# Acromioclavicular Joint Augmentation at the Time of Coracoclavicular Ligament Reconstruction Fails to Improve Functional Outcomes Despite Significantly Improved Horizontal Stability


## Abstract

Purpose

Acromioclavicular joint reconstruction is a well-established and frequently performed procedure. Recent scientific and commercial interest has led to a drive to develop and perform surgical techniques that more reliably restore horizontal stability in order to improve patient outcomes. The aim of this systematic review was to evaluate the biomechanical evidence for procedures directed at restoring horizontal stability and determine whether they are associated with superior clinical results when compared to well-established procedures.

Methods

A review of the online databases Medline and EMBASE was conducted in accordance with the PRISMA guidelines on the 23rd December 2017. Biomechanical and clinical studies reporting either static or dynamic horizontal displacement following acromioclavicular joint reconstruction (Coracoclavicular reconstruction or Weaver-Dunn) were included. In addition, biomechanical and clinical studies reporting outcomes after additional augmentation of the acromioclavicular joint were included. The studies were appraised using the Methodological index for non-randomised studies tool.

Results

The search strategy identified 18 studies eligible for inclusion; six biomechanical and 12 clinical studies. Comparative biomechanical studies demonstrated that acromioclavicular augmentation provided significantly increased horizontal stability compared to the coracoclavicular reconstruction and Weaver Dunn procedure. Comparative clinical studies demonstrated no significant differences between coracoclavicular reconstruction with and without acromioclavicular augmentation in terms of functional outcomes (American Shoulder and Elbow Surgeon and Constant score), complication or revision rates. However, one comparative study did demonstrate an improvement in Taft (p=0.018) and Acromioclavicular Joint Instability scores (p=0.0001) after acromioclavicular augmentation.

Conclusion

In conclusion, coracoclavicular reconstruction with augmentation of the acromioclavicular joint has been shown to provide improved horizontal stability in both biomechanical and clinical studies compared to isolated coracoclavicular reconstruction. However, comparative studies have shown no clinical advantage with respect to American Shoulder and Elbow Surgeon or Constant scores and therefore the results of this systematic review do not support acromioclavicular augmentation in routine clinical practice.

**This systematic review provides level IV evidence**

**Key Terms:**

Acromioclavicular joint dislocation

Acromioclavicular stabilisation

Horizontal stability

Coracoclavicular ligament

## Introduction

Acromioclavicular (AC) joint reconstruction is a well-established and frequently performed procedure for high Rockwood grade injuries [28] (IV and above) and those with grade III injuries that fail non-operative treatment. The aim of surgical treatment is to reduce and fix the AC joint, and repair or reconstruct the coracoclavicular (CC) ligaments. The most frequently performed procedures are the modified Weaver Dunn procedure and anatomic reconstruction of the CC ligaments, which can include a single or double bundle repair technique, using an autograft, allograft or synthetic ligament.

The wide range of surgical procedures reported for the management of AC joint dislocations reflects that each is associated with limitations and that none have been demonstrated to be superior to the others with respect to clinical outcomes [22, 23]. An emerging concept in the quest for improved results is to address not only vertical instability but also persistent horizontal AC joint instability. Several authors have reported that persistent horizontal instability after surgical reconstruction is associated with inferior outcomes; Minkus et al. demonstrated that dynamic posterior translation was significantly correlated to clinical instability scores [25] whereas Blazar et al. [6] demonstrated that the amount of anteroposterior translation was correlated to increasing pain after AC joint excision. Previous biomechanical studies have suggested that CC ligament reconstruction alone may not provide sufficient horizontal stability [3, 9, 31, 32].

Several studies have shown the importance of the capsule of the AC joint for horizontal stability even in the presence of intact CC ligaments [9, 11, 17, 20]. The superior and posterior acromioclavicular ligaments are the major structures responsible for limiting the posterior translation of the distal clavicle, whereas the inferior AC ligament is the main structure limiting anterior translation [4, 17, 20]. Techniques that augment or reconstruct the

AC ligaments have been developed. Recent scientific and commercial interest has led to a trend towards some surgeons performing AC augmentation procedures in addition to CC ligament repair or reconstruction. However, the effectiveness of these procedures at restoring horizontal instability and improving clinical results has yet to be proven. A systematic review of the literature is indicated to both guide clinical practice and future research. The aim of this study is to review the literature to evaluate the strength of evidence from biomechanical and clinical studies that investigate the effectiveness of AC ligament augmentation at the time of AC joint stabilisation.

## Materials and Methods

A systematic review of the literature was conducted in accordance with the PRISMA guidelines using the online databases Medline and EMBASE. The review was registered on the PROSPERO database on 8th January 2018 (Reference number CRD42018084923). The searches were performed independently by two authors on the 23rd of December 2017 and repeated on the 5th of January 2018 to ensure accuracy. Any discrepancies were resolved through discussion between these two authors, with the senior author resolving any residual differences. The Medline search strategy is illustrated in Appendix 1.

Biomechanical and clinical studies published in English were considered for eligibility. Biomechanical studies must have reported either static or dynamic horizontal displacement following surgical reconstructions that included the Weaver Dunn procedure, CC ligament reconstruction and AC augmentation. Clinical studies could be either cases series or comparative studies and were required to have reported a minimum follow-up of 12 months. Studies reporting results after either CC ligament reconstruction or the Weaver Dunn procedure must have specifically recorded static or dynamic horizontal instability or a specific instability score, Acromioclavicular joint instability (ACJI) or Taft Scores. In addition, any studies reporting surgical intervention for AC joint instability which included augmentation of the AC joint were included. Only primary research was considered for review with any abstracts, comments, review articles and technique articles excluded. The clinical studies were appraised independently by two authors using the Methodological index for non-randomised studies (MINORS) tool [35].

## Results

The search strategy identified 18 studies eligible for inclusion [1, 2, 7, 8, 10, 12, 13, 15, 16, 19, 21, 24, 31, 34, 37, 40, 42, 43]. Six biomechanical studies [2, 10, 13, 24, 31, 43]; two reporting on horizontal stability following CC ligament reconstruction (n=24) and four after AC ligament reconstruction (n=117). The remaining 12 studies were clinical [1, 7, 8, 12, 15, 16, 19, 21, 34, 37, 40, 42]; six reporting horizontal stability after CC ligament reconstruction (n=138), five after AC ligament augmentation (n=147) and the final study reporting results after a combination of AC joint reconstruction procedures (n=116). A flow chart of the search strategy is shown in Figure 1. Concise details of the biomechanical studies are given in Table 1 and the clinical studies in Tables 2 to 4.

## Biomechanical Studies

Four of the biomechanical studies compared horizontal stability after different reconstructive procedures of the AC joint. Gonzalez-Lomas et al. [13] and Saier et al. [31] compared CC ligament reconstruction alone against CC ligament reconstruction with AC augmentation. Gonzalez-Lomas et al. [13] performed a single tunnel CC ligament reconstruction and free intramedullary graft for AC augmentation which was secured by suture buttons. Translational loads of 10N and then 15N were applied with 3 different compression loads (10N, 20N and 30N) across the AC joint. The authors reported that the mean anterior-posterior translation after additional AC augmentation was 50% or less than that of CC ligament reconstruction in all loading conditions ($p<0.05$) although no difference in vertical translation was demonstrated. Whereas Saier et al. [31] compared a double tunnel CC ligament reconstruction using the TightRope device (Arthrex) against additional AC augmentation with FiberTape (Arthrex). Cadaveric samples underwent 5000 cycles of anteroposterior directed 70N load and displacement pre and post loading was recorded. The authors demonstrated that only reconstruction of both CC and AC ligaments gave comparable horizontal translation to the native joint.

Michlitsch et al. [24] compared the stability of the AC joint after CC ligament reconstruction with AC augmentation using a free tendon graft against the Weaver Dunn procedure. Translational loads of 10N and then 15N were applied in 4 directions (anterior, posterior, superior and inferior) with 3 different compression loads (10N, 20N and 30N) applied across the AC joint. The study demonstrated that CC ligament and AC augmentation had significantly lower horizontal and vertical translation ($p<0.001$) compared to the Weaver Dunn procedure.

Beitzel et al. [2] used cadaveric specimens to analyse if horizontal stability was improved following single or double tunnel CC ligament reconstruction when compared to the Modified Weaver Dunn procedure. After reconstruction, specimens were preconditioned from 0 to 25N for 10 cycles in each direction and then tested to 70N in three directions (anterior, posterior and superior). The authors report that both single and double tunnel CC ligament reconstruction provided significantly higher horizontal stability with less anterior and posterior translation (p=0.005) than the Weaver Dunn procedure. Comparisons between the two techniques for CC ligament reconstruction revealed no significant difference in horizontal stability.

## Clinical Studies

### Horizontal Instability

Tauber et al. performed a prospective cohort study (Level of evidence 2) of chronic AC joint injuries (grade III and above) treated at two centres with either single bundle CC ligament reconstruction or triple bundle technique, which involved reconstruction of both CC ligaments individually as well as AC augmentation. The authors measured static horizontal stability at follow up on the axillary view and reported it as stable, subluxated, or dislocated if the lateral clavicle showed anteroposterior translation compared with the uninjured side of less than 50%, between 50% and 100%, and more than 100%, respectively. The study demonstrated that horizontal stability was significantly higher (p =0.011) after the triple bundle technique (75% stable) compared to the single bundle CC ligament reconstruction (29% stable) [42].

Comparison of CC ligament reconstruction to the Weaver Dunn procedure showed a higher rate of persistent posterior subluxation after the Weaver Dunn procedure (8.3% versus 0%) at a mean 37 months follow up, although this did not reach statistical significance [40]. Studies reporting on horizontal instability after double tunnel CC ligament reconstruction demonstrated this was present in between 0% and 53% of cases [1, 7, 8, 19]. The range of horizontal instability after CC ligament reconstruction with AC augmentation ranged from 5.8% to 13% [15, 16].

**Functional Outcomes**

Five studies reported either the Constant or American Shoulder and Elbow Surgeons (ASES) scores following CC ligament reconstruction using a double tunnel technique [7, 8, 12, 19, 34], see Table 2. The Constant score was reported in all five studies with the mean values ranging from 90.2 to 95.5. Glanzmann et al. demonstrated that 95% of patients returned to sporting activities [12]. Tauber et al. [40] compared a Modified Weaver Dunn and double tunnel CC ligament reconstruction using autogenous semitendinosus graft. At a mean 37 months follow up the functional scores after double tunnel CC ligament reconstruction were significantly better than after the modified Weaver Dunn procedure ($p<0.001$); ASES 96 versus 74 and Constant score 93 versus 81.

Four studies reported either the Constant or ASES score following CC ligament reconstruction using a double tunnel technique with AC augmentation [15, 16, 21, 37]. The Constant score was reported in all four studies with the mean values ranging from 84 to 92.4. Tauber et al. prospectively compared single bundle CC ligament reconstruction against triple bundle reconstruction that included AC augmentation. At two years there was no significant difference in functional scores; Constant Score 88.8 versus 82.6 and ASES 95.3 versus 88 [42].

Five clinical studies reported specific instability functional scores for the AC joint, see Table 2. These were the Taft score [38] and the Acromioclavicular Joint Instability Score (ACJI score) [32]. The Taft score was first described in 1987 and measures three criteria each with a maximum score of 4 (maximum 12): 1) Subjective rating of pain and stiffness 2) Objective rating of abduction strength and range of motion 3) Radiological outcome. In addition, 1 point was subtracted from the objective rating for joint tenderness, crepitus or a poor cosmetic appearance.  The ACJI score (maximum, 100 points) was described in 2011 by

Scheibel et al. and evaluates 5 items: 1) Pain (20 points) 2) Activities of Daily Living (10 points) 3) Cosmesis (10 points) 4) Function (25 points) 5) Radiological Assessment (35 points). It is important to note that neither the Taft or ACJI score have been validated in the assessment of AC joint instability.

Tauber et al. demonstrated that triple tunnel reconstruction (combined CC ligament reconstruction and AC augmentation) was associated with a significantly improved Taft score (10.9 versus 9, p=0.018) and ACJI score (84.7 versus 58.4, p=0.0001) when compared to single bundle CC ligament reconstruction [42]. Two case series reported instability scores after double tunnel CC ligament reconstruction; ACJI score 75.9-87.3 and Taft score 10.5 [7, 19] which were comparable to the two case series that reported instability scores after double tunnel CC ligament reconstruction with AC augmentation; ACJI score 87 and Taft score 9 to 11 [15, 16].

**Complications and Revision Surgery**

The complication rate was reported in 9 of the 12 studies, including in all the comparative studies (Table 4). 4 of the 12 studies failed to report the rate of revision [8, 37, 40, 42] which included two comparative studies (Table 4) [40, 42]. The mean follow-up ranged from 12 to 37 months with 9 studies having a mean follow up of over two years.

The comparative study conducted by Tauber et al. [42], demonstrated that AC augmentation using a triple bundle technique was associated with a lower complication rate (16.7% versus 35.7%) than single bundle repair. The triple bundle repair group had a lower rate of vertical redislocation (8.3% vs 21.4%) and persistent hypesthesia (8.3% vs 14.3%). Tauber et al. [40] demonstrated an equal complication rate between the Weaver Dunn procedure and double tunnel reconstructions (8.3% in both groups). Case series reporting the outcome of double tunnel CC ligament reconstruction reported a complication rate ranging from 2.5% to 70.7% and revision rate from 3% and 15.8% [7, 12, 19, 34]. Case series reporting CC ligament reconstruction with AC augmentation reported a complication rate ranging of 18.75% and revision rate from 11.6% and 12.5% [15, 16, 21]. The most common reasons for complications including the need for revision surgery, were implant related irritation, infection, stiffness and loss of reduction. None of the authors reported complications specifically attributable to the additional AC joint augmentation procedures.

## Discussion

The most important finding of the present study was that additional AC augmentation failed to improve functional outcomes, as determined by the ASES and Constant scores, when compared to CC ligament reconstruction alone, despite biomechanical studies reporting improved horizontal stability. The included biomechanical studies clearly demonstrate that CC ligament reconstruction with additional AC augmentation is associated with a statistically significant improvement in horizontal stability when compared to CC ligament reconstruction alone [13, 31]. Tauber et al. [42] also demonstrated in their clinical study that 75% of cases repaired using the triple bundle techniques (including AC augmentation) were horizontally stable compared to 29% in the single bundled repair group.

Clinical studies have shown CC ligament reconstruction, whether it is performed in conjunction with augmentation of the AC joint or not, is associated with good functional scores. The only comparative study included in this review, from Tauber at al. demonstrated no statistically significant difference in Constant and ASES scores between the techniques [42] but it should be noted that these functional scores have not been validated for acromioclavicular joint instability and therefore may not be sensitive enough to capture any clinical differences. In contrast, Tauber et al. did report an improvement in specific ACJ instability scores after combined CC ligament reconstruction and AC augmentation [42] but it is imperative to understand the limitations of these findings. Although the Taft [38] and ACJI scores [32] have been designed to measure AC joint instability, neither has been validated for this purpose. Furthermore it should be highlighted that even if a statistically significant difference is demonstrated, the lack of validation, specifically the failure to establish a threshold of minimal clinically important difference, limits the clinical relevance of the findings related to the Taft and ACJI scores. Additionally, it should be noted that the study from Tauber et al, included only 26 patients, a sample size calculation was not performed, and the allocation of patients to each type of procedure was not stated thus raising concerns about potential selection bias. In view of these weaknesses in study design and reporting, the strength of evidence and clinical relevance of the reported improvement in the Taft and ACJI scores must be considered to be very low.

The clinical studies failed to demonstrate a clear difference in complication or revision rate between those undergoing CC ligament reconstructions and those having additional AC augmentation but lack of explicit reporting, small overall numbers and short term follow up limit the confidence in this specific evaluation. One of the main concerns of drilling additional tunnels or placing implants within the acromion is fracture. This was not reported in any of the studies, and may not have occurred, but it is important to highlight that future studies should explicitly report acromial fracture and any other procedure specific complications. Revision rates reported in the case series of the two techniques, 3% to 15.8% after double tunnel CC ligament reconstruction [7, 12, 19, 34] and 11.6% to 12.5% after CC ligament reconstruction with AC augmentation [15, 16, 21], were comparable to a recent systematic review of various AC joint stabilisation procedures; suspensory device 6.2%, free tendon graft 10.3% and modified Weaver Dunn procedures 12.5% [26].

Appraisal of the non-randomised clinical studies using the Methodological index for non-randomised studies (MINORS) tool [35] demonstrated a variety of limitations which are summarised in Table 5. Common limitations included the lack of a control group and low patient numbers in the majority of the studies. Variation in inclusion criteria (acute, chronic or revision surgery), surgical technique (Weaver Dunn, single tunnel, double tunnel, triple tunnel CC ligament reconstruction and intramedullary augmentation), open or arthroscopic procedures, choice of outcome measurements and threshold for reporting complications/revision were present in most studies.

A further limitation of this systematic review is the confounding effect of the broad spectrum of Rockwood grades of AC joint instability included. Of the clinical studies, six included patients with Grades III to V injuries, three included only grade V injuries and the remaining three studies included either Grade III and IV, Grade III and V or Grade IV and V injuries. Previous work by Tauber et al. has demonstrated that the incidence of horizontal instability varies between injury grade, being 57.1%, 80% and 100% in Grades II, III and V respectively [42]. Only two studies commented on the effect of the Rockwood grading on functional outcome [1, 40] and none of the included studies reported on correlation between grading and the residual horizontal instability. Therefore future research needs to more clearly define the type of instability being studied and correlate different types of instability with outcomes.

The findings of this review are directly applicable to the recent trend towards performing AC augmentation procedures in addition to CC ligament reconstruction in an attempt to improve functional outcomes. The main clinical relevance of this study is that a lack of significant improvement in ASES and Constant scores is demonstrated. This should prompt a cautious approach to adding AC augmentation procedures to CC ligament reconstruction.

## Conclusion

CC ligament reconstruction with augmentation of the AC joint has been shown to provide improved horizontal stability in both biomechanical and clinical studies compared to isolated CC reconstruction. However, comparative studies have shown no clinical advantage with respect to ASES or Constant scores and therefore the results of this SR do not support AC augmentation in routine clinical practice.

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**Figure 1: Flow diagram of review process**

**Table 1 – Summary of Biomechanical studies**

**Table 2 – Summary of clinical studies and functional outcomes**

**Table 3 – Radiological outcomes in clinical studies**

**Table 4 – Complications in clinical studies**

**Table 5: Methodological items for non-randomised studies (MINORS) Scores for clinical studies**

**Appendix 1: Search strategy for Medline**