Chapter 39

The Classification and Treatment of Acromioclavicular Separations

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Mechanism of Injury and Classification

The acromioclavicular (AC) joint frequently is injured in physically active individuals including athletes who participate in contact sports. The most common mechanism of injury is a direct blow onto the superior aspect of the shoulder. The most commonly used classification, the Rockwood system, is based on the anatomic structures injured. Rockwood type I and II injuries involve the AC joint capsule; types III, IV, and V injuries involve the coracoclavicular (CC) ligaments as well as the capsule. A type III injury is displaced superiorly, and a type IV injury is displaced posteriorly. In addition to the CC ligament and capsular injuries, a type V injury involves deltotrapezial disruption leading to increased separation and often to incarceration of the clavicle into the deltotrapezial fascia. Type III and V separations that result in superior displacement of the clavicle are believed to be caused by drooping (ptosis) of the arm rather than by he clavicle's rising superiorly. Therefore, a sling that bears part of the weight of the arm often reduces the separation. A type VI injury is rare and involves clavicular displacement inferiorly in a subcoracoid position.[1,2]

Clinical Evaluation

History and Physical Examination

The patient often describes a direct injury to the superior aspect of the shoulder, as in forceful contact with the ground or a fall from a height. There is pain and swelling in the superior aspect of the shoulder. The pain usually precludes the patient's raising the arm or continuing to be involved in sports. There may be associated neck pain or numbness and tingling.

The components of the examination depend on the level of separation. With a type I or II injury, the patient has pain with palpation of the AC joint. Cross-body adduction testing also is painful. The only deformity is slight swelling. With a type III or V injury, the patient has a painful deformity of the AC joint in which the clavicle sits superior to the acromion because of the downward force of the arm. A type III injury often can be reduced when the arm is simply pushed upward while the distal clavicle is held down or when the patient shrugs the shoulders. A type V injury usually cannot be reduced with this maneuver because the clavicle is trapped within the trapezius.[1,2] This distinction is helpful in initial surgical decision making: a type V injury is best treated surgically, and a type III injury still is considered to be best treated nonsurgically.[3,4] However, the preferred treatment of type III injuries is controversial. A type IV injury is notable for the posterior protrusion of the clavicle. Often the protrusion is subtle and best seen radiographically, but in some patients it can be seen on physical examination if the patient is closely evaluated for horizontal instability.

Imaging

Injury to the AC joint generally can be definitively diagnosed through radiographs. The AC joint view (also called the Zanca view) typically shows the separation well (**Figure 1,** *A*). This view is obtained with reduced radiation and the x-ray beam directed 15° cephalad to avoid overlap between the spine of the scapula and the AC joint. An axillary view is essential to detect posterior displacement in a type IV injury (**Figure 1,** *B*). Radiographs also are important in ruling out the main differential diagnosis, which is a distal clavicle fracture that can mimic an AC joint separation. In a young adolescent patient, a periosteal sleeve fracture can be identified if only a thin line of calcification from the periosteum is noted around a displaced distal clavicle. Imaging of the entire clavicle and scapula may be indicated to ensure the patient does not have an associated sternoclavicular injury (a bipolar clavicle) or a fracture within the clavicle or scapula (a floating shoulder), especially if tenderness or swelling is noted within these areas.

In a type I injury, there is no evidence of separation on plain radiographs. In a type II injury, often there is slight widening or superior elevation that can only be

Neither Dr. Klepps nor any immediate family member has received anything of value from or has stock or stock options held in a commercial company or institution related directly or indirectly to the subject of this chapter.

Figure 1 **A,** AP (Zanca) radiograph of the AC joint showing a type III separation with 100% displacement of the clavicle superior to the acromion. **B,** Axillary radiograph of the shoulder showing the clavicle posteriorly displaced relative to the anterior edge of the acromion.

appreciated by radiographically comparing the injured and contralateral AC joints. For a thin patient, one radiograph often is sufficient for obtaining an image of both joints. For a larger patient, bilateral views can be helpful if a type II separation is suspected. Although bilateral views showing type II separation do not significantly affect management, they can be useful for confirming the diagnosis for the patient. Weighted radiographs generally are not helpful and have fallen out of favor. The increase in coracoclavicular distance (best seen on contralateral radiographs) is 25% to 100% in a type III injury and 100% to 300% in a type V injury.[1] Type IV injuries are best seen on axillary views with the clavicle sitting posterior to the anterior edge of the acromion.

Surgical Versus Nonsurgical Treatment

Type I and II separations are treated nonsurgically to achieve symptom relief and a gradual return to activity. Generally these injuries heal well with a short course of rehabilitation. However, type II separations have been associated with persistent pain, and degenerative changes that have been reported to develop 5 to 10 years after injury.[5] The patient should be made aware of these possible outcomes, but generally they do not affect the initial treatment. Distal clavicle resection can be considered for a patient with a type II separation who remains symptomatic. If instability is noted at time of surgery, AC joint reconstruction also may be necessary; distal clavicle resection alone has been associated with persistent pain believed to result from the underlying instability.[5] For this reason, open resection should be considered for distal clavicle resection following type II separations because it allows manual evaluation for subtle instability.

Although type III separations are controversial, in the United States they are usually treated nonsurgically, with some exceptions.[4] For instance, patients who are overhead athletes or do heavy manual labor have been considered for early repair, but studies have reported good results with nonsurgical treatment even in these patients.[4,6-8] In some countries including Germany and Spain, type III separations generally receive initial surgical treatment.[6,7] There is still no definitive study to show better results after surgical or nonsurgical treatment. A recent meta-analysis did find that surgical treatment led to better cosmesis but not to better results related to throwing, pain, or function.[9] Another attempted meta-analysis did not find sufficient randomized controlled studies to form an outcome-based conclusion.[10] One of the six studies examined within this study found that nonsurgical treatment led to an earlier return to sport or work and lower rates of complications such as infection or hardware failure, but that surgical treatment led to higher Constant scores. Unfortunately, the studies in this meta-analysis involved treatment using Kirschner wires (five studies) and hook plates (one study), neither of which is currently considered the best reconstructive option. The question remains as to whether a more modern reconstruction method would outperform nonsurgical treatment for type III injuries.

Nonsurgically treated patients with a type III injury generally require a longer time for complete recovery than those with a type I or II injury; as long as 3 months may be needed for return to full function and return to sport or work. For this reason, there is some question about the advisability of acute repair in athletes injured near the end of the season because a full course of nonsurgical treatment followed by surgery might not provide adequate time for recovery before the next season begins. Arthroscopic surgery and repair options such as the use of cerclage sutures or hook plates are less invasive than the typical reconstruction

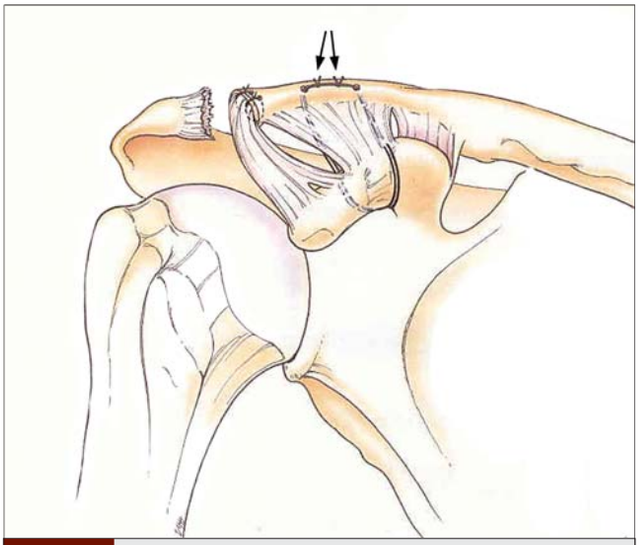

Figure 2 Schematic drawing of the Weaver-Dunn reconstruction, showing the CA ligament transferred to the distal end of the clavicle, with suture augmentation beneath the coracoid and through drill holes in the clavicle *(arrows)*.

and have led to more early repairs being performed. These methods have replaced fixation with Kirschner wires or Bosworth screws, although they work on the same principle. In general, type IV and V separations are initially treated surgically in a healthy patient because these injuries tend to remain symptomatic if treated nonsurgically.

Surgical Treatment

Hundreds of surgical techniques have been described, and it can be difficult to determine which surgical option is best. Surgeons should be aware of the various techniques so as to make an informed decision on the best option for an individual patient. Regardless of the surgical technique, the surgeon must decide whether the distal clavicle needs to be resected as part of the reconstruction. In general, the distal clavicle can be left in place during an acute repair because it has not developed significant hypertrophy or irregularity. Some authors describe removing the intra-articular disk, especially if it is torn.[11] There is some risk of long-term pain or osteoarthritis at the AC joint if the distal clavicle is not resected, but in the short term, patients appear to do well regardless of whether distal clavicle resection is done with the reconstruction. Removing the distal clavicle is believed to add to horizontal instability after repair.[6,11] For chronic separations, the distal clavicle typically is resected, especially if significant irregularity or hypertrophic changes are present.

Several important technical points apply to all AC joint reconstruction techniques; these were developed in part from recent biomechanic and clinical studies. To avoid slippage, it is important to place the sutures or grafts that wrap around the coracoid at the base of the coracoid rather than at the tip. Placing suture anchors into the coracoid or a hole through the coracoid has been proposed as a means of avoiding slippage, but this technique is associated with an added cost for anchor placement and a risk of coracoid fracture because the hole weakens the coracoid.[12,13] When placing sutures or graft around the coracoid it is important to pass them from medial to lateral to reduce the risk of neurologic injury.[14] Augmentation with tape (rather than suture fixation) has become common but can lead to coracoid or clavicle fracture because tape is stronger than suture and can cut through bone. The risk of suture failure has led to the use of multiple sutures; a 91% success rate was reported in suture-only acute repairs in which the suture was placed both in a cerclage fashion beneath the coracoid and either over or through the distal clavicle.[11]The clavicle holes for suture augmentation should not be placed too distally within the clavicle because doing so can lead to widening of the AC joint space as it pulls the clavicle medially. Essentially the same clavicle drill hole location should be used for a Weaver-Dunn and an anatomic reconstruction. Overreduction of the clavicle is useful in compensating for stretching of the reconstruction.[2] Wide stripping of the clavicle periosteum with débridement of any scar tissue below the clavicle is essential to allow mobilization and anatomic reduction before the repair.[2] Oversewing the deltotrapezial fascia at the end of the procedure is important for stability, and therefore large, thick flaps of tissue should be mobilized during the exposure.

The Modified Weaver-Dunn Reconstruction

The modified Weaver-Dunn reconstruction has become the standard surgical option, although many variations of AC reconstruction have been proposed over the years. This method involves transferring the coracoacromial (CA) ligament from the acromion to the distal clavicle, with supplementation placed between the coracoid and the clavicle using heavy sutures or suture tapes (**Figure 2**). The modified Weaver-Dunn reconstruction has performed well, but its association with postoperative loosening has led to the development of multiple modifications, such as the Chuinard reconstruction (transfer of the acromion bone fragment with the CA ligament), conjoined tendon transfer, and anatomic reconstruction (free graft transfer).[15]

There are many potential advantages to performing reconstructions using local tissue. For instance, the use of local tissue with its vascular supply for the graft may maximize the healing potential. The sacrifice is minimal; the CA ligament often is taken down to treat impingement without significant effect. The conjoined tendon is transferred in shoulder stabilization procedures such as the Latarjet, with minimal effect. The use of local tissue also avoids the risk of reaction and the cost of using foreign material.

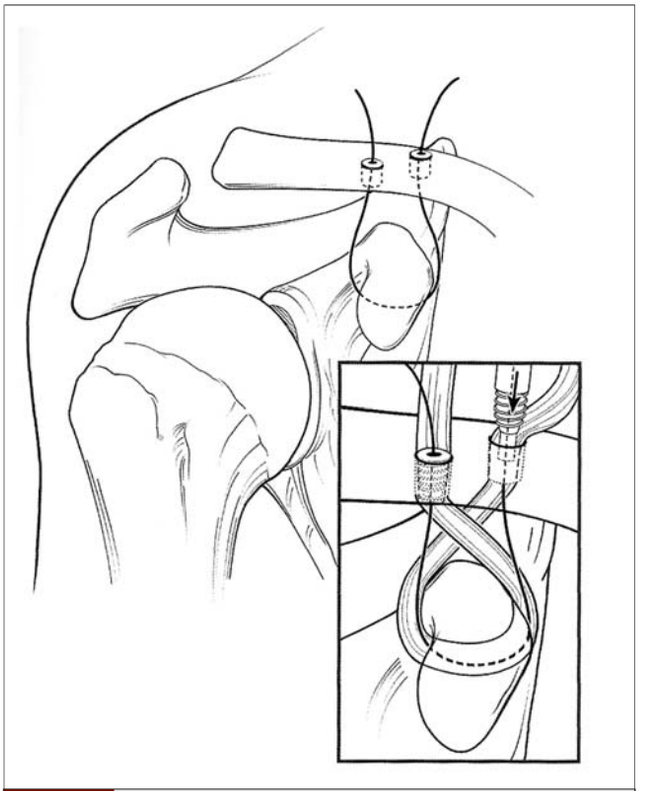

Figure 3 Schematic drawing of the anatomic reconstruction, showing the tendon graft and sutures passed beneath the coracoid and transferred through drill holes in the distal clavicle. Fixation is accomplished with interference screws *(inset)*.

The Anatomic Reconstruction

The anatomic reconstruction has become popular during the past 5 to 10 years primarily as a reaction to the risk of loosening after the Weaver-Dunn reconstruction. Anatomic reconstruction involves transferring a tendinous graft such as the semitendinosus or gracilis around or through the coracoid and through drill holes in the clavicle (**Figure 3**). The main advantages of graft placement below the coracoid is that it provides a stronger construct than a coracoacromial (CA) ligament transfer and is technically easier than the Weaver Dunn reconstruction because mobilizing the CA ligament often leaves inadequate tissue for the reconstruction. Autograft or allograft can be used. The graft can be fixed with sutures or with interference screws in the clavicle. Often the graft is woven onto itself to avoid screw placement. Screws have been shown to provide the biomechanically strongest fixation, but the use of absorbable screws can lead to a reaction (osteolysis) and subsequent fracture. This factor has lead some surgeons to use only sutures for fixation.[12,16]

Often the tendon is extended over the AC joint and attached to the acromion to further strengthen the construct, especially in the anterior-posterior plane. The reconstruction of coracoclavicular ligaments has been shown to provide good superior-inferior stability but to leave anterior-posterior instability, which has been considered a limitation of standard reconstructions. In one new concept, intramedullary graft placed between the acromion and the clavicle is combined with the anatomic reconstruction; this technique has been shown to provide better anterior-posterior stabilization than the anatomic and Weaver-Dunn reconstructions.[16] In cadaver studies, the AC joint capsule has been shown to provide most of the anterior-posterior stability, and superior or intramedullary placement of the AC joint graft is designed to make up for this capsular insufficiency.

As with the Weaver-Dunn reconstruction, it is important to avoid too-distal placement of the clavicle screw holes, which can lead to a widened AC joint. Based on anatomic study, the entire clavicle length is measured as a straight line to determine drill hole placement. The holes are placed at 20% and 30% of the clavicle length from the distal end of the clavicle.[17] Keeping the tunnels at least 15 mm apart also is believed to be useful for decreasing the risk of fracture.[12] Some authors promote a single-tunnel or no-tunnel reconstruction as a means of further decreasing the risk of fracture, but this technique could lead to sawing through or loosening of the tendon.[2,18] Decreasing the size of the clavicle holes, with suture fixation only, also has been recommended.[12] Although several biomechanical cadaver studies have compared the anatomic reconstruction with the Weaver-Dunn reconstruction,[1,2,16,19] these have been time-zero studies using a variety of techniques, and they have not resolved the question of whether the anatomic reconstruction is clinically better than the Weaver-Dunn reconstruction.

One prospective clinical study directly compared the Weaver-Dunn and anatomic reconstructions in 24 patients.[20] The 12 anatomically treated patients had better American Shoulder and Elbow Surgeons Shoulder Index and Constant scores as well as a reduced CC interval. However, patients in both treatment groups had excellent results. Despite these positive results, the question remains as to whether the clinical benefit of anatomic reconstruction justifies the cost of graft and screws, the donor site morbidity, and a possible foreign tissue reaction. Further studies are warranted before the anatomic reconstruction can be strongly recommended over the classic Weaver-Dunn reconstruction.

Arthroscopic Reconstruction

Arthroscopic techniques have been developed for AC joint repair and reconstruction. Acute repair fixation is performed using heavy sutures and locking metal clips, such as the Tightrope device (Arthrex, Naples, FL), placed between the clavicle and the coracoid. This fixation device allows motion through the sutures; unlike screw fixation, it is not rigid, and device removal therefore is not required. The principle is to place the clavicle in its native position in the hope that the CC ligaments will reconstitute themselves. This concept is similar to that of Bosworth screw or Kirschner wire fix-

ation, which is left in place for 6 weeks before removal, but with the advantage of not requiring a second surgery. The Bosworth screw and Kirschner wire fixation methods also carried a risk of screw failure, pin migration, infection, or pullout. Unfortunately, disruption of Tightrope-like devices has occurred.[14] As a result, these fixation devices have been modified by changing the shape or size of the button (for example, to a dog bone shape) or increasing the amount of fixation (as with the double-tunnel technique).[21] Some manufacturers have added tendon to a flip-button device, which can still be placed arthroscopically.[22]

Arthroscopic methods for reconstructing chronic separations also have been developed. These techniques include the GraftRope system and tendon or CA ligament transfer technique (with or without a fleck of acromion).[22,23] A study of 10 patients treated with an arthroscopic Weaver-Dunn procedure for chronic instability reported a 90% success rate.[23] However, no studies have shown a significant advantage to any of the various arthroscopic techniques. There is concern that arthroscopic surgery is inferior to open surgery in the ability to mobilize the distal clavicle or oversew the deltotrapezial fascia; these are believed to be key surgical components, especially for chronic instability. The technical challenges of the arthroscopic techniques have probably prevented them from being more widely used.

One advantage of the arthroscopic technique is that it allows the shoulder to be evaluated for intra-articular pathology at the time of the AC joint repair and reconstruction. One study found a 15% rate of pathology, such as rotator cuff and labral tearing, that can be corrected at the time of AC joint surgery.[24]

Hook Plates

Hook plates have been used for the treatment of AC separations, although in general they are more commonly used for distal clavicle fractures. As with Bosworth screw fixation, short-term placement allows the CC ligaments and other structures to stabilize.[25] However, hook plates did not improve outcomes when compared with suture augmentation, and they required removal. The role of hook plate placement in primary AC joint separations was further called into question by a report of hook plate–specific complications in a study of 313 patients. These complications included hook plate erosion into the acromion with possible acromial fracture (1 patient), hook plate fracture (4 patients), infection (6 patients), and redislocation after hook plate removal (7 patients).[25,26] Hook plates were found to perform best when used with a soft-tissue graft, but this method appears to defeat the purpose of minimally invasive plate placement. A comparison study found better results after Weaver-Dunn reconstruction than after hook plate treatment, including less pain at rest and better Constant scores.[27]

Although hook plates do not appear to have a major role in acute, isolated AC joint injuries, they may have a role in specific patients. For instance, hook plates may be useful for AC separations associated with coracoid or scapula fracture, in which fixation cannot be placed between the coracoid and clavicle (**Figure 4**). The hook plate is placed along the distal clavicle and under the spine of the acromion, with the acromion rather than coracoid relied on for stability. Hook plates also have been used for revision AC reconstruction, especially if excess distal clavicle was resected and poor soft-tissue quality remains.

Rehabilitation

In patients who are nonsurgically treated, the higher grade type III, IV, and V injuries typically require more time for recovery than the lower grade type I and II injuries. A type I or II injury typically requires 2 to 3 weeks of nonsurgical treatment followed by a gradual return to sport, and a type III injury typically requires 4 to 6 weeks. Return to sport requires full range of motion and full strength as well as a nontender AC joint. Nonsurgical treatment is considered unsuccessful if the patient is unable to return to sport or work at 3 months, and surgery should be considered.[28]

A recently developed program of progressive rehabilitation is organized into four phases.[29,30] In phase I, ice, NSAIDs, and minimal immobilization are used in an effort to reduce pain and swelling. Scapula stabilization treatment and lower extremity strengthening are begun. A sling is used for comfort only; patients having a type III injury typically require a longer period of sling use than those with a lower grade injury. Patients advance to phase II when they are at 75% of normal range of motion. Phase II treatment consists of restoring full range of motion, and early strengthening exercises are allowed. Patients proceed to phase III when 75% of strength returns. The goal of phase III is to regain full strength; power and endurance are emphasized. Patients advance to phase IV when the strength of the injured arm equals that of the contralateral arm. Phase IV involves sport-specific training. Patients who do not fully recover after 6 weeks of nonsurgical treatment are more likely to require surgery than patients who do recover.

Many different postoperative rehabilitation protocols have been proposed. Typically, the shoulder is immobilized for the first 6 weeks. During the next 6 weeks, full active and passive range of motion is pursued, with limited lifting. Strengthening is initiated at 3 months, with moderate lifting. Full activity and throwing begins at 4 months, with return to contact sports at 6 months.

Summary

AC joint injuries are common among physically active individuals. Most patients recover well with nonsurgical management and regain full function. A stepwise

Figure 4 AP (**A**) and outlet (**B**) radiographs of a type III AC separation with a displaced coracoid fracture. AP (**C**) and axillary (**D**) radiographs of the hook plate placed for stabilizing the AC joint and a single screw placed into the coracoid for fixation. Interval healing of the fracture can be seen.

approach to rehabilitation appears to best restore patient function. However, certain injury patterns, such as types IV, V, and VI, are best treated surgically. In addition, patients who do not recover after 3 months of nonsurgical treatment also are best treated surgically. Controversy still exists as to the best surgical option, but good outcomes can be expected as long as principles including adequate mobilization, augmented fixation with appropriately placed screw holes and suturing or taping, and appropriate rehabilitation are adhered to. Anatomic reconstruction provides a biomechanically strong reconstruction. Some surgeons have re-

ported the use of less invasive techniques, which may become more popular as better fixation devices are developed or midterm results are reported. Hook plates have become more popular as a method of fixation, but their role in the treatment of AC joint injuries still is being developed.

Annotated References

1. Johansen JA, Grutter PW, McFarland EG, Petersen SA: Acromioclavicular joint injuries: Indications for treatment and treatment options. *J Shoulder Elbow Surg* 2011;20(2, Suppl)S70-S82.

   The management of AC joint injuries is summarized, with a focus on diagnosis and treatment. The role of surgical management is discussed, with indications for surgery based on current literature.

2. Hsu SH, Ahmad CS, Henry PD, McKee MD, Levine WN: How to minimize complications in acromioclavicular joint and clavicle surgery. *Instr Course Lect* 2012;61:169-183.

   The treatment of AC joint injuries is summarized, with a focus on avoiding complications of surgical treatment. Methods for managing and evaluating patients postoperatively are discussed in terms of complications and patient outcome.

3. Nissen CW, Chatterjee A: Type III acromioclavicular separation: Results of a recent survey on its management. *Am J Orthop (Belle Mead NJ)* 2007;36(2):89-93.

   Members of the American Orthopaedic Society for Sports Medicine and orthopedic residency directors were surveyed concerning treatment of type III AC joint separations. More than 80% of respondents recommended nonsurgical treatment.

4. Schlegel TF, Burks RT, Marcus RL, Dunn HK: A prospective evaluation of untreated acute grade III acromioclavicular separations. *Am J Sports Med* 2001; 29(6):699-703.

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6. Lizaur A, Sanz-Reig J, Gonzalez-Parreño S: Long-term results of the surgical treatment of type III acromioclavicular dislocations: An update of a previous report. *J Bone Joint Surg Br* 2011;93(8):1088-1092.

   At an average 24-year follow-up of 38 patients treated with Kirschner wire fixation for acute AC joint separation, 35 patients were satisfied. Two patients had redisplacement, and 1 had osteoarthritis of the AC joint.

7. Bäthis H, Tingart M, Bouillon B, Tiling T: The status of therapy of acromioclavicular joint injury: Results of a survey of trauma surgery clinics in Germany. *Unfallchirurg* 2001;104(10):955-960.

8. Bannister GC, Wallace WA, Stableforth PG, Hutson MA: The management of acute acromioclavicular dislocation: A randomised prospective controlled trial. *J Bone Joint Surg Br* 1989;71(5):848-850.

9. Smith TO, Chester R, Pearse EO, Hing CB: Operative versus non-operative management following Rockwood grade III acromioclavicular separation: A meta-analysis of the current evidence base. *J Orthop Traumatol* 2011;12(1):19-27.

   A meta-analysis of six studies attempted to determine whether surgical or nonsurgical treatment of type III AC separation was preferable. Only one study found better results with surgery. The older Kirschner wire technique was used in five studies. Surgical treatment had a better cosmetic result, but nonsurgical treatment was associated with less time to recovery. No difference was found related to strength, pain, or throwing.

10. Ceccarelli E, Bondì R, Alviti F, Garofalo R, Miulli F, Padua R: Treatment of acute grade III acromioclavicular dislocation: A lack of evidence. *J Orthop Traumatol* 2008;9(2):105-108.

    A literature review of the outcomes of surgical and nonsurgical treatment found only five randomized controlled studies. Patients had a similar result regardless of whether they were treated with or without surgery, but those treated surgically had a higher complication rate. Therefore, nonsurgical treatment was found to be valid for these patients.

11. Lädermann A, Grosclaude M, Lübbeke A, et al: Acromioclavicular and coracoclavicular cerclage reconstruction for acute acromioclavicular joint dislocations. *J Shoulder Elbow Surg* 2011;20(3):401-408.

    An excellent result was reported for 34 of 37 patients who underwent AC and CC suture fixation using nonabsorbable sutures for acute AC separation, with no soft-tissue transfer. Isokinetic study found normal function. There was no need for hardware removal.

12. Turman KA, Miller CD, Miller MD: Clavicular fractures following coracoclavicular ligament reconstruction with tendon graft: A report of three cases. *J Bone Joint Surg Am* 2010;92(6):1526-1532.

    Three patients had clavicle fracture after CC ligament reconstruction with tendon graft. This complication may be avoidable with preoperative counseling to avoid postoperative overactivity, use of small-diameter tunnels, maintenance of an adequate bone bridge, and avoidance of posterior cortical breach.

13. Gerhardt DC, VanDerWerf JD, Rylander LS, McCarty EC: Postoperative coracoid fracture after transcoracoid acromioclavicular joint reconstruction. *J Shoulder Elbow Surg* 2011;20(5):e6-e10.

    The risk of coracoid fracture after AC joint reconstruction using transcoracoid fixation should be considered in choosing the best reconstructive method.

14. Motta P, Maderni A, Bruno L, Mariotti U: Suture rupture in acromioclavicular joint dislocations treated with flip buttons. *Arthroscopy* 2011;27(2):294-298.

Four of 20 patients undergoing acute AC joint repair using flip buttons had postoperative suture rupture. All patients had hyperlaxity. Horizontal instability of repair may lead to shearing of the suture and subsequent failure of repair.

15. Jiang C, Wang M, Rong G: Proximally based conjoined tendon transfer for coracoclavicular reconstruction in the treatment of acromioclavicular dislocation: Surgical technique. *J Bone Joint Surg Am* 2008; 90(Suppl 2 Pt 2):299-308.

    The lateral half of the conjoined tendon was used, rather than the CA ligament, for AC joint reconstruction in 38 patients. They result was good or excellent in 89% of patients. The main advantage is the adequate soft tissue, with no sacrifice of the CA arch or need for soft-tissue transfer.

16. Gonzalez-Lomas G, Javidan P, Lin T, Adamson GJ, Limpisvasti O, Lee TQ: Intramedullary acromioclavicular ligament reconstruction strengthens isolated coracoclavicular ligament reconstruction in acromioclavicular dislocations. *Am J Sports Med* 2010;38(10):2113-2122.

    A cadaver study compared CC anatomic reconstruction alone and with intramedullary graft placement in the AC joint. The intramedullary graft improved horizontal stability.

17. Rios CG, Mazzocca AD: Acromioclavicular joint problems in athletes and new methods of management. *Clin Sports Med* 2008;27(4):763-788.

    The relevant anatomy, classification, evaluation, and treatment of AC joint pathology is systematically reviewed.

18. Grutter PW, Petersen SA: Anatomical acromioclavicular ligament reconstruction: A biomechanical comparison of reconstructive techniques of the acromioclavicular joint. *Am J Sports Med* 2005;33(11):1723-1728.

19. Thomas K, Litsky A, Jones G, Bishop JY: Biomechanical comparison of coracoclavicular reconstructive techniques. *Am J Sports Med* 2011;39(4):804-810.

    A cadaver study compared Weaver-Dunn, nonanatomic allograft, anatomic allograft, anatomic suture, and GraftRope reconstructions. In comparison with native control shoulders, the anatomic allograft had the highest load to failure, which was significantly higher than those of the other subgroups. The nonanatomic allograft technique did not bring the tendon through the clavicle and did not weave the tendon on itself. No significant difference was found among other subgroups.

20. Tauber M, Gordon K, Koller H, Fox M, Resch H: Semitendinosus tendon graft versus a modified Weaver-Dunn procedure for acromioclavicular joint reconstruction in chronic cases: A prospective comparative study. *Am J Sports Med* 2009;37(1):181-190.

    A retrospective study of 24 patients compared the Weaver-Dunn and anatomic reconstructions. The 12 patients who received the anatomic reconstruction had superior clinical and radiographic outcomes.

21. Scheibel M, Dröschel S, Gerhardt C, Kraus N: Arthroscopically assisted stabilization of acute high-grade acromioclavicular joint separations. *Am J Sports Med* 2011;39(7):1507-1516.

    Arthroscopically assisted stabilization of acute AC separation using a double TightRope technique had excellent clinical result in 28 patients, despite greater CC distance compared with the contralateral side. Patients' fairly high rate of horizontal instability did not appear to affect the clinical results.

22. DeBerardino TM, Pensak MJ, Ferreira J, Mazzocca AD: Arthroscopic stabilization of acromioclavicular joint dislocation using the AC graftrope system. *J Shoulder Elbow Surg* 2010;19(2, Suppl)47-52.

    Early results are reported for the AC flip button device with incorporated allograft as used for arthroscopic repair of acute AC joint separations. No complications were reported, and patients had an early return to function.

23. 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(2):149-160.

    Ten patients with chronic AC joint instability underwent arthroscopic CA ligament transfer along with a fleck of acromion. All patients were satisfied, and 9 returned to sport. One patient had a superficial infection. The bone fragment healed in 8 patients. Level of evidence: IV.

24. Pauly S, Gerhardt C, Haas NP, Scheibel M: Prevalence of concomitant intraarticular lesions in patients treated operatively for high-grade acromioclavicular joint separations. *Knee Surg Sports Traumatol Arthrosc* 2009; 17(5):513-517.

    Forty patients underwent diagnostic arthroscopy during surgery for high-grade AC separation. Six patients (15%) were found to have pathology including 2 with subscapularis tears, 3 with superior labrum anterior and posterior (SLAP) tears, and 1 with a combined supraspinatus-subscapularis tendon tear.

25. Kienast B, Thietje R, Queitsch C, Gille J, Schulz AP, Meiners J: Mid-term results after operative treatment of rockwood grade III-V acromioclavicular joint dislocations with an AC-hook-plate. *Eur J Med Res* 2011; 16(2):52-56.

    Midterm results were reported for an AC hook plate used to treat of 313 acute AC joint separations. The result was excellent in 89%, with an average Constant score of 92.4. The complication rate was 10.6%, with six infections, one acromial fracture, and seven redislocations.

26. Chiang CL, Yang SW, Tsai MY, Kuen-Huang Chen C: Acromion osteolysis and fracture after hook plate fixation for acromioclavicular joint dislocation: A case report. *J Shoulder Elbow Surg* 2010;19(4):e13-e15.

Acromial osteolysis followed by fracture developed after hook plate placement for AC separation. The patient did not have the plate removed 4 months after surgery, as recommended, and the complication developed at 8 months. Early plate removal is recommended.

27. Boström Windhamre HA, von Heideken JP, Une-Larsson VE, Ekelund AL: Surgical treatment of chronic acromioclavicular dislocations: A comparative study of Weaver-Dunn augmented with PDS-braid or hook plate. *J Shoulder Elbow Surg* 2010;19(7):1040-1048.

    A retrospective study compared Weaver-Dunn reconstructions with polydioxanone braid or a hook plate for augmentation. The clinical results were similar, but the necessity of an additional surgical procedure for hook plate removal led to a recommendation for suture augmentation.

28. Trainer G, Arciero RA, Mazzocca AD: Practical management of grade III acromioclavicular separations. *Clin J Sport Med* 2008;18(2):162-166.

    A protocol is presented for the initial treatment of grade III AC joint separations depending on the timing of injury (in-season or off-season) and the response to initial nonsurgical treatment. Surgery was recommended after 3 months of unsuccessful nonsurgical treatment.

29. Cote MP, Wojcik KE, Gomlinski G, Mazzocca AD: Rehabilitation of acromioclavicular joint separations: Operative and nonoperative considerations. *Clin Sports Med* 2010;29(2):213-228, vii.

    The anatomy and biomechanics of the AC joint are considered in determining a rehabilitation protocol for patients treated nonsurgically or surgically.

30. Lervick GN, Klepps SK: Shoulder dislocations, clavicle fractures, and acromioclavicular separations. *Orthopaedic Knowledge Online Journal*. March 1, 2011. http://orthoportal.aaos.org/oko/article.aspx?article=OKO_SHO042#abstract. Accessed September 6, 2012.

    A practical method is provided for enabling athletes to return to play after AC joint and clavicle injuries based on rehabilitation protocols and biomechanical studies.