Original Article

# The Morphology of the Acromioclavicular Joint Does Not Influence the Postoperative Outcome Following Acute Stabilization—A Case Series of 81 Patients

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**Purpose:** To specifically evaluate the influence of the acromioclavicular (AC)-joint morphology on the outcome after arthroscopically assisted coracoclavicular (CC) stabilization surgery with suspensory fixation systems and to investigate whether an additional open AC-joint reduction and AC cerclage improves the clinical outcome for patients with certain morphologic AC-joint subtypes. **Methods:** Patients with an acute acromioclavicular joint injury, who underwent arthroscopically assisted CC stabilization with suspensory fixation systems with or without concomitant AC cerclage between January 2009 and June 2017 were identified and included in this retrospective cohort analysis. AC-joint morphology was assessed on preoperative radiographs and categorized as "flat" or "non-flat" ("oblique"/"curved") subtypes. After a minimum of 2 years of follow-up, postoperative Single Assessment Numeric Evaluation (SANE), American Shoulder and Elbow Surgeons (ASES), and visual analog scale (VAS) scores for pain were collected. A subgroup analysis of clinical outcomes depending on the surgical technique and morphological subtype of the AC joint was performed. **Results:** Eighty-one patients (95% male, mean age 35 ± 12 years) could be included at a mean follow-up of 57 ± 14 months. Radiographic assessment of AC-joint morphology showed 24 (30%) cases of flat type, 38 (47%) cases of curved type, and 19 (23%) cases of oblique morphology. Postoperatively, no clinically significant difference could be detected after the treatment of AC joint injury via CC stabilization with or without concomitant AC cerclage ($VAS_{rest}$: $P = .067$; $VAS_{max}$: $P = .144$, ASES: $P = .548$; SANE: $P = .045$). No clinically significant differences were found between the surgical techniques for the flat morphologic subtype ($VAS_{rest}$: $P = .820$; $VAS_{max}$: $P = .251$; SANE: $P = .104$; ASES: $P = .343$) or the non-flat subtype ($VAS_{res}$: $P = .021$; $VAS_{max}$: $P = .488$; SANE: $P = .243$, ASES: $P = .843$). **Conclusions:** In arthroscopically assisted AC stabilization surgery with suspensory fixation systems for acute AC-joint injury, the AC-joint morphology did not influence the postoperative outcome, independent of the surgical technique. No clinical benefit of performing an additional horizontal stabilization could be detected in our collective at mid-term follow-up. **Level of Evidence:** Level IV, therapeutic case series.

Acromioclavicular (AC) joint injuries occur commonly, accounting for approximately 12% of injuries to the shoulder.[1] There exists a general consensus throughout the literature that acromioclavicular joint injuries (ACJI) Rockwood type I, II, and IIIA can be managed nonoperatively, whereas ACJI Rockwood type IIIB and IV-VI dislocations should be treated surgically.[2-5] Surgical management with arthroscopically assisted suspensory fixation for coracoclavicular stabilization may result in favorable outcomes.[3,4,6-14]

Recently, several biomechanical studies have reported a superior stability after additional open AC-joint

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reduction and stabilization.[15-18] To date, a paucity of evidence is available on whether a controlled, open reduction of the AC joint as part of a cerclage procedure to ensure optimal clavicular reduction in relation to the acromion additionally to the minimally invasive coracoclavicular (CC) stabilization is a central factor of success in the procedure. The anatomical variance in AC morphology classified by Colegate-Stone et al.,[19] depending on shape and inclination of the articular-sided surface of the acromion and clavicle in its mechanical interplay with the articular disc, may be of relevance for successful intraoperative reduction of the AC joint.[20] As the intraoperative grade of reduction of the AC joint has been identified as a factor predictive for postoperative clinical outcomes,[21] an AC morphology predisposing for an entrapment of the articular disc, which is known to affect AC-joint ligament complex injury patterns and thus influence the decision to perform mini-open repair,[22] may influence the clinical outcome.

The purposes of the study were to specifically evaluate the influence of the AC-joint morphology on the outcome after arthroscopically assisted CC-stabilization surgery with suspensory fixation systems and to investigate whether an additional open AC-joint reduction and AC cerclage improves the clinical outcome for patients with certain morphologic AC joint subtypes. It was hypothesized that patients with a non-flat joint configuration would be more likely to benefit from an additional AC cerclage, as these morphologic subtypes are prone to an entrapment of the articular disc during closed reduction and thus at risk for a secondary dislocation of the clavicle.

## Methods

### Study Population

This was an institutional review board (no. 422/19-S)-approved Level IV retrospective outcome study of prospectively collected data. Review of our institutional data bank was performed to identify patients meeting the following inclusion criteria: patients who underwent arthroscopically assisted AC-joint stabilization to address acute Rockwood type IV and V ACJI at the senior author's (A.B.I.) institution between January 2009 and July 2017 with a minimum of 2 years postoperative follow-up. Only patients with an acute ACJI, defined as an interval of 3 weeks between trauma and surgery, treated with a CC stabilization technique with a single suspensory fixation system (DogBone; Arthrex, Naples, FL) with or without concomitant AC stabilization by AC cerclage were included. Interventions were randomized by assigning patients to 2 intervention groups (isolated CC stabilization and CC stabilization + AC cerclage) according to the weekday of their first consultation at the outpatient clinic of the senior authors institution and thus the surgeon in charge on that day respectively. Patients were excluded if AC-joint injury was chronic, treated with another surgical technique, or if additional shoulder surgery unrelated to the AC joint on the ipsilateral shoulder was performed, to avoid confounding of the outcome assessment.

### Indications

AC-joint instability was classified according to Rockwood on preoperative radiographs in panorama view and cross-body adduction view projections. For the purpose of this study, surgical AC-joint stabilization of acute ACJI was indicated in patients with Rockwood type IV and V injuries.

### Surgical Technique

Surgery was performed arthroscopically assisted under general anesthesia with additional interscalene nerve blocks, with the patient placed in the beach-chair position. Examination under anesthesia was performed to assess AC-joint instability. The arm was placed in a pneumatic arm holder, and the operation site was prepared and draped in a sterile fashion. Diagnostic arthroscopy was then performed using a standard posterior viewing portal using a 30° arthroscope. An anterolateral working portal was established in outside-in technique through the rotator interval parallel to the subscapularis tendon. Concomitant intraarticular injuries (e.g., SLAP lesions) were addressed if needed. Consecutively, the arch and base of the coracoid were prepared with an electrothermal ablation device. Optimal visualization and preparation of the coracoid base was ensured via an additional lateral transtendinous viewing portal through the supraspinatus tendon. If isolated CC stabilization was indicated, in the next step, the AC joint was reduced by lifting the arm. Following visual and radiographic control of AC-joint reduction, a skin incision was placed over the clavicle at the anatomic position of the trapezoid and conoid ligament. Using an AC joint drill guide introduced via the anterolateral portal, a transclavicular and transcoracoid CC tunnel was established employing a 2.4-mm cannulated drill. Via a shuttle suture wire (SutureLasso; Arthrex, Naples, FL), 2 high-strength suture tapes (FiberTape) were shuttled through coracoid and clavicle. CC stabilization was completed by threading the strands of the tape through a special titanium button (DogBone), caudally of the coracoid and cranially of the clavicle, where the strands—once tightened—were knotted and reduction was controlled via intraoperative fluoroscopy.

If an additional AC cerclage was performed, a skin incision was placed over the AC joint in the orientation of the distal clavicle and soft tissue preventing joint reduction was removed from the AC joint before reduction and CC-stabilization. Consecutively,

horizontal tunnels parallel to the AC joint line were drilled into the lateral clavicle 10 to 15 mm medial to the AC joint and into the acromion 10 mm lateral to the AC joint, respectively, using a 2.4-mm cannulated drill. Using shuttle sutures (SutureLasso), a 1.5-mm polydioxanone cord was passed through the drill holes. At the end of the procedure, following completion of CC stabilization, the cord was tied completing the AC cerclage in a "box" or "figure of 8" technique. Incisions were then closed in a sterile fashion, completing the surgical procedure.[23]

### Postoperative Rehabilitation

As a part of a structured rehabilitation program, the operated arm was immobilized in a sling postoperatively. Postoperative physiotherapy was initiated in the hospital. Initially, the patient's passive range of motion (ROM) was limited and gradually increased until free passive ROM was reached after 6 weeks. Free active ROM was permitted after 6 weeks and return to overhead activity with load after 12 weeks. Return to full-contact sports was allowed 6 months postoperatively.

### Radiographic Evaluation

AC joint morphology was assessed on preoperative radiographs in Zanca view and/or panorama view projections employing the picture archiving and communication system. Two blinded reviewers, J.P., and B.S., senior consultants who specialized in shoulder pathologies, each classified the anatomical variance in AC morphology depending on shape and inclination of the articular-sided surface of the acromion and clavicle according to Colegate-Stone et al.[19] in flat-type, oblique type and curved type morphology, as shown in Figure 1. It was hypothesized that the obliquely angulated and curved-shaped morphologic AC joint subtypes would benefit from an additional open reduction, as AC joint morphology in these cases may prevent a closed, noninvasive AC-joint reduction. Thus, the oblique type and curved type morphology were summarized in a "non-flat type" subgroup. To asses intra- and interrater reliability, the assessment was repeated 3 weeks after the first evaluation. The intraclass correlation coefficient of quantitative measurements showed excellent intrarater (0.98; 95% confidence interval 0.98-0.99) and interrater (0.93; 95% confidence interval 0.90-0.95) reliability.

### Clinical Evaluation

Subjective evaluations were obtained with the Single Assessment Numeric Evaluation (SANE), American Shoulder and Elbow Surgeons (ASES) Score, and visual analog scale for pain (VAS) scores at a minimum of 2 years postoperatively.

### Statistical Analysis

Data analysis was performed using SPSS software, version 22.0 (IBM-SPSS, Armonk, NY).

Normally distributed data are reported as mean ± standard deviation, whereas non-normally distributed data are reported as median and range (interquartile range, from the 25th to the 75th percentile).

Depending on the distribution, the parametric Student *t* test or the nonparametric Mann−Whitney *U* test for 2 independent samples were used to compare the postoperative outcome scores of the different subgroups based on the respective different morphologic subtypes and CC-stabilization surgery performed either with or without AC-cerclage. The level of significance was set at $P < .05$.

Given that this was a retrospective analysis, the availability of data determined the sample size. However, a power analysis was performed to determine the capability of the sample size to detect a clinical difference of 17 points ASES score. Assuming a standard

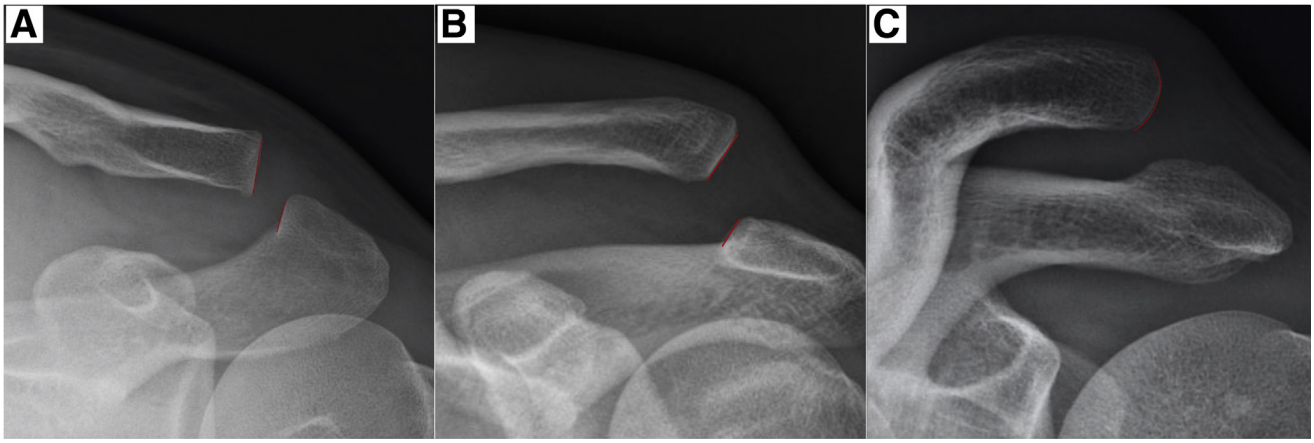


**Fig 1.** Evaluation of AC-joint morphology: Preoperative radiographs (left shoulders): AC-joint morphology (red line) was categorized into "flat" (A), "oblique" (B), and "curved" (C) subtypes, as described by Colgate-Stone et al.[19] (AC, acromioclavicular.)

deviation of 20 points, a sample size of 46 patients would provide 80% power at an alpha level of 0.05 determined in an a priori power analysis, performed with G*Power (Erdfelder, Faul, Buchner, Lang, HHU Düsseldorf, Düsseldorf, Germany).

## Results

During the study period, there were 120 patients who underwent surgery for ACJI, with a minimum of 2-year postoperative follow-up. Of those, 20 patients were excluded for a variety of reasons (Fig 2). The remaining 100 patients could be included. An additional 19 patients were lost to follow-up, leaving 81 patients available for evaluation (77 men, 4 women; 81% follow-up). Mean age at the time of index surgery was 35 ± 12 years, with a mean postoperative follow-up of 57 ± 14 months. Twenty-seven patients (26 male, 1 female) were treated with isolated CC-stabilization, whereas 54 patients (51 male, 3 female) additionally underwent open AC-joint reduction and horizontal stabilization with AC-cerclage. Detailed characteristics of the patient collective can be found in Table 1.

### Radiologic Outcomes

The preoperative radiologic classification of the patients AC joint morphology showed 24 cases (30%) of flat-type morphology, 38 cases (47%) of curved type morphology, and 19 cases (23%) of oblique-type morphology, resulting in 24 flat-type AC joints and 57 non−flat-type AC joints. In the flat-type AC joint subgroup, 7 patients underwent isolated CC stabilization whereas 17 patients underwent CC stabilization with additional AC stabilization. In the non−flat-type subgroup, 20 patients underwent isolated CC-stabilization, whereas 37 patients underwent CC stabilization with an additional AC cerclage.

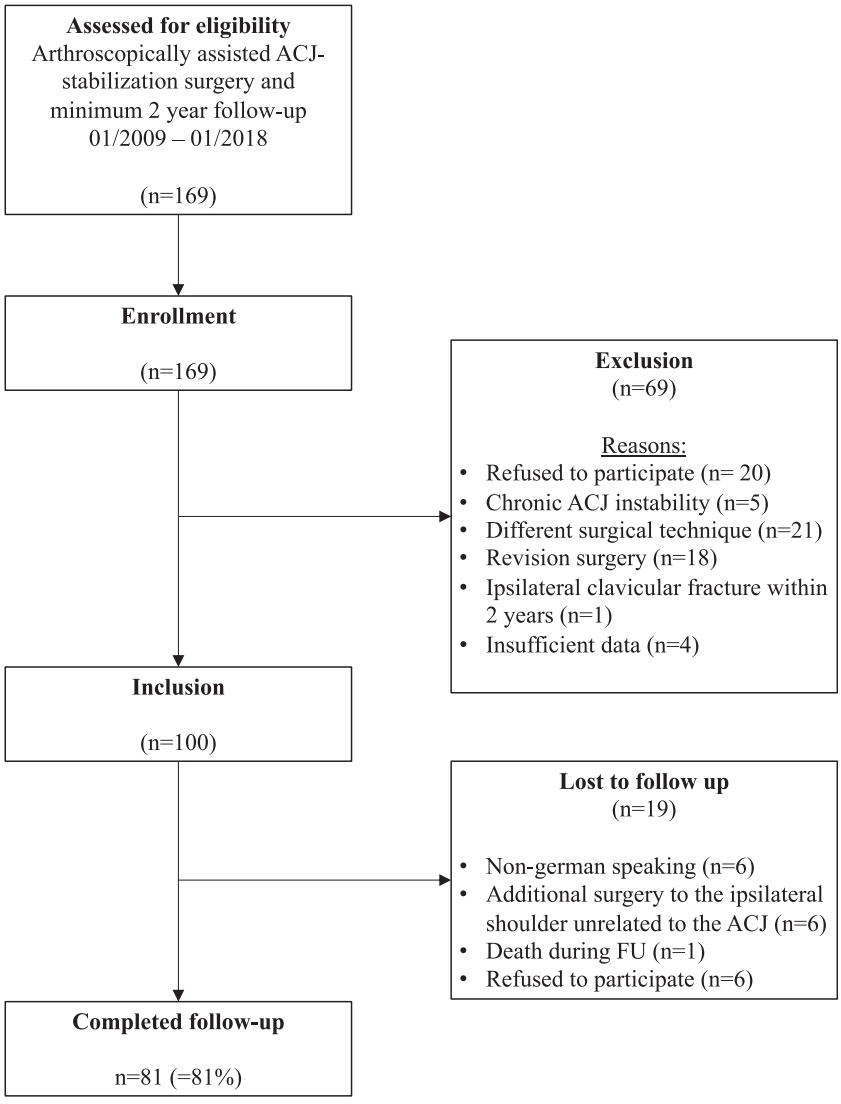


**Fig 2.** Flowchart of included and excluded patients. (ACJ, acromioclavicular joint; FU, follow-up.)

**Table 1.** Patient Characteristics

| Variable | Total Study Group |
|---|---|
| Number of included patients, n (%) | 81 (100%) |
| Sex distribution, n (%) | |
| Male | 77 (95%) |
| Female | 4 (5%) |
| Age, y | 35 ± 12 (19-72) |
| Follow-up, mo | 57 ± 14 (28-85) |
| Surgical technique, n (%) | |
| Isolated CC stabilization | 27 (33%) |
| CC stabilization and AC cerclage | 54 (67%) |
| Rockwood type, n (%) | |
| Type IV | 42 (39.5%) |
| Type V | 49 (60.5%) |

NOTE. Categorical variables are presented as count and percentage; continuous variables are presented as mean ± standard deviation (range).

AC, acromioclavicular; CC, coracoclavicular.

### Clinical Outcomes

Postoperatively, no significant difference in the postoperative pain and functional scores could be detected between patients with ACJs of flat and non-flat morphologic subtypes, when performing isolated CC-stabilization surgery. Similarly, no significant difference between the morphologic subtypes could be detected, if a CC stabilization and an additional AC cerclage were performed concomitantly.

Across the study population, no clinically significant difference could be found between the treatment of ACJI with isolated CC stabilization and CC stabilization with concomitant AC cerclage, when comparing postoperative pain and functional scores independently of the morphology of the ACJ (Table 2). SANE scores of the operated shoulder showed statistically significant superior values following isolated CC stabilization compared with combined CC stabilization and AC cerclage ($P = .045$).

Performing a subgroup analysis depending on AC morphology, no significant differences clinical scores could be observed in the flat morphologic subtype (Table 3).

Interestingly, no clinically significant difference in postoperative pain and functional scores could be detected in patients with the non-flat morphologic ACJ subtype, when comparing isolated CC-stabilization surgery and CC-stabilization with additional AC-cerclage (Table 4). Only for the $VAS_{rest}$ pain score, a statistically significant difference in favor of combined AC cerclage and CC stabilization could be observed.

## Discussion

The present study constitutes 2 main findings. First, no difference was found in the postoperative outcome regardless of A- joint morphology or surgical technique. Moreover, no clinically significant difference in postoperative clinical outcomes could be detected between the treatment of acute ACJI with isolated CC stabilization or CC stabilization combined with concomitant AC cerclage.

To date, there is limited evidence regarding the influence of the AC-joint morphology on the postoperative outcome. The initial description of the classification by Colegate-Stone et al.[19] described oblique (39%) and flat (38%) type as most common morphologies, followed by the curved type (19%). Interestingly, the distribution of the morphologic subtypes in our collective was different, which reported the curved type (47%) as most common, followed by the flat (30%) and oblique (23%) morphology, classified with an excellent intra- and interrater reliability. This difference may root in the exclusion of patients with AC-joint dislocations in the initial description by Colegate-Stone et al.,[19] as well as differences in demographic variables. Thus, a possible influence of AC morphology in the pathogenesis or etiology of ACJI, as observed to be the case for articular disc morphology,[22] cannot be excluded and will be subject of further investigations. Furthermore, data reported by Maziak et al.[21] identified the intraoperative grade of reduction of the AC joint as a factor predictive for the outcome after AC-joint stabilization. The hypothesis, that obliquely angulated and curved-shaped morphologic AC-joint subtypes would clinically benefit from an additional open reduction after acute ACJI, as AC joint morphology in these cases may prevent a closed, non-invasive optimal AC-joint reduction due to impingement of the articular disc and adjacent soft tissue,[20] was discarded based on the results of the present study. Similarly, while relevant for a different entity and patient population, previous studies correlating AC

**Table 2.** Comparison of Postoperative Outcome Scores Depending on Surgical Technique With Either Isolated CC Stabilization or Combined Procedure With Additional AC Cerclage

| Type of Surgery | Isolated CC Stabilization | CC Stabilization and AC Cerclage | *P* Value |
|---|---|---|---|
| Age, y | 35 ± 13 | 34 ± 11 | .888 |
| VAS [rest] | 1.3 ± 0.9 | 1.1 ± 0.3 | .067 |
| VAS [max] | 1.8 ± 1.6 | 2.1 ± 1.5 | .144 |
| SANE [operated shoulder] (%) | 94 ± 7 | 90 ± 10 | .045* |
| SANE [nonoperated shoulder] (%) | 99 ± 3 | 98 ± 6 | .661 |
| ASES (%) | 94 ± 10 | 93 ± 9 | .548 |

NOTE. Values are reported as mean ± standard deviation.

AC, acromioclavicular; ASES, American Shoulder and Elbow Surgeons; CC, coracoclavicular; SANE, Single Assessment Numeric Evaluation; VAS, visual analog scale.

*Statistically significant difference between groups (level of significance, $P < .05$).

**Table 3.** Comparison of Postoperative Outcome Scores in the "Flat" ACJ Morphologic Subtype Depending on Surgical Technique With Either Isolated CC Stabilization (n = 7) or Combined Procedure With Additional AC Cerclage (n = 17)

| Type of Surgery | Isolated CC Stabilization | CC Stabilization and AC Cerclage | *P* Value |
|---|---|---|---|
| Age, y | 38 ± 20 | 35 ± 13 | .923 |
| VAS [rest] | 1.3 ± 0.8 | 1.2 ± 0.5 | .820 |
| VAS [max] | 2.3 ± 2.8 | 2.6 ± 1.9 | .251 |
| SANE [operated shoulder] (%) | 94 ± 5 | 87 ± 10 | .104 |
| SANE [non-operated shoulder] (%) | 99 ± 2 | 99 ± 4 | .871 |
| ASES (%) | 92 ± 15 | 89 ± 12 | .343 |

NOTE. Values are reported as mean ± standard deviation.

AC, acromioclavicular; ACJ, acromioclavicular joint; ASES, American Shoulder and Elbow Surgeons; CC, coracoclavicular; SANE, Single Assessment Numeric Evaluation; VAS, visual analog scale.

morphology and surgical outcomes following surgical AC joint resection did not report AC morphology to affect the clinical outcome.[24]

The overall results reported in the present study, with a mean postoperative ASES score of 94% as the primary outcome measure, underscore the favorable outcome of arthroscopically assisted technique employing suspensory fixation systems for acute ACJI in a relatively large collective. In accordance, previous studies in the literature reported postoperative ASES scores ranging from 82% to 98% after an arthroscopically assisted technique employing suspensory fixation systems.[3,4,10,11,13] The difference noted in this study between SANE scores of isolated C-stabilization and combined CC stabilization and AC cerclage across the study population (Table 1) and $VAS_{rest}$ scores in the non-flat subtype (Table 3) that reach statistical significance do not reach the minimal clinically important difference and are thus not regarded clinically relevant.[25]

In general, substantial biomechanical evidence has been published that an isolated vertical stabilization may not provide adequate horizontal A-joint stability.[16,17,26-32] Multiple investigations have repeatedly highlighted the biomechanical importance of an intact AC-joint capsule for vertical and rotational stability independently of the integrity of CC ligaments.[16,27-32] More specifically, a stabilizing biomechanical role against horizontal posterior translation has been propagated for the posterosuperior capsule.[26,29,31] The anterosuperior capsule has been demonstrated to function as the dominant resistor against posterior rotational forces.[16,32] Ultimately, an anteriorly stabilizing role has been proposed for the inferior AC joint capsule.[33] Thus—biomechanically—a combined stabilization of the AC capsule and CC ligaments has repeatedly been shown to most effectively restore native AC joint integrity and stability against translational or rotational loading.[15-18]

Clinically, a persistent horizontal instability after isolated CC stabilization has been described in multiple studies.[21,34-36] Persistent dynamic posterior clavicular translation may result in inferior outcomes.[21,35] However, in the present study, no clinically significant difference in outcomes could be detected between the treatment of acute AC-joint injury with isolated CC stabilization or CC stabilization combined with concomitant AC stabilization. This discrepancy between biomechanical evidence of improved horizontal stability but unchanged clinical outcome has been noted in previous studies, that did not show an improvement of general patient reported shoulder scores.[10,37,38] A recently published study by Voss et al.[39] directly compared patients suffering from acute ACJI treated with either isolated CC stabilization or CC stabilization combined with concomitant AC stabilization and did not find significant difference in outcome scores at final follow-up. However, as the increase in AC distance, measured from the inferior border of lateral clavicle to inferior border of acromion, at final follow-up was generally lower with an additional AC cerclage, the authors recommended to perform an additional AC cerclage to prevent the scapula from tilting too far lateral.[39] A significantly superior outcome for procedures including an additional AC stabilization however has been shown in studies employing AC joint specific scores including radiological outcome such as the Taft score and AC-joint instability score.[10]

The acute nature of the injury, associated with superior biological healing potential of the AC capsular tissue, may contribute to the explanation of this

**Table 4.** Comparison of Postoperative Outcome Scores in the "Curved" and "Oblique" (i.e., "Non-Flat") ACJ Morphologic Subtypes Depending on Surgical Technique With Either Isolated CC Stabilization (n = 20) or Combined Procedure With Additional AC Cerclage (n = 37).

| Type of Surgery | Isolated CC Stabilization | CC Stabilization and AC Cerclage | *P* Value |
|---|---|---|---|
| Age (years) | 35 ± 11 | 34 ± 11 | .921 |
| VAS [rest] | 1.3 ± 0.9 | 1.0 ± 0.0 | .021* |
| VAS [max] | 1.7 ± 1.0 | 1.9 ± 1.2 | .488 |
| SANE [operated shoulder] (%) | 94 ± 7 | 92 ± 9 | .243 |
| SANE [nonoperated shoulder] (%) | 99 ± 3 | 98 ± 7 | .750 |
| ASES (%) | 94 ± 8 | 95 ± 7 | .843 |

NOTE. Values are reported as mean ± standard deviation.

AC, acromioclavicular; ACJ, acromioclavicular joint; ASES, American Shoulder and Elbow Surgeons; CC, coracoclavicular; SANE, Single Assessment Numeric Evaluation; VAS, visual analog scale.

*Statistically significant difference between groups (level of significance, $P < .05$).

finding.[40-42] The potential of biological healing is most accentuated during the posttraumatic inflammatory and proliferative biological phases.[40-42] Thus, if an anatomically stable coracoclavicular situation is surgically established in this acute phase and ROM and load are limited—as performed in the acutely treated collective of the present study—the optimal biological healing potential may be leveraged and result in an acceptable integrity and stability of the AC joint capsule. Indeed, a radiologic evaluation of the AC and CC ligaments via magnetic resonance imaging demonstrated adequate AC-ligament consolidation following isolated CC stabilization in acute cases.[43]

### Limitations

This study is not without limitations. First, while the data were collected prospectively, the study inherits the associated biases of a retrospective design. No statement about the pre- to postoperative changes could be made, as no preoperative clinical scores were available. Second, no postoperative radiologic evaluation of persistent dynamic posterior translation was conducted, as the clinical outcome was defined as the primary end point of this study. Ultimately, the long-term impact of an additional AC joint stabilization procedure has to be investigated before drawing a clinical conclusion, as a potentially persistent horizontal microinstability in the AC joint may potentially affect the long-term results.

## Conclusions

In arthroscopically assisted AC-stabilization surgery with suspensory fixation systems for acute AC-joint injury, the AC-joint morphology did not influence the postoperative outcome, independent of the surgical technique. No clinical benefit of performing an additional horizontal stabilization could be detected in our collective at mid-term follow-up.

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