

Mid to long-term results of open acromioclavicular-joint reconstruction using polydioxansulfate cerclage augmentation

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Abstract

Introduction There is still controversy about the optimal operative treatment of acromioclavicular (AC)-joint dislocations. However, in the current literature, only few studies are available on mid- to long-term results of different stabilization methods. This retrospective study presents the clinical and radiographical results after open reduction and stabilization of AC-joint dislocations using polydioxanesulfate (PDS) cerclage augmentation.

Methods Fifty patients with a mean age of 35 years were treated with open reduction and PDS cerclage augmentation. Rockwood classification showed 44 type V, 5 type III and 1 type IV AC-joint dislocation. The clinical and radiographic follow-up (Constant Score, DASH Score, subjective shoulder value and stress radiographs of the shoulder girdle) were performed postoperatively at an average of 70 months.

Results Clinical scores were good to excellent with a mean constant score of 91.7 ± 8.7 points. The mean DASH Score was 5 ± 8.8 points and the mean subjective shoulder value was 92 ± 10.7 . Radiographically, 80% showed a difference of coracoclavicular distance in comparison to the contralateral side of <5 mm, 14% of 5–10 mm and 6% of >10 mm. Radiographical signs of osteoarthritis were present in 37 and in 6% of all patients also evident during clinical examination. Coracoclavicular calcifications were seen in 68%. Complications were: one superficial wound infection, one extensive coracoclavicular calcification and two complete secondary redislocations.

Conclusions Treatment of AC-joint dislocation using PDS cerclage augmentation leads to good to excellent clinical results. However, mid- to long-term follow-up reveals a high incidence of radiographic signs of osteoarthritis of the AC-joint. Whether this is due to the surgical technique and could be reduced using other, more anatomical fixation techniques or whether the injury itself leads to these changes, need to be shown.

Keywords Acromioclavicular-joint · PDS-cerclage · Acromioclavicular-joint dislocation · Coracoclavicular cerclage

Introduction

Acromioclavicular (AC) -joint separations are the third frequent injury of the shoulder girdle, accounting for 4–6% of all joint dislocations [14]. Several surgical techniques exist for the treatment of acute AC-joint separations with new techniques still evolving [5, 21]. Although numerous techniques have been reported to result in good and excellent clinical outcome, general treatment recommendations are still missing. The most frequently used techniques in the past have been temporary transfixation of the AC-joint using k-wire pinning [8], open reduction and fixation using a Bosworth screw or hook plate [4, 23], dynamic stabilization with muscle or ligament transfer [31], and open reduction and retention of the joint using a coracoclavicular loop cerclage [18, 25]. For each of these techniques specific benefits and disadvantages or complications have been shown, such as the risk of pin migration using k-wires, [28] secondary implant removal or bony defects when using Bosworth screws or hook plates [2, 15, 22] and symptomatic joint instability when using dynamic transfers [9]

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Coracoclavicular cerclage techniques have been reported to provoke malreduction of the joint due to anterior subluxation in experimental settings [1, 20] and to provoke osteolysis and stress fractures with the use of non-resorbable materials [24].

The presented technique using open AC-joint reduction and polydioxansulfate (PDS) cerclage augmentation of the coracoclavicular ligaments has been described in the literature by different authors [12, 13, 16, 18, 19, 26]. Advantages of this technique are exclusion of implant migration or breakage, no need for secondary implant removal and superior results in comparison to hook plate and k-wire retention regarding complication rates and joint stability [12].

However, mid- to long-term results of this technique have rarely been described. Also, it is unclear, whether a possible redislocation or malreduction can lead to arthrosis of the AC-joint or other clinical symptoms.

The present study, evaluates the clinical and radiological outcome of a series of 50 consecutive patients treated by open reduction and PDS cerclage augmentation for acute AC-joint dislocation.

Patients and methods

This study was based on a series of 66 consecutive patients who underwent surgery from November 1994 to August 2003 for AC-joint dislocation by open reduction and PDS cerclage augmentation of the coracoclavicular ligaments. Patients were included in this study based on the following criteria: acute AC-joint dislocation type Rockwood III–V according to the modified classification system of AC-joint injuries of Rockwood [27]. (1) Operative stabilization of the injury no later than 21 days after trauma. (2) Absence of a history of AC-joint dislocation or other shoulder injury or previous surgical intervention of the involved AC- and shoulder joint. Exclusion criteria were accordingly: (a) chronic AC-joint dislocations; (b) history of previous surgical intervention or injury of the AC-joint and (c) associated fractures of the coracoid, the acromion or the clavicle. Sixteen patients were lost to follow-up: seven patients moved away and could not be contacted, seven patients refused to take part in the study, one patient could not be re-examined due to his medical condition making him unable to take part in the study and one patient died unrelated to the sustained surgical procedure. This left a total of 50 patients (76%) for clinical and radiographic follow-up. The patient collectively consisted of 7 women and 43 men. The average age of the patients at time of the operation was 35.3 ± 10.2 years (range: 15–56). In 26 cases (56%) the injury affected the dominant extremity. The mean follow-up time was 70 months (range: 30–121 months).

Preoperative radiographs, documented intra-operative findings and surgery reports were reviewed to analyze and verify the classification of the injury. Horizontal instability and horizontal displacement in axial views was classified Rockwood IV, vertical displacement in stress view of 25–100% of the contralateral side was classified Rockwood III and vertical displacement of $\geq 100\%$ as Rockwood V [27]. According to the modified Rockwood classification, there were 44 Rockwood V injuries, 5 Rockwood III injuries and 1 Rockwood IV injury. In 47 cases the AC-joint dislocation was not associated with concomitant injuries. In the remaining three cases the associated injuries did not involve the operated arm like blunt thoracic and abdominal trauma with rib fractures or rupture of the spleen.

The operation was done in a beach chair position with the injured limb freely mobile. PDS-cerclage reconstruction was performed according to previously published literature [13, 16]. A standard saber cut approach medial of the AC-joint was performed in each case. If necessary, the most lateral clavicular aspect of the deltoid was detached to visualize the base of the coracoid. The subcoracoid passage was prepared by blunt dissection for subcoracoid transfer of a 7.5-mm PDS (polydioxanone) band (Ethicon®). The joint is reduced by direct visualization and the PDS cerclage is fastened with knots. The deltoid was reattached and the delto-trapezoid fascia reconstructed. The limb was immobilized in a sling postoperatively. Early controlled passive mobilization of the shoulder was started within 24 h postoperatively. After discharge, patients completed a physical therapy program with passive and active mobilization of the joint with limitation of flexion and abduction of the shoulder joint to 90° for at least the first 2 weeks. Heavy labor and sports were limited for 12 weeks postoperatively.

The clinical follow-up consisted of the Constant Score (CS) [6] and the Disabilities of the Arm, Shoulder and Hand (DASH) Score, a self-report questionnaire designed to measure physical function and symptoms in people with any of several musculoskeletal disorders of the upper limb [10]. Moreover, the subjective shoulder value (SSV), defined as the patient's subjective shoulder evaluation in percentage of an entirely normal shoulder (100%) [11] was recorded. Patients underwent a full clinical examination of both shoulders with special focus on intra-articular glenohumeral and AC-joint pathologies. Radiographic evaluation of the shoulder girdle was performed in 49 patients. One patient refused repetitive radiographs and was excluded for further analysis. Stress radiographs of the shoulder girdle with 10 kg weights suspended on each arm with wrist straps were performed. Radiographs were analyzed according to previously published data [16] by measuring the distance between the highest point of the coracoid and the inferior border of the clavicle at both sides.

The acromioclavicular joint was evaluated radiographically for onset of osteoarthritis and coracoclavicular ligament calcification was determined according to the classification of Dimakopoulos et al. [7]. Ossifications were classified as absent, minor, or major; minor ossifications represented spots or small ossicles located in the coracoclavicular ligaments, whereas major ossifications were considered as almost complete bridging between the clavicle and the coracoid process.

Statistics

Statistical analysis was performed with use of SPSS version 13.0 software (SPSS, Chicago, IL) to determine relationships between variables. The Kruskal–Wallis test and the Mann–Whitney *U* Test were used for qualitative data analysis. Correlation of clinical test values was performed using Pearson correlation. Independent *t* test analysis was performed to compare groups. The significance level was set at $P = 0.05$. The variables analyzed to look for statistical correlations included the postoperative CS, DASH and SSV at 70 months. Moreover, the influence of acromioclavicular calcifications, coracoclavicular dislocation and onset of acromioclavicular osteoarthritis was recorded.

Results

Clinical evaluation

The mean absolute CS after 70 months was 91.7 ± 8.7 points out of 100 (range 62–100) with a mean agCS of $101.0 \pm 11.1\%$ (range 67–129). Constant Score results were subdivided in the following categories according to the Neer score in: excellent (100–90 points), good (89–80 points), satisfactory (79–70), fair (<70) [30]. Regarding the absolute CS there were 37 (74%) excellent results, 8 good results (16%), 3 satisfactory results (6%), and 2 fair results (4%).

The SSV showed a mean score of $92 \pm 10.7\%$ of the injured side and a score of 98 ± 8.6 points of the contralateral side.

Evaluation of the DASH Score revealed good subjective overall evaluation with a mean of 5 ± 8.8 points (0–41.6) with 0 points as the best possible score result and 100 points as the worst possible score result. Reciprocal DASH Score and Constant Score results correlated significantly (Fig. 1). Examination of the AC-joint showed pathological clinical signs (e.g., AC-joint soreness to palpation, body cross maneuver) on the operated side in 7 patients and on the contra-lateral side in 1 patient. In the investigated patients there were no clinical signs indicating rotator cuff

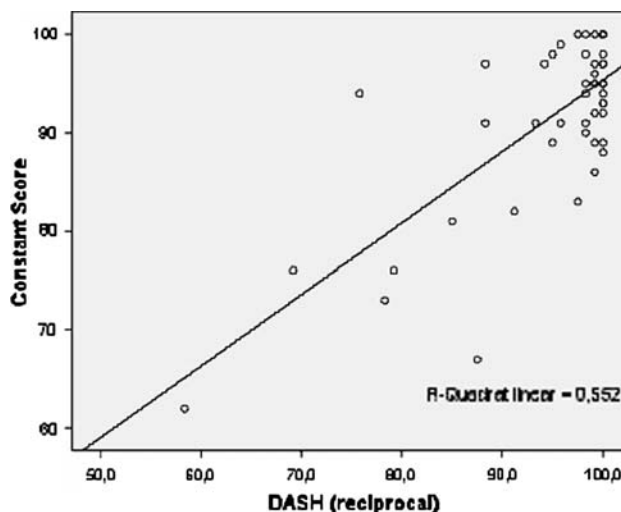


Fig. 1 Pearson correlation of the reciprocal DASH and absolute CS results of investigated patients. There was a significant correlation with a coefficient of 0.743 ($P < 0.05$)

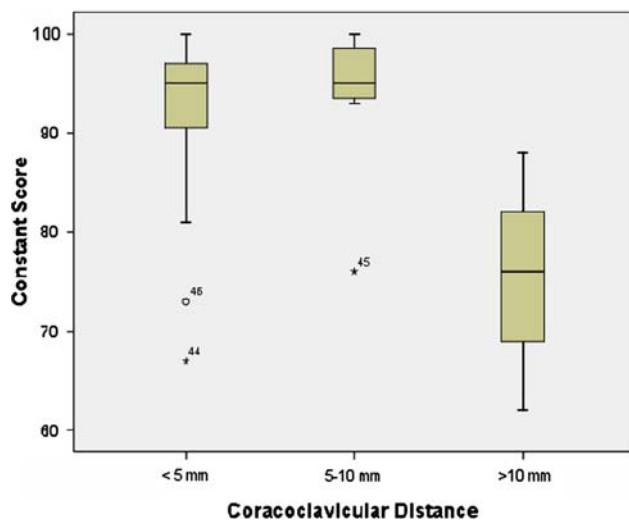
disease, impingement syndrome or other concomitant pathologies of the shoulder joint.

Radiographic evaluation

The coracoclavicular distance was analyzed as the difference to the contra-lateral side and in percentage to the contralateral side. Two patients showed complete redislocations with a coracoclavicular distance of more than 100% to the contralateral side. The mean difference in coracoclavicular distance without the two redislocations was $2.2 \text{ mm} \pm 2.8$ with a mean of $22.4\% \pm 28.3$ increase in coracoclavicular distance in comparison to the contralateral side. There was no significant correlation between clinical score results (CS, DASH, SSV) and the difference in coracoclavicular distance and the percentage of dislocation in comparison to the contralateral side. Results were divided into three groups: difference of coracoclavicular distance to the contra-lateral side <5 mm, 5–10 mm and >10 mm. There were 39 cases (80%) with a distance of <5 mm, 7 cases (14%) with a distance of 5–10 mm and 3 cases (6%) with a distance of >10 mm. Detailed results are shown in Table 1. Patients with a coracoclavicular distance <5 mm showed significant better results in absolute CS in comparison to patients with a coracoclavicular distance of >10 mm (Fig. 2). Evaluation of radiographs according to the Rockwood classification showed 15 cases with a coracoclavicular distance greater than 25%. There were only two cases with a coracoclavicular distance of more than 100% in comparison to the not injured side. Comparison of clinical score results (CS, DASH, SSV) of these groups revealed no significant differences.

Table 1 Coracoclavicular difference in comparison to the contralateral side

CC-distance in mm	Number of patients
≤0	15
1	6
2	10
3	4
4	4
5	1
7	2
8	3
9	1
>10	3

**Fig. 2** Coracoclavicular distance in comparison to the contra-lateral side. Patients with a dislocation of >10 mm showed significant lower values in CS. (* $P < 0.05$: <5 to >10 mm; ** $P < 0.05$: 5–10 to >10 mm)

In 34 cases (68%) radiographs showed calcifications in different dimensions in projection to the coracoclavicular ligaments. However, there was no significant relationship between calcifications and CS results. Also the used subclassification of coracoclavicular calcifications [7] showed no significant coherence with other investigated parameters.

Evaluation of radiographs revealed in 18 cases signs of osteoarthritis of the AC-joint on the operated side and in 9 cases on the contralateral side. However, of these patients only 3 showed signs of osteoarthritis during clinical evaluation.

The coracoclavicular distance in mm and in percentage of the contralateral side showed no significant differences between the groups with clinical or radiographical signs of AC-joint disease and the remaining group. However, there was a tendency of lower coracoclavicular distances in the

group showing radiographical signs of AC-joint arthritis (coracoclavicular distance $1.5 \text{ mm} \pm 2.8$) and the rest of the group (coracoclavicular distance $3.1 \text{ mm} \pm 3.3$).

There was no significant difference in clinical score results and coracoclavicular difference between patients with Rockwood III, IV and V injuries.

Postoperative complications in the presented group was one superficial wound infection which was revised 6 days after surgery and one extensive coracoclavicular calcification which caused limited function and was surgically resected 2 years after the operation. Both patients recovered completely after revision surgery and presented a coracoclavicular distance in comparison to the contralateral side of <5 mm and CS values of 94, respectively, 96 points. Two patients showed a complete redislocation with a coracoclavicular distance of greater than 100% in comparison to the contralateral side. Revision surgery was not performed in both cases due to subjective satisfactory results with DASH score results of 20.8, 3.5, respectively, SSV of 80 and 90%. CS results of these patients were 76 and 88 points.

There were no severe peri- and postoperative complications like nerve injury, deep infections, or horizontal coracoclavicular instability leading to revision surgery.

Discussion

Operative treatment of acromioclavicular joint dislocations has been described by numerous techniques. Several techniques are currently utilized and there are no clear technique-specific recommendations of their respective use. Moreover, new techniques are emerging with minimal invasive or arthroscopic reconstruction procedures. The use of PDS cerclage in the reconstruction of acromioclavicular joint dislocation has been previously described in the literature with favorable results [13, 16, 17, 26]. Its use was most propagated in the past decade and reports of short-term and midterm results were good to excellent. However, one major disadvantage of this procedure is the lack of horizontal stabilization of the clavicle. Cadaveric studies showed that the coracoclavicular PDS cerclage and related techniques can lead to an anterior displacement of the clavicle [1, 20, 25]. However, whether this displacement may cause clinical complaints has not been investigated so far. The aim of the present study was to analyze clinical and radiographical long-term results of PDS cerclage technique for acromioclavicular dislocations.

To our knowledge, this study presents one of the longest published follow-up series with a majority of Rockwood V injuries at a mean follow-up of 70 months. The long follow-up period is especially important since the onset of osteoarthritis of the acromioclavicular joint and other

degenerative changes might occur foremost after several years due to the injury or a possible lack in reconstruction stability. The presented clinical results were good to excellent with a mean CS of 92 points, a DASH score of 5 points and a mean subjective shoulder value of 92%.

Although score results were predominately good to excellent, satisfactory and fair results were found in 5 patients. Evaluation of data of these patients showed various factors diminishing the score results. All of the patients had at least three of the following negative factors: pain, stiffness, dislocation, AC-joint arthritis, abduction force. All of them still complaint about moderate pain in the operated shoulder and abduction force of the shoulder was decreased in all of them. Two of them showed limited range of motion due to shoulder stiffness and corresponding limitations in activities of daily living. Two patients showed clinical signs of AC-joint disease which was accompanied in one case with radiographic changes in the AC-joint. Two of the patients showed a coracoclavicular distance of 90% of the operated shoulder.

Stress radiographs revealed vertical stability in the majority of cases and complete relaxation in just 4% of the investigated patients. Pathological clinical signs of AC-joint disease were found in 14% of the patients. Although the rate of radiographic osteoarthritic changes in combination with corresponding clinical complaints was low (6%), X-rays showed signs of degenerative joint disease in 36% of cases, which was twice as much in comparison to the contra-lateral side. Onset of radiographic osteoarthritic changes was not correlated with lower clinical score results nor with vertical dislocation of the clavicle. However, there was a tendency of lower coracoclavicular distances in mm and % in the group with radiographical signs of AC-joint arthritis in comparison to the rest of the group. Although this difference was not statistically significant, an explanation could be that the loss of contact of the lateral clavicle to the acromion in vertical displacement prevents radiographical onset of osteoarthritic changes. Ventral displacement and malrotation of the clavicle, which has been shown for the coracoclavicular cerclage technique in experimental settings [1, 20, 25], may contribute to the onset of degenerative changes in the AC-joint. Taft et al. [29] analyzed long-term results of different surgical stabilization methods and compared results with conservative treatment. After an average follow-up of 10 years, posttraumatic osteoarthritis of the AC-joint was mainly associated with either the acromioclavicular pin fixation technique or with a loss of anatomical reduction. Since in the present study osteoarthritis was not associated with vertical instability, the described malreduction in the horizontal plane might be at least partly responsible for the observed rate of posttraumatic degenerative changes.

The investigated coracoclavicular calcifications have appeared in a high percentage of cases, but showed no correlation to our clinical results. One patient was revised 2 years after the operation for complete synostosis of the coracoid and the clavicle and extensive calcification leading to limited range of motion and impingement syndrome. However, after revision surgery, clinical and subjective results were excellent.

Previous investigation described the constant score has been described to overestimate clinical results in instability patients and propagandized the subjective shoulder value to qualify these results [11]. Although this has been mainly described for glenohumeral instability, instability complaints of the shoulder girdle might be further elucidated, too. The present study showed a high conformity in CS, DASH and SSV score results which underlines the quality of the demonstrated results.

A critical point remains the fact that at least in Rockwood III injuries conservative treatment has been reported to produce favorable results [3]. The majority of cases in the present study have been treated for Rockwood V injuries and the patients treated for Rockwood III injuries represent a group of young and active patients who were informed about alternative conservative treatment options.

In summary, the presented data suggest that operative stabilization of acromioclavicular dislocations with the use of PDS cerclage leads to favorable mid- to long-term results with low complication rates. Although the incidence of radiographical osteoarthritic changes doubled in comparison to the non-injured side, its influence on clinical outcome could not be shown yet. Whether new, more anatomic reconstruction methods or minimally invasive methods may reduce complication rates and provide improved reproducibility of clinical results and may further improve clinical outcome, reducing the onset of osteoarthritis, needs to be evaluated in future studies.

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