl Radiol* 1989; 18: 29-34
 7. Urist MR. Complete dislocations of the acromioclavicular joint; the nature of the traumatic lesion and effective methods of treatment with an analysis of forty-one cases. *J Bone Joint Surg Am* 1946 Oct; 28(4): 813-37
 8. Phillips AM, Smart C, Groom AF. Acromioclavicular dislocation. Conservative or surgical therapy. *Clin Orthop Relat Res* 1998 Aug; (353): 10-7
 9. Glick JM, Milburn LJ, Haggerty JF, Nishimoto D. Dislocated acromioclavicular joint: follow-up study of 35 unreduced acromioclavicular dislocations. *Am J Sports Med* 1977 Nov-Dec; 5(6): 264-70
 10. Gurd FB. The Treatment of Complete Dislocation of the Outer End of the Clavicle: An Hitherto Undescribed Operation. *Ann Surg* 1941 Jun; 113(6): 1094-8
 11. Lizaar A, Marco L, Cebrian R. Acute dislocation of the acromioclavicular joint. Traumatic anatomy and the importance of deltoid and trapezius. *J Bone Joint Surg Br* 1994 Jul; 76(4): 602-6
 12. Leidel BA, Braunstein V, Kirchhoff C, Pilotto S, Mutschler W, Biberthaler P. Consistency of long-term outcome of acute Rockwood grade III acromioclavicular joint separations after K-wire transfixation. *J Trauma* 2009 Jun; 66(6): 1666-71
 13. Sage FP, Salvatore JE. Injuries of the acromioclavicular joint: a study of results in 96 patients. *South Med J* 1963 May; 56: 486-95
 14. 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 Jul; 47: 1024-6
 15. Sethi GK, Scott SM. Subclavian artery laceration due to migration of a Hagie pin. *Surgery*. 1976 Nov; 80(5): 644-6
 16. Salem KH, Schmelz A. Treatment of Tossy III acromioclavicular joint injuries using hook plates and ligament suture. *J Orthop Trauma* 2009 Sep; 23(8): 565-9
 17. Ladermann A, Grosclaude M, Lubbeke A, Christofilopoulos P, Stern R, Rod T, Hoffmeyer P. Acromioclavicular and coracoclavicular

- cerclage reconstruction for acute acromioclavicular joint dislocations. *J Shoulder Elbow Surg* 2010 Mar; 20(3): 401-8
18. Esenyel CZ, Ozturk K, Bulbul M, Ayanoglu S, Ceylan HH. Coracoclavicular ligament repair and screw fixation in acromioclavicular dislocations. *Acta Orthop Traumatol Turc* 2010; 44(3):194-8
 19. Sundaram N, Patel DV, Porter DS. Stabilization of acute acromioclavicular dislocation by a modified Bosworth technique: a long-term follow-up study. *Injury* 1992; 23(3): 189-93
 20. Lewicky YM, Robertson CM, Foran JRH, Harwin SF. Anatomic coracoclavicular and acromioclavicular ligament reconstruction for high-grade acromioclavicular separations: the gracilis weave. *Orthopedics* 2010 Mar; 33(3): 166-71
 21. DeBerardino TM, Pensak MJ, Ferreira J, Mazzocca AD. Arthroscopic stabilization of acromioclavicular joint dislocation using the AC graftrope system. *J Shoulder Elbow Surg* 2010 Mar;19(2 Suppl): 47-52
 22. 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 Feb; 26(2): 149-60
 23. Murena L, Vulcano E, Ratti C, Ceconello L, Rolla PR, Surace MF. Arthroscopic treatment of acute acromioclavicular joint dislocation with double flip button. *Knee Surg Sports Traumatol Arthrosc* 2009 Dec; 17(12): 1511-5
 24. 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 Jun ; 38(6): 1179-87
 25. Zooker CC, Parks BG, White KL, Hinton RY. TightRope versus fiber mesh tape augmentation of acromioclavicular joint reconstruction: a biomechanical study. *Am J Sports Med* 2010 Jun; 38(6): 1204-8
 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 Dec; 36(12): 2398-406
 27. Lim YW. Triple endobutton technique in acromioclavicular joint reduction and reconstruction. *Ann Acad Med Singapore* 2008 Apr; 37(4): 294-9
 28. Scheibel M, Ifesanya A, Pauly S, Haas NP. Arthroscopically assisted coracoclavicular ligament reconstruction for chronic acromioclavicular joint instability. *Archives of Orthopaedic and Trauma Surgery* 2007 Nov; 128(11): 1327-33
 29. 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 Nov; 41(11): 1103-6
 30. Boldin C, Fankhauser F, Ratschek M, Haller-Schober EM. Foreign-body reaction after reconstruction of complete acromioclavicular

- dislocation using PDS augmentation. *J Shoulder Elbow Surg* 2004 Jan-Feb;13(1): 99-100
31. Stewart AM, Ahmad CS. Failure of acromioclavicular reconstruction using Gore-Tex graft due to aseptic foreign-body reaction and clavicle osteolysis: a case report. *J Shoulder Elbow Surg* 2004 Sep-Oct; 13(5): 558-61
32. Weaver JK, Dunn HK. Treatment of acromioclavicular injuries, especially complete acromioclavicular separation. *J Bone Joint Surg Am* 1972 Sep; 54(6): 1187-94
33. LaPrade RF, Wickum DJ, Griffith CJ, Ludewig PM. Kinematic Evaluation of the Modified Weaver-Dunn acromioclavicular joint reconstruction. *Am J Sports Med* 2008 Nov; 36(11): 2216-21
34. 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 Jan; 37(1): 181-90
35. 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 Jun;38(6):1196-203
36. 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* 2011Jan; 27(1): 24-30
37. Lafosse L, Baier GP, Leuzinger J. Arthroscopic treatment of acute and chronic acromioclavicular joint dislocation. *Arthroscopy* 2005 Aug; 21(8): 1017
38. Jones HP, Lemos MJ, Schepsis AA. Salvage of failed acromioclavicular joint reconstruction using autogenous semitendinosus tendon from the knee. Surgical technique and case report. *Am J Sports Med* 2001 Mar - Apr; 29(2): 234-7
39. Mazzocca AD, Santangelo SA, Johnson ST, Rios CG, Dumonski ML, Arciero RA. A biomechanical evaluation of an anatomical coracoclavicular ligament reconstruction. *Am J Sports Med* 2006 Feb; 34(2): 236-46
40. LaPrade RF, Hilger B. Coracoclavicular ligament reconstruction using a semitendinosus graft for failed acromioclavicular separation surgery. *Arthroscopy* 2005 Oct; 21(10): 1277
41. Baldwin K, Namdari S, Andersen JR, Lee B, Itamura JM, Huffman GR. Luggage tag technique of anatomic fixation of displaced acromioclavicular joint separations. *Clin Orthop Relat Res* 2010 Jan; 468(1): 259-65
42. Millett PJ, Braun S, Gobezie R, Pacheco IH. Acromioclavicular joint reconstruction with coracoacromial ligament transfer using the docking technique. *BMC Musculoskeletal Disord* 2009 Jan 14; 10(1): 6
43. Thomas K, Litsky A, Jones G, Bishop JY. Biomechanical comparison of coracoclavicular reconstructive techniques. *Am J Sports Med* 2011Apr; 39(4): 804-10