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# Systematic review of the treatment of acromioclavicular joint disruption comparing number of tunnels and graft type

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**Background:** The management of high-grade acromioclavicular separations remains unclear. The surgical interventions have shifted to more anatomic, less invasive techniques. The purpose of this study was to systematically review the outcomes and complications of anatomic coracoclavicular ligament reconstruction using a tendon graft.

**Methods:** Twenty-one studies (n = 460 patients) met the criteria for inclusion. A double clavicle tunnel tendon graft construct was used in 348 patients (75.7%), whereas a single clavicle tunnel technique was used in 112 patients (24.3%). No significant difference in loss of reduction was found between the 2 techniques. Of 460 patients, 96 (20.9%) demonstrated some form of radiographic displacement at the final follow-up. The overall complication rate was 21.3% (98 of 460), and a higher complication rate was found in the double clavicle tunnel technique ($P < .001$). The overall reoperation rate was 7.6% (37 of 460). The most common reason for reoperation was clavicle fracture (8 of 37). There was a statistically significant increase in reoperation when allograft was used ($P = .003$).

**Conclusion:** The results of this study suggest that despite newer techniques, approximately 20% of patients develop loss of reduction and/or experience a surgical complication. Attempts to minimize trauma to the clavicle and use autograft tendon may reduce the risk of reoperation.

**Level of evidence:** Level IV; Systematic Review

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**Keywords:** Acromioclavicular joint reconstruction; double clavicle tunnel; single clavicle tunnel; outcomes; systematic review; complication rates

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Acromioclavicular (AC) joint disruption is a common injury in athletes and young, active individuals, accounting for nearly 10% of all shoulder injuries.[2] Despite the high prevalence of these injuries, the management of high-grade AC separations remains an area of debate, as indications for

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**Table I** Rockwood classification for AC injury

| | |
|---|---|
| Type I | Sprain of AC ligaments |
| Type II | Disruption of AC ligaments<br>Sprain of CC ligaments |
| Type III | Disruption of AC and CC ligaments |
| Type IV | Similar to Type III with clavicle displaced posteriorly |
| Type V | Disruption of AC and CC ligaments<br>Deltoid and trapezius muscle detachment; CC interspace > 100% wider than in normal shoulder |
| Type VI | Similar to V with clavicle displaced inferiorly under coracoid |

*AC*, acromioclavicular; *CC*, coracoclavicular.

surgery, timing of surgery, and methods of fixation are exceedingly variable.

The most commonly used system for diagnosis is the Rockwood classification (Table I). Operative management has historically been advocated for Rockwood types IV-VI injuries, whereas the optimal management of type III injuries remains uncertain. Furthermore, there is a lack of consensus on the optimal method of surgical treatment, with over 150 different techniques described in the literature.[2] Historical methods of surgical treatment for AC separations included nonanatomic reconstructions, such as the Weaver-Dunn procedure whereby the coracoacromial ligament is transferred to the distal clavicle. However, biomechanical studies have demonstrated the superior strength of various techniques of coracoclavicular (CC) reconstruction over ligamentous imbrication or the Weaver-Dunn procedure.[3]

Recent reports have also detailed the successful application of arthroscopic techniques to perform or augment CC reconstruction.[4,20,26] However, these techniques can be associated with complication rates as high as 42% with short- to mid-term results including suture breakage, coracoid or clavicle fracture, loss of reduction (LOR), infection, or construct failure.[24] However, the complication rates vary significantly in the literature depending on which complications are being considered, the indications for surgery, and the specific surgical technique being used.

Newer, anatomic reconstructions have attempted to better recreate the native anatomy of the conoid and trapezoid ligaments onto the insertion at the coracoid to improve both horizontal and vertical instability associated with high-grade AC separations. These techniques have implemented the principals of strong, initial biomechanical stability while also providing biologic augmentation to aid in long-term healing. In recent years, there has been a growing trend to use tendon grafts as biologic augments for these anatomic CC ligament reconstructions, with numerous studies demonstrating favorable clinical outcomes at short- and mid-term follow-up.[5,9,13,17,19,22,25,28]

However, there is a paucity of comparative data to guide surgeons between the various reconstruction techniques, and little is known about the effects that certain surgical variables, such as graft choice or surgical timing, may have on outcomes. Furthermore, complications such as LOR, clavicle fractures, and coracoid fractures have been reported, leading to poor outcomes and possible revision surgery. Certain surgical aspects, such as the number, size, and position of clavicular and coracoid drill tunnels, have been hypothesized as potential causative factors for construct failure. However, there is no consensus with regard to what technical factors may mitigate these devastating complications. The trend is to minimize bone removal with fewer, smaller holes, while still recreating the anatomic orientation of the CC ligaments to optimize vertical stability. There has also been a growing trend to incorporate biologic augmentation with autograft or allograft to assist with healing, especially when treatment occurs beyond the ''acute'' setting. Acute often refers to treatment within the first 3 weeks of injury, but it remains poorly defined in the literature.

It is difficult to determine the optimal AC reconstruction technique based on the current literature, as older nonanatomic techniques were often included in their analyses. The purpose of this study was to systematically review the outcomes and complications of anatomic CC ligament reconstruction with tendon graft augmentation. Our hypothesis was that modern techniques that minimize bone removal through the coracoid and clavicle may be associated with fewer complications and improve patient outcomes. In particular, we hypothesized that techniques using a single clavicle tunnel and autograft would have fewer complications.

## Materials and methods

### Study design

A systematic, comprehensive literature review was performed on anatomic CC ligament reconstruction using a tendon graft. An initial search was performed, and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines were followed to evaluate and assess study methodology.

### Search strategy

A systematic, computerized search of the literature using PubMed, Embase, and CINAHL was conducted with a controlled vocabulary and keywords related to CC ligament reconstruction and AC joint injury. The timeframe of the search was from January 1, 1980, to December 31, 2017. A references list was populated from this search. To identify relevant articles, 2 reviewers (L.R. and J.L.G.) independently screened titles and abstracts of all identified citations. Full-text articles were retrieved if the abstract provided insufficient information to establish eligibility or if the article had passed the first eligibility screening. Articles with patients younger than 18 years were excluded from the study.

## Inclusion/exclusion criteria

Relevant studies were inspected for eligibility based on the predetermined inclusion and exclusion criteria. Inclusion criteria included clinical studies that investigated anatomic CC ligament reconstruction with a free tendon autograft or allograft. Each study was required to include patient demographic data, surgical indications, complication rate, reoperation rate, and a detailed description of the operative technique sufficient to determine the reconstruction method used. Exclusion criteria included biomechanical studies, anatomic studies, case reports, technique papers, non–English language studies, case series with fewer than 10 patients, studies with less than 12 months' follow-up, and studies investigating nonanatomic reconstructions (such as the Weaver-Dunn procedure), reconstructions for distal clavicle fractures, reconstructions using synthetic ligaments, reconstructions using removable implants, such as K-wires, Bosworth screws, metallic cerclage wires, or Steinmann pins.

## Study selection

Two reviewers (L.R. and J.L.G.) assessed title and abstracts for relevance to the inclusion and exclusion criteria. Full-text documents identified by either reviewer as possibly applicable were then collected for further examination. In the event of a disagreement between the 2 reviewers, a third reviewer (M.J.K.) resolved the discrepancy.

## Quality assessment

Two reviewers independently performed a quality assessment incorporating a modified Downs and Black scale. The Downs and Black scale has been established as a reliable tool for case-control and cohort studies. A consensus for methodological quality was decided on between the 2 reviewers (L.R. and J.L.G.), and a third author (M.J.K.) resolved the disagreement if a consensus could not be reached.

## Data extraction

Data extraction and input into a database were performed by 1 reviewer (L.R.). Disputes concerning the study inclusion and exclusion criteria were resolved through deliberation between 3 reviewers (L.R., J.L.G., M.J.K.). Demographic data points extracted from each study included sample size, sex, age, level of injury, and time to surgery. Surgical variables analyzed included graft type, number of clavicular tunnels, number of coracoid tunnels, size of tunnels, supplemental fixation methods, use of arthroscopy to assist in graft placement, concomitant distal clavicle excision, and the use of supplemental AC reconstruction. Surgical outcome data extracted included length of follow-up, clinical outcome scores, complication rates, radiographic outcomes, and revision surgeries.

# Results

Ultimately, 21 studies were included (Table II). There were 2 Level II studies, 3 Level III studies, and 16 Level IV studies.

## Patient demographics and study characteristics

From the 21 selected studies, 460 patients were treated with a biologically augmented CC reconstruction and used for the study. In the 18 studies that recorded sex, there were a total of 326 males (85.6%) and 55 females (14.4%). Three studies did not record patient sex. Of 21 studies, 19 (398 of 460 patients) recorded the Rockwood grade of the AC separation. There were 151 Rockwood Grade III injuries (37.9%), 20 Grade IV injuries (5.0%), 225 Grade V injuries (56.5%), and 2 Grade VI injuries (0.5%). The time to surgery was recorded in 17 studies. A total of 113 patients (31.9%) were operated on acutely (defined as less than 3 weeks), whereas 241 patients had surgery beyond 3 weeks and categorized as chronic injuries (68.1%).

## Surgical techniques

There were a wide variety of surgical techniques used across 21 studies. However, all techniques were able to be classified as either a double clavicular tunnel (DCT) reconstruction (Fig. 1)[21] or a single clavicular tunnel (SCT) reconstruction (Fig. 2).[21] The most common reconstruction technique was the DCT tendon graft construct, which was used in 16 studies and 348 patients (75.7%). The DCT reconstruction was popularized by Carofino and Mazzocca[5] and involves the independent creation of 2 separate clavicular tunnels to recreate the coronoid and trapezoid ligament origins on the clavicle.

Six studies (112 patients) used an SCT technique. In this technique, an SCT was used to reconstruct the conoid and trapezoid ligaments.[6,12,14,15,17,30] The tendon graft was then looped around the coracoid (2 studies)[6,31] or drilled into the coracoid and secured with a cortical fixation button (4 studies).[14,17,30,32] Among the 112 patients in this group, there were 22 LORs (19.6%), 11 complications (9.8%), and 7 reoperations (6.3%). LOR postoperatively was based on imaging studies measuring the distance of displacement over time or by contralateral comparison. The 3 distances specified in each study were the CC distance of >25% on radiographs from the contralateral side, >10 mm of CC distance on side-to-side radiographs, >10 mm CC distance on follow-up radiographic imaging, or >8 mm distance on ultrasound.

A comparison of the SCT vs. DCT revealed that there were no significant differences between the 2 techniques in terms of LOR or reoperation rates ($P = .71$ and .60, respectively). However, the DCT technique did demonstrate a statistically significant increase in total number of complications compared with the SCT technique ($P < .001$). Complications in this cohort included superficial surgical site infection, deep infection, AC joint instability, clavicular tunnel widening, clavicle fracture, and coracoid fracture.[4,19,23]

**Table II** Studies included in systematic review

| Author (publication year) | Study design | LOE | Enrollment period | Mean age (yr) (SD/range) | Number of patients | Rockwood type, n | Number of tunnels | Tunnel size | Graft type | Complications, n |
|---|---|---|---|---|---|---|---|---|---|---|
| Yoo et al (2010)[31] | Retrospective Case Series | IV | 2005-2008 | 39.8 ± 14.8 | 21 | III: 5; IV: 1; V: 10; fracture: 4 | Single CT: 21 | 5-6 mm (1.5-2 cm from ACJ) | Autograft (SemiT): 21 | Superficial infection: 2 |
| Yoo et al (2011)[32] | Retrospective Case Series | IV | 2007-2009 | 28.4 ± NR | 13 | III: 3; IV: 0; V: 10 | Double CT: 13 | 5.5 mm (×2) (25 and 45 mm) | Allograft (SemiT): 13 | None |
| Garofalo et al (2017)[11] | Retrospective Case Series | IV | 2005-2011 | 28.0 ± 8.3 | 32 | V: 32 | Double CT: 32 | 4 mm (×2) (25 and 40 mm) | Autograft (SemiT): 32 | None |
| Kibler et al (2017)[16] | Case Series | IV | 2009-2014 | 42.0 ± 18.0 | 15 | III: 12; IV: 0; V: 2 | Double CT: 15 | 4.5 mm (×2) (25 and 45 mm) | Allograft (SemiT): 15 | None |
| Petri et al (2016)[23] | Retrospective comparative study | IV | 2006-2012 | 38.6 (18-79) | 41 | III: 41 | Double CT: 12 | 4.5 mm (×2) (25 and 45 mm) | Unspecified Allo/Auto | Clavicle Fx: 1; painful hardware: 1 |
| Virtanen et al (2014)[29] | Retrospective case series | IV | 2005-2011 | 44 (22-59) | 25 | II: 2; III: 6; IV: 1; V: 15 | Double CT: 25 | 5.5 mm (×2) NR | Autograft (SemiT and gracilis) | Wound infection: 2; AC instability: 11; tunnel widening: 20; lateral clavicle osteolysis: 14; AC joint incongruity: 14; clavicle fracture: 3; coracoid fracture: 5; reoperation: 4 |
| Saccomanno et al (2014)[25] | Prospective case series | IV | 2010-2012 | 27.5 ± 8.2 | 18 | III: 8; IV: 4; V: 6 | Double CT: 18 | 5 mm (×2) (20 and 40 mm) | Autograft SemiT: 18 | NR |
| Choi et al (2017)[6] | Retrospective case series | IV | 1999-2013 | 42 ± 12.3 | 30 | III: 20; IV: 0; V: 10 | Single CT: 30 | 4.5 mm (3 cm from ACJ) | SemiT autograft: 30 | Clavicle fracture: 3; ossification of CC interspace; osteolysis of clavicle: 1; superficial infection: 1 |
| Martetschlager et al (2013)[18] | Retrospective case series | IV | 2006-2011 | 43.6 ± 13.3 | 55 | III: 19; IV: 6; V: 34 | Double CT | Allograft group (46 patients): 6 mm (×2) location NR; cortical button group (13 patients) 4 mm (×2) location NR | SemiT allograft: 46 | Coracoid fracture: 1; hardware failure: 2; hardware failure:7; clavicle fracture: 2; hardware pain: 2; PDS granuloma: 1; axillary N compression: 1; frozen shoulder: 1 |

(*continued on next page*)

**Table II** Studies included in systematic review (*continued*)

| Author (publication year) | Study design | LOE | Enrollment period | Mean age (yr) (SD/range) | Number of patients | Rockwood type, n | Number of tunnels | Tunnel size | Graft type | Complications, n |
|---|---|---|---|---|---|---|---|---|---|---|
| Hegazy et al (2016)[13] | Prospective cohort study | III | NR | 39.0 ± 9.8 | 10 | III: 10 | Double CT: 10 | 5.5-6 mm (30 and 45 mm from ACJ) | SemiT autograft: 10 | Superficial infection: 3 |
| Hou et al (2014)[14] | Retrospective cohort study | III | 2003-2009 | 37.0 ± 8.8<br>42.0 ± 10.8 | 11; 10 | III: I; IV: 0; V: 10/IV: 1; V: 8; VI: 1 | Single CT: 11; Double CT: 10 | Single tunnel 6 mm (15-20 mm from ACJ); double tunnel 5.5 mm (30 and 45 mm) | SemiT Allograft: 21 | Coracoid fracture: 1; infection: 2 |
| Fauci et al (2013)[9] | Prospective randomized comparative study | II | 2004-2008 | 35 ± 3.6 | 40 | III: 14; IV: 26 | Double CT: 40: Group A SemitT, Group B synthetic | NR (20 and 45 mm) | Group A: SemiT allograft (20)<br>Group B: LARS (synthetic) (20) | Subluxation: 8; dislocation: 3; ACJ arthritis: 25; CC ossification: 13; clavicular osteolysis: 38 |
| Ye et al (2016)[30] | Prospective RCT | II | 2012-2013 | 33.4 (30-46) | 23 | III: 23 | Double CT: 23 | NR | SemiT autograft: 23 | None |
| Parnes et al (2015)[22] | Retrospective case series | IV | 2011-2012 | 25 (20-35) | 12 | V: 12 | Double CT: 12 | 55 mm (×2) (25 and 45 mm) | Both | Superficial infection: 1 |
| Eisenstein et al (2016)[8] | Retrospective case series | IV | 2000-2013 | 31.3 ± 8.5 | 38 | III: 12; IV: 0; V: 26 | Double CT: 38 | NR | SemiT autograft: 9; SemiT allograft: 26 | NR |
| Millett et al (2015)[19] | Retrospective case series | IV | 2006-2011 | 43.9 ±14.1 | 31 | III: 9; IV: 0; V: 22 | Double CT: 31 | 6.0 mm (×2) (25 and 45 mm) | Allograft (TA: 29; PL: 2) | Distal clavicle fracture: 2; minor complication: 4 |
| Cook et al (2013)[7] | Retrospective case series | IV | 2009-2011 | NR | 10 | III: 2; IV: 0; V: 8 | Double CT: 10 | 5.0-6.0 mm (NR) | Both Auto/Allo | NR |
| Carofino and Mazzoca (2010)[5] | Retrospective case series | IV | 2003-2008 | 44 ±14 | 22 | III: 14; IV: 0; V: 8 | Double CT: 22 | 5.0 mm (×2) (25 and 45 mm) | Allograft (SemiT and TA) | Deep infection: 1; loss of reduction: 1; persistent pain: 1 |
| Jensen et al (2013)[15] | Retrospective case series | IV | 2008-2010 | 40 ± 10 | 16 | III: 11; IV: 0; V: 5 | Double CT: 16 | 6.0 mm (×2) (35 and 45 mm) | Autograft (gracilis): 16 | Superficial infection: 1 |
| Takase and Yamamoto (2016)[28] | Retrospective case series | IV | 2008-2013 | 38.1 ± 12.5 | 22 | III: 0; IV: 0; V: 22 | Double CT: 22 | 4.0 mm (×2) (25 and 45 mm) | Autograft (PL): 22 | NR |
| Kocaoglu et al (2017)[17] | Retrospective cohort study | III | 2008-2013 | 39.7 ± 9.5 | 16 | III: 13; IV: 2; V: 1 | Single CT: 16 | 5.0-6.0 mm (×2) NR | Autograft (PL + GraftRope): 16 | Superficial infection: 1 |

*LOE*, level of evidence; *SD*, standard deviation; *RCT*, Randomized Control Trial; *CT*, clavicular tunnel; *ACJ*, acromioclavicular joint; *LARS*, Ligament Augmentation and Reconstruction System; *TA*, Tibialis anterior; *PL*, Palmaris Longus; *CC*, coracoclavicular; *PDS*, polydioxanone.

**Figure 1** Double clavicular tunnel reconstruction.

**Figure 2** Single clavicular tunnel reconstruction.

Several authors described their methods of augmentation of the graft with nonabsorbable suture, absorbable suture, or cortical fixation buttons across the CC interval. Because of the heterogeneity of these augmentation techniques, further analysis was not possible; however, all of these studies were included as part of the systematic review.

Seven studies (124 patients) in the DCT group routinely used excess tendon graft to reconstruct the AC joint.[5,8,11,16,22,25,29] In these studies, excess tendon graft from the superior aspect of the clavicle after CC ligament reconstruction was secured into the acromion to supplement the AC reconstruction. These studies of concomitant AC reconstruction had 12 LORs (9.6%), 9 complications (7.3%), and 2 reoperations (1.6%). Complications in this cohort included superficial/deep infection, AC joint instability, clavicular tunnel widening, clavicle fracture, and coracoid fracture.[4,19,24]

Nine studies (224 patients) in the DCT group did not perform concomitant AC reconstruction. There were 62 LORs (27.7%), 78 complications (34.8%), and 25 reoperations (11.1%). A comparison of the DCT with and without concomitant AC reconstruction demonstrated a statistically significant decrease in LOR, complications, and reoperation rate ($P \leq .001$, $<.001$, and .001, respectively) for the DCT with the AC reconstruction group.

## Autograft vs. allograft

Ten studies (208 patients) used an autograft for the biologic augmentation.[6,11,13,15,17,25,28-31] The specific type of autograft varied, including semitendinosus (6), gracilis (1), palmaris longus (2), and a combination of semitendinosus and gracilis (1). There were 51 LORs (24.5%), 40 total complications (19.2%), and 11 reoperations (5.3%).

Seven studies exclusively used allograft tendons (163 patients).[5,9,14,16,18,19,32] The type of graft included semitendinosus (4), tibialis anterior (2), and semitendinosus or tibialis anterior (1). There were 16 LORs (9.8%), 28 complications (17.2%), and 23 reoperations (14.1%). When compared with the autograft group, there was a statistically significant increase in reoperations when using allograft tissue ($P = .003$).

## Loss of reduction

All studies (21) reported the final radiographic outcome of the construct. In general, the reconstructions were determined to have either maintained anatomic reduction, subluxed slightly, or completely lost reduction. Nine studies measured the CC distance or AC distance in a method to better quantify the degree of postoperative displacement; the remaining studies used nominal terms of reduced, subluxed, or completely displaced.

Ninety-six of 460 patients demonstrated some form of radiographic displacement (20.9%) at the final follow-up. In the SCT group, 22 of 112 patients demonstrated a complete LOR (19.6%). In the DCT group, 74 of 348 patients demonstrated a complete LOR (21.9%). There was no significant difference between the 2 groups in terms of LOR ($P = .71$).

## Complications and reoperations

The overall complication rate for all techniques described was 21.3% (98 of 460 patients). These complications ranged in severity from coracoid or clavicle fractures to superficial skin infections. A comprehensive list of complications can be found in Table II. There was wide variability across studies with regard to what was considered a complication. For example, some studies considered the presence of calcification in the CC ligaments and

asymptomatic LOR as complications, despite no documented deleterious effect on clinical course or outcome.

Complications were stratified according to the type of reconstruction used.

There were 11 clavicle fractures (2.4%). In the DCT group, there were 8 clavicle fractures among 285 procedures (2.8% fracture rate). In the SCT, there were 3 clavicle fractures among 112 procedures (2.7% fracture rate). A total of 6 coracoid fractures were reported. In the DCT group, 5 coracoid fractures were seen in 285 total cases (1.8% fracture rate). All of these complications occurred in a single case series.[29] In the SCT cohort, only 1 coracoid fracture was demonstrated (0.9%).

Superficial infections were seen in both SCT and DCT groups. In the DCT group, 8 superficial infections were seen (2.3%), whereas the SCT group had 3 superficial infections (2.7%). Chronic infections were rare, occurring in only 2 patients in the DCT group (0.7%). Both patients were treated with removal of the graft.

Reoperation rate was recorded in all studies. There were 37 reoperations out of 460 index surgeries (8% of patients). When comparing SCT and DCT constructs, there was no difference in reoperation rate between the 2 methods (6.3% and 7.6%, respectively, $P = .60$). Clavicle fractures accounted for 8 of 37 revisions (21.6%) and were the most common reason for revision surgery. Five clavicle fractures requiring revision surgery occurred in the DCT group (5 of 348 patients; 0.01%), whereas there were 3 clavicle fractures that required revision surgery in the SCT group (3 of 112 patients; 2.7%).

## Discussion

This systematic review evaluated how surgical techniques and the use of autograft vs. allograft affect the outcomes and complications of AC joint reconstruction. There were 21 studies that met the inclusion criteria with the majority of the studies being Level III and IV evidence. No Level I studies were available. This topic, in particular, has historically been difficult to investigate due to a variety of surgical techniques as well as the relatively small number patients who undergo surgery at each institution.

Biomechanical studies have shown that anatomic reconstruction of the CC ligaments through a double-tunnel technique can improve the native kinematics of the shoulder.[1,27] Attempts to reconstruct the conoid and trapezoid ligaments are attractive because of the improved biomechanical stability but come with the potential increased risk of clavicle fracture. Hou et al[14] performed a retrospective study that compared single-tunnel vs. double-tunnel AC joint reconstruction with a semitendinosus allograft in 21 patients.[14] The majority of the patients had Rockwood type V injuries with a mean follow-up of 16 months. They found that the double-tunnel group had more good-to-excellent University of California, Los Angeles (UCLA) outcomes compared with the single-tunnel group (70%-18%). In contrast, we found no clear consensus as to which technique is superior in terms of loss or reduction or reoperation rates. No significant difference was found between SCT and DCT constructs in terms of LOR or reoperation rates; however, there was a higher overall complication rate when the DCT technique was used (25% in the DCT vs. 9.8% in the SCT).

With regard to graft selection, our review found a higher reoperation rate in the allograft group (14.1% in the allograft group vs. 5.3% in the autograft group, $P = .003$). Interestingly, an increased risk of LOR was found with an autograft compared with allograft (24.5% vs. 9.8%, $P < .001$). This implies that most reoperations are not performed for LOR.

Most studies used a semitendinosus autograft or allograft as the graft of choice. No study directly compared autograft with allograft in the treatment of AC joint reconstruction. However, a recent study by Choi et al[6] evaluated the complications associated with the use of an autograft semitendinosus tendon in acute AC dislocations. In that study, single-tunnel CC ligament reconstruction with a semitendinosus autograft resulted in an LOR rate of 47%. A total of 23% of the patients had reoperation for LOR. Graft elongation was cited as one of the potential reasons for failure, and the authors recommended over-reduction and supplemental nonabsorbable sutures to counteract the elongation.

Biomechanically, the semitendinosus tendon has a similar load to failure when compared with CC ligaments but has been shown to elongate in comparison with native CC ligaments.[10] In this review, the semitendinosus autograft was found to have the least number of reoperations when compared with the allograft but did show an increased LOR when compared with the allograft. Interestingly, securing the excess graft over the AC joint did have a statistically significant improvement with reductions in LOR, complications, and reoperations. Additional studies should consider whether this also results in an improvement in patient-reported outcomes.

The main limitation to this study was the lack of high-level studies in the literature. The majority of papers included in this analysis were Level IV papers with a small number of patients. While attempting to focus on specific variables including number of tunnels and graft choice, the sample size became even smaller. Although this study does provide information regarding the outcomes associated with clavicular tunnels and graft choice, the limited number of high-level studies limited our final conclusions. The interval between onset of injury and surgical intervention was variable. Acute injuries may respond differently to surgery than subacute and chronic injuries. By only including studies with biologic augmentation, most patients were beyond the acute setting in this review. We attempted to combine similar techniques into 2 major categories: autograft vs.

allograft and single-tunnel vs. double-tunnel. However, there is still considerable technique variability within each group, making the interpretation of group comparisons challenging. It could be that other factors, such as size of the tunnels, fixation methods, patient factors, or timing of surgery, could cause significant confounding variability in the outcomes. Additional Level I and II studies are needed to further examine optimal treatment methods for AC joint reconstruction.

## Conclusion

In this systematic review comparing the number of clavicle tunnels and graft type in AC reconstruction, a higher complication rate was found in the DCT group. The allograft group had less LOR but more reoperations. However, despite the technique used, complications and LOR remain high in AC joint reconstruction. More high-level studies are needed to determine the optimal method of surgical treatment. Much of the current evidence guiding treatment is Level III and IV studies. To increase our understanding of the treatment of these injuries, higher level studies including multicentered prospective randomized controlled studies will be needed to further investigate these highly variable injuries.

## Disclaimer

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