Anatomical Double-Bundle Coracoclavicular Reconstruction in Chronic Acromioclavicular Dislocation

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abstract

The purpose of this study was to evaluate the clinical and radiological outcomes of anatomical double-bundle coracoclavicular (CC) reconstruction using the coracoacromial (CA) ligament and the conjoined tendon for the treatment of chronic acromioclavicular (AC) joint dislocation. A retrospective evaluation was performed on 18 patients who underwent an anatomical CC reconstruction using the CA ligament and the conjoined tendon for chronic AC joint dislocation. Patients were treated surgically between April 2007 and January 2012. Mean follow-up was 35.3 months (range, 24-49 months). All patients were evaluated for functional outcomes using the modified University of California, Los Angeles (UCLA) shoulder rating scale for chronic AC injury and the Constant-Murley shoulder outcome score. Range of motion and shoulder and elbow strength were also measured. Plain radiographs were taken to evaluate reduction status and CC distance. Mean modified UCLA shoulder rating scale at final follow-up was 18.1 points (range, 13-20 points). No significant difference in mean Constant-Murley scores existed between the injured and contralateral shoulders ($P= .26$). At final follow-up, 15 (83.3%) patients had well-maintained reduction and 2 (11.1%) patients had a partial loss of reduction. One other patient had a complete loss of reduction due to a postoperative fall. The CC distance was not significantly different between the injured and contralateral shoulders in the immediate postoperative period ($P=.46$) or at final follow-up ($P=.14$). One superficial wound infection occurred and was treated with routine wound care. An anatomical double-bundle CC reconstruction using the CA ligament and the conjoined tendon for the treatment of chronic AC joint dislocation is a reliable surgical method with good results. [Orthopedics. 2015; 38(8):e655-e662.]
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cromioclavicular (AC) joint dislocation is a commonly encountered traumatic injury representing 12% of all dislocations of the shoulder girdle. The most common mechanism of injury is the direct force applied to the site by an individual falling onto the acromion with the upper limb in the adducted position. Acute AC joint injuries were originally classified by Tossy et al and Rockwood extended the classification into 6 degrees of severity.

General recommendations for treatment are nonoperative for type I or II injuries and operative for types IV through VI injuries. The treatment for type III injuries remains controversial, and patients are usually treated nonoperatively, except for young patients with physically demanding occupations or sporting interests. However, 15% to 40% of patients who are treated nonoperatively after an acute, complete AC joint separation report residual pain, painful subluxation, paresthesia, shoulder weakness, fatigue with overhead activities, and cosmetic concerns. When patients experience these symptoms for more than 6 weeks after the initial injury, AC joint dislocation is considered to be chronic because there is a partial or total resorption of the coracoclavicular (CC) ligaments and the healing potential of the ruptured ligaments is limited. Therefore, surgical reconstruction of the ruptured CC ligament complex is an essential procedure to stabilize the clavicle in chronic AC joint dislocation.

Various reconstruction techniques, including the use of coracoacromial (CA) ligament, autogenous semitendinosus tendon, or fascia lata, have been proposed. Some authors use synthetic materials such as polydioxanone sulfate bands, Dacron, carbon fiber, and braided polyester prosthetic ligament to maintain reduction. Weaver and Dunn introduced a promising approach to reconstruct a chronic AC joint dislocation, and it has been widely used and popularized. The Weaver-Dunn procedure uses the CA ligament detached from the acromion and transposes it to the medullary canal at the distal end of the clavicle to reconstruct the CC ligament complex. However, in the original series, the rate of incomplete reduction of the clavicular deformity was 27%, and poor results with a loss of reduction due to avulsion or pullout of the transferred CA ligaments have been reported in other series. To reinforce and protect the reconstruction, several modifications have been introduced for augmentation techniques. Augmentation of the reconstruction is facilitated by screw fixation, cerclage wire, suture anchor, K-wire, or Steinmann pin. However, such methods are associated with disadvantages, including screw breakage, bony erosion, high cost, and pin migration, which can cause serious complications of major vascular injury and penetration of cardiothoracic organs and require an additional procedure for removal.

A better choice is the lateral half of the conjointed tendon on the coracoid process, which is entirely tendinous and can easily be harvested just anterior to the CA ligament without neurovascular injury and without concerns relating to the metal fixation. The CA ligament is also an ideal substitution for the disrupted CC ligament because it is strong, it lies adjacent to the same anatomical layer of the CC ligament, and it is made of the same material. These 2 ligaments are appropriate for anatomical CC reconstruction because they allow a closer reproduction of the normal ligamentous state and achieve anatomical reduction and restoration of normal arthrokinetics.

The purpose of this study was to retrospectively evaluate the clinical and radiological outcomes of anatomical double-bundle CC reconstruction using the CA ligament and the conjointed tendon in chronic AC joint dislocation.

**MATERIALS AND METHODS**

This study was approved by the authors’ institutional review board, and all patients who underwent the procedure were available for review.

Eighteen consecutive patients (14 men and 4 women; 10 right and 8 left shoulders; mean age, 36.5 years [range, 24-52 years]) with chronic AC joint dislocations were treated surgically at the authors’ institution between April 2007 and January 2012 and were included in this study. Inclusion criteria were (1) all type IV and V chronic AC joint dislocations by Rockwood’s classification with more than 6 weeks of surgical delay from initial injury, (2) chronic type III dislocations with persistent pain or functional loss after conservative treatment, and (3) unilateral injuries. All patients were available for follow-up, including functional outcome assessment and radiological evaluation, for more than 2 years. Patients with a neurologic upper extremity deficit were excluded. All procedures were performed by the same surgeon.

Mechanisms of injury included falling (7 patients), traffic accidents (6 patients), and contact sports (5 patients). There were 5 type III dislocations, 2 type IV dislocations (Figure 1), and 11 type V dislocations. Three patients had multiple associated injuries due to high-energy trauma. Two patients had a history of failed prior surgery on the affected shoulder. All patients underwent anatomical double-bundle CC reconstruction surgery using the CA ligament and the conjointed tendon. Mean follow-up was 35.3 months (range, 24-49 months).

Functional outcomes were evaluated with the modified University of California, Los Angeles (UCLA) shoulder rating scale for chronic AC injury. This rating scale is commonly used to evaluate the postoperative treatment of chronic AC dislocation. This rating system, which has a maximum score of 20 points, includes the following clinical categories: maintenance of reduction, range of motion (ROM), strength, pain, weakness, changes in occupation, patient satisfaction, and complications. Patients are assigned results of excellent, good, fair,
or poor in each category, according to their points. The Constant-Murley shoulder outcome score\(^{26}\) was also used to evaluate the functional outcomes; this system includes the following clinical data: pain, activities of daily living, shoulder ROM, and muscle power. The UCLA score was recorded for the affected shoulder only and the Constant-Murley score was recorded for the injured and contralateral shoulders at final follow-up. Elbow flexion strength was checked on both sides by manual muscle strength test because it can be affected by conjoined tendon transfer. Shoulder and elbow strength and ROM were evaluated by one surgeon using a goniometer.

**Surgical Technique**

Under general or interscalene anesthesia, the patient was placed in the beach-chair position on a radiolucent operating table. A skin incision was made from posterior to the AC joint to the distal tip of the coracoid process. After subcutaneous dissection, the injured AC joint ligament complex was identified (Figure 2A). The deltopectoral interval was then split, with careful attention not to injure cephalic vein, and the anterior portion of the deltoid was detached from the clavicle in the direction of its fibers to expose the coracoid process, CA ligament, and conjoined tendon. By dissecting the interval between the pectoralis major and the deltoid, the conjoined tendon could be exposed.

The lateral half of conjoined tendon was harvested 4 to 5 cm distal to the tip of the coracoid process, which is near the musculotendinous junction (Figure 2B). The CA ligament was also released from the base of the acromion to gain adequate length for transfer (Figure 2C). The muscle fibers and soft tissues were carefully trimmed off from the harvested tendons, and #2 Ethibond sutures (Ethicon, Somerville, New Jersey) were placed into the end of the harvested tendons with Bunnell-type weave sutures (Figure 2D). Next, a temporary reduction was tried with 2 K-wires, which were inserted from the lateral margin of the acromion to the clavicle with manual reduction of the AC joint by direct visualization of the exposed joint (Figure 2E). Anteroposterior and vertical translation was carefully identified, and the status of the reduction was confirmed by fluoroscopy.

The conoid tubercle located on the posteromedial undersurface of the distal clavicle was palpated and identified. The holes for pullout sutures were then drilled. The medial hole was drilled first through the conoid tubercle, and the lateral hole was drilled next, approximately 1 cm from the medial hole obliquely anterolaterally. The suture ends of the lateral half of the conjoined tendon were passed through the medial hole, and those of the CA ligament were passed through the lateral hole (Figure 2F). These suture ends were tied tightly over the surface of the clavicle while verifying the proper tendon length and tension. The K-wires used for provisional fixation were removed. Repair of the deltopectoral fascia and plication of the AC joint were finished (Figure 2G), and routine wound closure.
was performed. Figure 3 displays a schematic illustration of the final construct.

Postoperative Management

An abduction brace was used for 6 weeks postoperatively. Active ROM exercises of the wrist and hand were encouraged immediately postoperatively, and gentle passive shoulder motion through a pendulum exercise was allowed 2 or 3 days postoperatively, when pain had subsided. Progressive active ROM exercises of the shoulder were allowed up to 90° for another 3 weeks after beginning pendulum exercises, and full ROM exercises were allowed 3 months postoperatively. Gentle active ROM exercises of elbow flexion and forearm supination were allowed 3 weeks postoperatively, and forceful motion was prohibited for 3 months due to concerns about donor-site morbidity of the conjoined tendon, which consists of the short head of the biceps brachii and coracobrachialis. The patients were restricted from carrying any weight with the arm or stressing the AC joint by reaching, pushing, and pulling for 3 months, and they were advised to avoid sports for a minimum of 6 months postoperatively. All patients were educated on the scheduled rehabilitation program and the requirement to exercise at least 3 times per day for more than 30 minutes at a time.

Postoperative Evaluation

Postoperatively, anteroposterior (AP) radiographs of both AC joints were obtained for each patient. Axial radiographs were obtained for the affected side only. Plain radiographs were taken every week for 3 weeks, then every 3 weeks for 3 months, and then every 6 months there-
after until final follow-up. The radiographs were used to assess maintenance of reduction of the AC joint, classified as well-maintained reduction, subluxation, and complete loss of reduction. Well-maintained reduction shows no difference in CC distance, which is the height between the upper border of the coracoid process and the inferior cortex of the clavicle, between the injured and contralateral shoulders on AP radiographs. Also, the proper anatomical location is verified between the acromion and the clavicle on axial radiographs. Subluxation shows a difference in CC distance of less than the width of the clavicle. Complete loss of reduction shows a difference in CC distance greater than the width of the clavicle.

The CC distance was measured on radiographs immediately postoperatively and at each follow-up visit. To reduce measurement errors, measurements were obtained twice by each author, and average values were used. Intraobserver reliability was considered as the criteria of Winer (degree of bias and mean squared error). Reliability was classified, according to the intraclass correlation coefficient, as absent to poor (0-0.24), low (0.25-0.49), fair to moderate (0.50-0.69), good (0.70-0.89), or excellent (0.90-1.0). The authors achieved an interobserver reliability of 0.94.

Statistical Analysis

Descriptive statistical analyses were performed using SPSS version 20.0 statistical software (IBM Corporation, Armonk, New York). Wilcoxon signed rank test was performed to compare Constant-Murley score and mean CC distance. A P value less than .05 was considered statistically significant.

RESULTS

Mean modified UCLA score at final follow-up was 18.1 points (range, 13-20 points). Mean Constant-Murley score was 90.7 points (range, 70-97 points) for the injured shoulder and 94.7 points (range, 88-100 points) for the contralateral shoulder at final follow-up. No significant difference existed in Constant-Murley scores between the injured and contralateral shoulders (P=.26). All patients had a symmetrical grade of 5 for elbow flexion strength on the manual muscle strength test at final follow-up. Mean active shoulder ROM at final follow-up was as follows: abduction, 163.5° (range, 135°-170°); forward flexion, 165.7° (range, 140°-170°); external rotation, 50.2° (range, 40°-60°); and internal rotation, 73.3° (range, 50°-90°).

Anatomical reduction was confirmed for all patients at the time of surgery with postoperative radiographs. At final follow-up, 15 (83.3%) of the 18 patients had well-maintained reduction and 2 (11.1%) patients had subluxation with a partial loss of reduction. These 2 patients had CC distances of 14.8 and 15.7 mm, respectively, and UCLA scores of 17 and 18 points, respectively. These 2 patients had full shoulder ROM, no pain with activities of daily living, and no dissatisfaction with their surgical results.

One (5.6%) patient had complete loss of reduction due to an accidental fall 2 months postoperatively. The patient had limited ROM of the shoulder, mild pain and weakness with strenuous activity, a UCLA score of 13 points, and a Constant-Murley score of 70 points. At final follow-up, the CC distance in the injured shoulder was 21.4 mm. However, the patient accepted the functional limit and appearance of the shoulder after the accident and did not want to undergo further surgery.

Immediate postoperative radiographs for all patients showed a mean CC distance of 10.7 mm (range, 9.6-11.8 mm) for the injured shoulder and 10.1 mm (range, 9.4-10.8 mm) for the contralateral shoulder. Mean CC distance at final follow-up was 11.9 mm (range, 9.7-21.4 mm) in the injured shoulder and 10.2 mm (range, 9.5-10.9 mm) in the contralateral shoulder. No significant difference existed between the injured and contralateral shoulders immediately postoperatively (P=.46) or at final follow-up (P=.17) (Figure 4).

Figure 4: Preoperative plain radiograph of a 26-year-old man with a type V acromioclavicular joint dislocation (A). Immediate postoperative radiograph shows satisfactory reduction of the dislocation (B). Radiograph at final follow-up shows a similar coracoclavicular distance to that of the left shoulder and a well-maintained reduction state (C).
One patient had a minor postoperative complication (superficial wound infection) 1 week postoperatively and was treated with routine wound management.

**DISCUSSION**

This study demonstrates a good, stable surgical option for chronic AC joint dislocation by transferring the double-bundle ligaments composed of the CA ligament and the lateral half of the conjoined tendon.

Severe AC joint separation (defined by Rockwood’s classification as types III through VI) could develop chronic symptomatic AC joint instability because the AC joint and surrounding ligaments, which suspend the scapula from the clavicle and support the weight of the upper extremity, are completely destroyed. In such cases, the stability of the joint is only maintained by the muscles, and this causes chronic symptoms of pain and weakness. Some patients report neurologic symptoms secondary to traction on the brachial plexus. This gives a rationale for reconstruction surgical treatment, which provides a chance to restore the normal AC joint anatomy and arthrokinetics. The treatment for chronic AC joint dislocation is challenging, and the results are often inferior to early surgical methods in the acute phase; consensus exists on a gold standard reconstruction technique.

Coracoacromial ligament transfer has been widely used in the treatment of chronic AC joint dislocation because it provides anatomic characteristics similar to the CC ligament and is in an excellent location to harvest. Neviaser was the first proponent to use the CA ligament for the treatment of AC dislocation by releasing the CA ligament from the coracoid process and transferring it to the distal end of the clavicle. Weaver and Dunn detached the CA ligament from the acromion, resected the distal clavicular end, and transposed it to the medullary canal to the lateral end of the clavicle. These procedures have been widely used in the treatment of AC joint dislocation. However, the initial biomechanical strength of the transferred CA ligament is known to have only 25% of the intact CC ligament complex, which is a high rate of loss of reduction. Therefore, several augmentations, such as screw, cerclage wire, suture anchor, K-wire, and Steinmann pin, have been proposed. Coracoclavicular reconstruction using allograft or autograft has also raised concerns recently, and these methods have the disadvantages of requiring a secondary procedure for implant removal, remote donor-site morbidity, and high cost. Above all, the CA ligament is a vascularized graft, which has more potential for healing vs a free tendon graft.

In the current study, the authors used the lateral half of the conjoined tendon on the coracoid process as the source of double-bundle CC reconstruction to supplement the biomechanical weakness of the CA ligament. The strength of the lateral half of the conjoined tendon is slightly stronger than the CA ligament, although not as strong as the native CC ligament. It can be easily harvested at the lateral musculotendinous junction without neurovascular injury because the musculocutaneous nerve passes through the medial muscular portion. Moreover, its origin is on the coracoid process just anterior to the CA ligament, meaning that one skin incision from posterior to the AC joint to the distal tip of the coracoid process is enough to perform the surgery.

The CC ligaments consist of the conoid and trapezoid ligaments. Debshi et al suggested in a fresh-frozen cadaveric study that these ligaments should not be considered as one structure in surgical treatments. Walz et al reported anatomical CC reconstruction of the conoid and trapezoid ligaments using 2 TightRope devices (Arthrex, Naples, Florida). Takase investigated the anatomic structure of the conoid and trapezoid ligaments using 40 shoulders in 20 cadavers. The clavicular attachment area of the conoid ligaments was found on the postero-medial undersurface of the lateral end of the clavicle; mean sagittal dimension of the attachment site was 17.4 mm, and mean coronal dimension was 5.4 mm. The attachment area of the trapezoid ligaments was also evaluated; it was found on the anterolateral undersurface of the lateral end of the clavicle. For the trapezoid ligaments, mean sagittal dimension of the attachment site was 18.5 mm and mean coronal dimension was 15.4 mm. The distance between the center points of each conoid ligament attachment site and trapezoid ligament attachment site was approximately 11.6 mm.

In the current study, the authors focused on the center points of the conoid and trapezoid ligament attachment sites to determine the exact location of the ligament reconstruction. They considered the conoid tubercle to be the center point of the conoid ligament attachment site. This can be a useful intraoperative landmark, which is why the authors drilled the medial hole first through the conoid tubercle. After this, the location of lateral hole was determined to be approximately 1 cm from the medial hole oblique-anterolaterally. The authors focused on restoring the normal anatomy and arthrokinetics with double-bundle ligament reconstruction to substitute the conoid and trapezoid ligaments.

The reconstruction was not augmented by any further metallic fixation because the strength of the transferred CA ligament is almost doubled by the additional transfer of the lateral half of the conjoined tendon. Also, the use of an abduction brace for 6 weeks postoperatively is helpful in protecting the reconstruction. Transarticular AC fixation is associated with pain and arthritis; furthermore, when the pin becomes loose and begins to migrate, it can cause serious complications, such as penetration of the major vessels or cardiothoracic organs, which would require additional procedures for implant removal. Therefore, in the current study, K-wires were used only for temporary fixation intraoperatively...
and were removed after the reconstruction was complete.

This study has some limitations. First, it was a retrospective study without a control group. This is due to the rarity of the chronic type of AC joint dislocation, especially those beyond type III injuries, in clinical practice. A multicenter study and comparisons with groups that use other treatment methods are warranted. Although the early results of this study are promising, longer-term monitoring and larger study populations are required to verify the data.

**Conclusion**

Satisfactory clinical outcomes were obtained with CC reconstruction with the combined use of CA ligament and conjoined tendon transfer. No major complications occurred. This technique has the advantages of not requiring a remote donor site or incurring the costs of allograft or implant use. In addition, it achieves anatomical reduction and restores the normal arthrokineistics of the AC joint. Anatomical double-bundle CC reconstruction using the CA ligament and the lateral half of the conjoined tendon is an acceptable alternative surgical method for high-grade chronic AC joint dislocation.

**References**


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