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Anatomic coracoclavicular ligament reconstruction with triple flip-buttons leads to good functional outcomes and low reduction loss: a case series

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Background: The management of acromioclavicular (AC) joint dislocation remains controversial. Recently, anatomic coracoclavicular (CC) fixation with a double clavicular tunnel and three flip-buttons has shown promising results. This study aimed to evaluate functional and radiological outcomes in patients with high-grade AC joint dislocation treated with anatomic CC fixation using double clavicular tunnels and three flip-buttons.

Methods: A retrospective, unicentric study was performed. The study included patients with high-grade AC joint dislocation who underwent surgery with anatomic CC fixation using double clavicular tunnels and three flip-buttons. Demographic data were obtained from medical records. A functional evaluation using subjective shoulder value (SSV), visual analog scale (VAS), and disabilities of the arm, shoulder, and hand (DASH) questionnaires was performed, and an evaluation of preoperative and postoperative comparative Zanca view images was performed. Factors associated with functional outcomes and radiological AC reduction were analyzed.

Results: A total of 83 patients completed follow-up and were included in the analysis. The mean SSV, VAS, and DASH scores were 92.8, 0.8, and 6.4, respectively. Patients who had complications experienced significantly worse functional outcomes (DASH: P=0.037). Suboptimal final AC reduction was observed in nine patients (11.1%), and significantly more frequently in patients older than 40 years (P=0.031) and in surgeries performed more than 7 days after injury (P=0.034). There were two reoperations (2.4%).

Conclusions: Anatomic CC fixation with a double clavicular tunnel and three flip-buttons leads to good functional outcomes, low complication rates, and high rates of optimal AC reduction.

Level of evidence: Level IV, case series.

Keywords: Acromioclavicular joint; Coracoclavicular fixation; Patient reported outcome measures; Outcome assessment; X-rays

INTRODUCTION

Acromioclavicular (AC) joint dislocations are frequent lesions representing 4%–12% of shoulder injuries [1,2]. Most of these injuries occur during sports activities in male patients during their second or third decades of life [3,4]. There is a consensus in the

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scientific literature that low-grade dislocations [5,6] (Rockwood classification types I and II [5] and International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS) consensus type IIIa [6]) can be treated conservatively [7,8]. Meanwhile, high-grade dislocations (grades IIIb, IV, V, and VI) benefit from surgical reduction and stabilization [9,10].

Multiple techniques have been described for the surgical treatment of these injuries, with the goal of obtaining anatomic reduction and stability of the AC joint. These techniques include flexible and rigid coracoclavicular (CC) fixation, AC fixation, tendon transfer, and reconstruction with grafts, among others [11-17]. Anatomic CC fixation mimics the native insertion point of the conoid and trapezoid ligaments using one point of fixation in the coracoid and two points of fixation in the clavicle [11,16,18-20]. Anatomic CC fixation has shown good functional outcomes [16,17] and lower reduction loss than single clavicular tunnel fixation [21]. This technique, without the use of grafts, has proven to be a useful treatment for acute AC joint dislocation (first 14–21 days from injury) [21-23].

Devices designed for CC fixation usually use a non-anatomic configuration with a single clavicular tunnel (TightRope, Dog Bone, ZipTight, and others) and have high costs. CC fixation using a flip-button (Fliptack) is an accessible and affordable option originally designed for a single clavicular tunnel [24]. Recently, Breuer et al. [16] described a modification of this device using a double clavicular tunnel and three Fliptack buttons, which showed good functional results and low rates of reduction loss.

This study aimed to evaluate functional and radiological outcomes together with complications in patients with high-grade AC joint dislocation treated with anatomic CC fixation using double clavicular tunnels and three flip-buttons. Our hypothesis is that the use of this technique in patients with unstable AC joint dislocation will lead to good functional outcomes, low complication rates, and low rates of reduction loss.

METHODS

This study protocol was approved by the Research Ethics Committee of Clínica Santa María (No. 85100023). Written informed consent was obtained from all participants.

A retrospective review of patients with AC joint dislocation who underwent surgery at a single clinical center between 2013 and 2019 was performed. The inclusion criteria were patients with: (1) high-grade AC joint dislocations (Rockwood IIIb, IV, V, and VI), (2) surgery with anatomic CC fixation using double clavicular tunnels and three flip-buttons (Fliptack), and (3) complete radiological studies (preoperative and delayed postoperative comparative Zanca views). The exclusion criteria were: (1) any other types of surgery to treat AC joint dislocation, such as transferences (Weaver-Dunn), AC fixation, rigid CC fixation (Bosworth), single flexible CC fixation and others; (2) other additional operative procedures during the surgery, such as distal clavicle resection; (3) surgeries more than 14 days after injury, considered as the limit for acute injury as reported by other authors [16,25,26]; and (4) a history of surgery in the affected shoulder.

For preoperative diagnosis and AC joint dislocation classification, comparative Zanca and bilateral axillary views were used. The indication for surgery was determined considering many variables, such as age, activity level, patient preference, and Rockwood grade. For patients who met the inclusion criteria, demographic data, including sport activity, injury mechanism, and days to surgery, among other factors, were obtained from medical records. All patients were contacted and asked to complete a final evaluation using the subjective shoulder value (SSV; subjective perception of shoulder function; scale of 0– 100, where 100 = best score) [27], a visual analog scale for pain (VAS; subjective perception of pain in the shoulder; scale of 0–10, where 0 = best score), and disabilities of the arm, shoulder, and hand (DASH; self-administered measure of symptoms and functional status; scale of 0–100, where 0 = best score) [28] questionnaires.

Similar to Clavert et al. [29] and Shin and Kim [25], we considered the following complications: visible osteoarthritis in the AC joint, visible osteolysis of the distal clavicle, system failure, persistent shoulder stiffness (defined as glenohumeral range of motion limitation [30] for more than six months, without improvement during clinical controls), coracoid or clavicle fractures, perioperative infection, or any other adverse event occurring within the peri- or postoperative period that deviated from the expected course as a result of the surgical intervention, as defined by Martetschläger et al. [18]. The authors investigated the occurrence of all post-operative complications through medical records and radiological data.

There were 112 patients who met the inclusion criteria. Of these patients, 83 (73%) completed follow-up with a median follow-up period of 4.2 years. For patients who completed the final evaluation, radiographic evaluation was performed. All radiological measurements were performed by one fellowship-trained shoulder surgeon (JTR) who did not participate in the surgeries of this study, using XERO Viewer 8.1.2 (Agfa HealthCare). A comparative Zanca view was used for both preoperative and postoperative images [31]. A line between the most cranial point of each coracoid was drawn. The CC distance between each coracoid and the clavicle was measured perpendicularly to the line

between the two coracoids (Fig. 1) [32]. In both preoperative and postoperative Zanca views, the CC distances of the affected and unaffected side, as well as the difference between them were recorded. The displacement ratio was expressed as a percentage and was calculated as the difference between the CC distance of the affected and unaffected sides divided by the unaffected side [21]. An optimal final AC reduction was considered to be less than 50% of the displacement ratio, and a suboptimal final AC reduction was more than 50% of the displacement ratio [31]. A comparative Zanca view taken immediately after surgery was not analyzed, so the of reduction was not calculated. Only the preoperative and final AC reductions were analyzed.

Surgeries were performed following the same technique by one surgeon on the shoulder team of a clinical center (RA, GG, SC, AV, HC). With the patient in a beach chair position, a supraclavicular approach was performed. All procedures were performed without arthroscopic assistance. A 4.0-mm drill hole was made on the coracoid, and one flip-button (Fliptack, Karl Storz SE & Co.) together with two high resistance sutures (Parcus suture, Parcus Medical) were passed through the coracoid hole and flipped under the coracoid. The position of the clavicular tunnels was chosen during the operation by the surgeon, taking into consideration the anatomic insertion of the native conoid and trapezoid ligaments and a distance of 4.5 cm and 2.5 cm from the lateral border of the clavicle. Subsequently, two 2.5-mm drill holes were made in the clavicle, and one of the Parcus sutures (two tails and the loop) was passed through each clavicle hole. A reduction of the AC joint was made, and the system was blocked using one flip-button on each tunnel with a knot [16].

Postoperatively, patients underwent a standard rehabilitation protocol. Patients used a shoulder brace for four weeks. Elevation over 90°, pressure on the injury and extension of the shoulder in the horizontal plane at 90° were forbidden. Passive movements of the shoulder and active motions of the elbow and wrist were performed starting after the first postoperative day. Physiotherapy started at the fourth week with progressive active and passive motions. Patients were allowed to resume their regular sport activities at the 12th week. Contact sports were allowed starting at the 16th postoperative week.

A descriptive analysis of the sample was performed. A Shap-

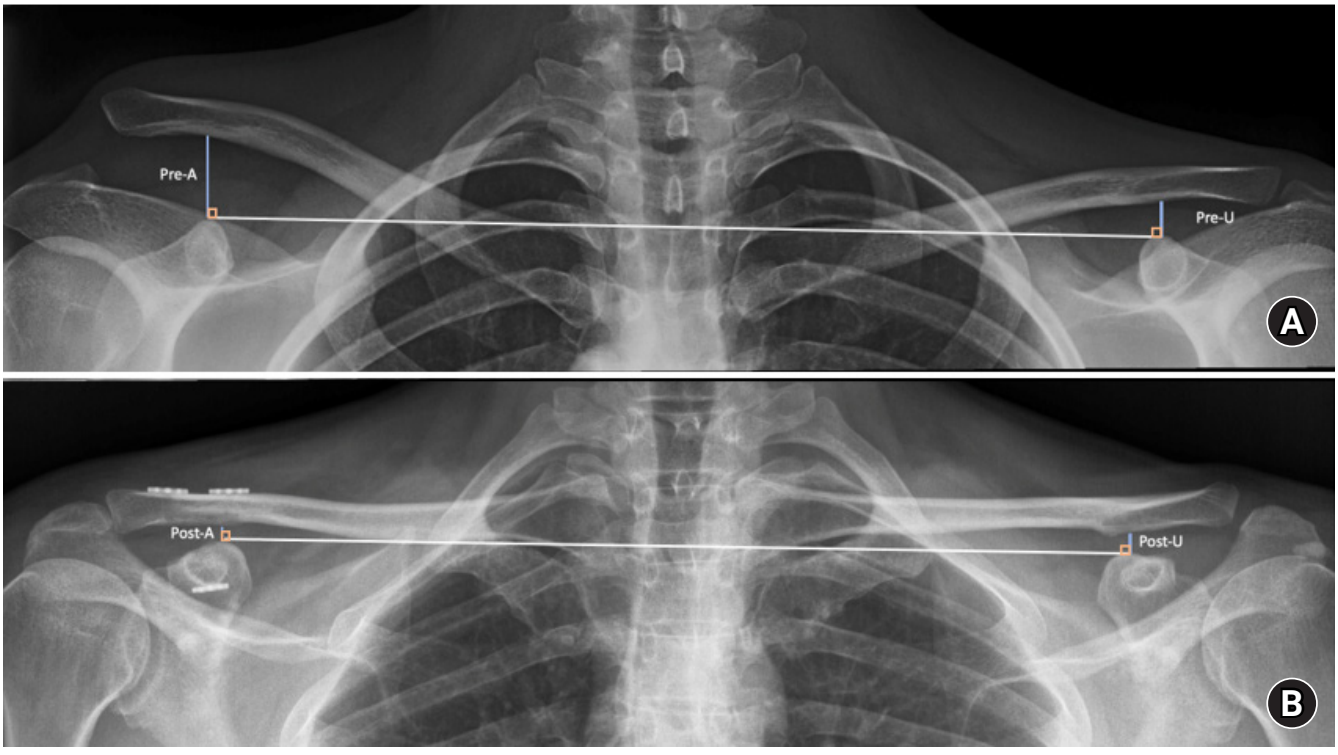

Fig. 1. (A) Preoperative Zanca view. (B) Postoperative Zanca view. A line was drawn between the most cranial point of each coracoid (white lines). The coracoclavicular (CC) distance between each coracoid and clavicle was measured perpendicular to the line between the two coracoids (blue lines).

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iro-Wilk test was used to assess normality in quantitative variables. Quantitative variables are expressed as the means and standard deviations and categorical variables are expressed as absolute frequencies and percentages. The t-tests and Wilcoxon–Mann-Whitney tests were used to compare quantitative variables according to normality distribution, and the chi-squared test or Fisher's exact test was used for categorical variables. A dichotomic analysis looking for associated factors was performed in patients with optimal and suboptimal final AC reduction. All analyses were performed using Stata ver. 14 (StataCorp.), and a significance level of 0.05 was chosen.

RESULTS

A total of 83 patients (37.7 years, 95% male) completed follow-up and were included in the analysis. Most of them (83%) were Rockwood type V with a mean time to surgery of 3 days (Table 1).

At the end of follow-up, the mean SSV, VAS, and DASH scores were 92.8, 0.8, and 6.4, respectively. Patients who had complications showed significantly worse functional outcomes (DASH: P = 0.037) (Table 2). There was no association between functional outcomes and final AC reduction.

There was a significant decrease in the CC distance of the affected side and in the displacement ratio (Table 3). There were

Table 1. Demographic data and injury classification

Variable	Value
Age (yr)	37 ± 10 (17–59)
Day to surgery	3.4 ± 3.1 (0.0–18.0)
Follow-up period (yr)	5.0 ± 2.0 (2.1–9.3)
Sex	
Male	79 (95.2)
Female	4 (4.8)
Side	
Right	46 (55.4)
Left	37 (44.6)
Dominant hand	45 (54.2)
Rockwood classification	
3	7 (8.4)
4	7 (8.4)
5	69 (83.1)
Sport level	
Non-competitive	59 (71.1)
Competitive	17 (20.5)
No sport	7 (8.4)
Age	
≤ 40 yr	47 (56.6)
> 40 yr	36 (43.4)
Day to surgery	
< 3	35 (42.2)
3–7	42 (50.6)
> 7	6 (7.2)

Values are presented as mean ± standard deviation (range) or number (%).

Table 2. Functional outcomes and comparison with different variables

Variable	SSV score		VAS score		DASH score	
	Mean ± SD (range)	P-value[a]	Mean ± SD (range)	P-value[a]	Mean ± SD (range)	P-value[a]
Final AC reduction		0.512		0.235		0.057
Optimal	92.6 ± 8.6 (65.0–100.0)		0.9 ± 1.2 (0.0–5.0)		6.8 ± 8.9 (0.0–36.4)	
Suboptimal	94.4 ± 6.8 (80.0–100.0)		0.4 ± 1.0 (0.0–3.0)		2.8 ± 5.5 (0.0–13.6)	
Side		0.536		0.189		0.836
Dominant hand	93.7 ± 7.7 (65.0–100.0)		0.7 ± 1.2 (0.0–4.0)		6.2 ± 8.3 (0.0–36.4)	
Non-dominant hand	92.1 ± 9.1 (65.0–100.0)		0.9 ± 1.2 (0.0–5.0)		6.5 ± 9.0 (0.0–36.4)	
Complication		< 0.001*		< 0.001*		0.037*
Yes	83.6 ± 12.1(65.0–100.0)		2.2 ± 1.2 (0.0–5.0)		11.1 ± 9.6 (0.0–34.1)	
No	95.3 ± 4.9 (80.0–100.0)		0.4 ± 0.0 (0.0–4.0)		5.1 ± 7.9 (0.0–36.4)	
Reoperation		0.393		0.547		0.452
Yes	97.5 ± 3.5 (95.0–100.0)		1.5 ± 2.1 (0.0–3.0)		8.0 ± 8.0 (2.3–13.6)	
No	92.8 ± 8.4 (65.0–100.0)		0.8 ± 1.2 (0.0–5.0)		6.3 ± 8.6 (0.0–36.4)	
Age		0.091		0.686		0.618
≤ 40 yr	92.4 ± 7.7 (70.0–100.0)		0.8 ± 1.2 (0.0–4.0)		6.8 ± 9.1 (0.0–36.4)	
> 40 yr	93.6 ± 9.2 (65.0–100.0)		0.8 ± 1.2 (0.0–5.0)		5.7 ± 8.0 (0.0–34.1)	
Delay surgery		0.698		0.766		0.935
≤ 7 day	92.8 ± 8.5 (65.0–100.0)		0.8 ± 1.2 (0.0–5.0)		6.5 ± 8.8 (0.0–36.4)	
> 7 day	94.2 ± 7.4 (80.0–100.0)		0.8 ± 1.2 (0.0–3.0)		4.5 ± 5.2 (0.0–13.6)	

SSV: subjective shoulder value, VAS: visual analog scale, DASH: disabilities of the arm, shoulder and hand, SD: standard deviation, AC: acromioclavicular.
[a]Wilcoxon Mann-Whitney test.
*Significant difference with P < 0.05.

Table 3. Preoperative and postoperative radiological evaluation

Variable	Preoperative	Postoperative	P-value[a)]
CC distance unaffected side (mm)	8.9 ± 1.9 (1.0 to 12.6)	9.2 ± 1.7 (5.1 to 12.6)	0.406
CC distance affected side (mm)	18.8 ± 4.7 (2.0 to 26.1)	8.9 ± 3.4 (3.0 to 19.4)	< 0.001*
Displacement ratio (%)	117 ± 0.5 (–0.1 to 2.6)	–1 ± 0.4 (–0.6 to 1.1)	< 0.001*

Values are presented as mean ± standard deviation (range).
CC: coracoclavicular.
[a)]Student t-test.
*Significant difference with P < 0.05.

nine patients (11.1%) who had a suboptimal final AC reduction. After searching for a threshold to identify significant differences between groups, patients older than 40 years and surgeries performed 7 days after the injury were associated with more suboptimal final AC reduction (P = 0.031 and P = 0.034, respectively) (Table 4).

Complications were observed in 16 patients (19.3%), with AC joint osteoarthritis being the most frequent (10.8%). There were two reoperations (2.4%). One of them was due to button failure (considered a complication), and the other was due to a supraspinatus tear not directly associated with the initial injury. There were two coracoid fractures, neither of which required surgery, and both had good functional outcomes. There were no infections, hematomas, thrombotic events, or other severe complications (Table 5).

DISCUSSION

The main finding of this study is that anatomic CC fixation with double clavicular tunnels and three flip-buttons is associated with good functional outcomes, low complication rates, and high rates of optimal AC reduction. Additionally, this study showed no association between final AC reduction and functional outcomes.

To the best of our knowledge, only one study has evaluated this technique. Breuer et al. [16] evaluated functional and radiological results and showed similar functional outcomes (SSV, 95; VAS, 0.9; DASH, 9.1) with 98% satisfaction. These authors showed better functional outcomes in younger patients, surgery before 10 days, and lower reduction losses. These associations were not found in this study, but an association with poor functional outcomes in patients who had complications was observed. All surgeries were performed openly, without arthroscopic assistance. An open procedure with a small incision gives excellent functional and radiological result [16], allowing the surgeon to explore the AC joint intraoperatively when needed.

There are controversies regarding the correlation between radiographic and clinical outcomes. Breuer et al. [16] showed greater CC distances were correlated with worse Constant scores.

Table 4. Comparison between optimal and suboptimal final reduction of AC joint

Variable	Optimal (n = 72)	Suboptimal (n = 9)	P-value[a)]
Sex			0.699
Male	69 (88.5)	9 (11.5)	
Female	3 (100.0)	0	
Side			0.307
Dominant hand	37 (86.0)	6 (14.0)	
Non-dominant hand	35 (92.1)	3 (7.9)	
Complication			0.843
Yes	14 (87.5)	2 (12.5)	
No	58 (89.2)	7 (10.8)	
Reoperation			0.789
Yes	2 (100.0)	0	
No	70 (88.6)	9 (11.4)	
Age			0.031*
≤ 40 yr	44 (95.7)	2 (4.3)	
> 40 yr	28 (80.0)	7 (20.0)	
Delay surgery			0.034*
≤ 7 day	69 (90.8)	7 (9.2)	
> 7 day	3 (60.0)	2 (40.0)	

Values are presented as number (%).
AC: acromioclavicular.
[a)]Fisher's exact test.
*Significant difference with P < 0.05.

Table 5. Reoperation and complications

Variable	No. (%)
Reoperation	2 (2.4)
Complication	16 (19.3)
Acromioclavicular osteoarthritis	9 (10.8)
Distal clavicular osteolysis	2 (2.4)
Shoulder stiffness	2 (2.4)
Coracoid fracture	2 (2.4)
Buttons failure	1 (1.2)

Nevertheless, other studies and the present one show no correlation between reduction loss and functional outcomes [26,33,34]. This could be interpreted as joint stability and lesser CC distances being enough to improve clinical outcomes even when the final reduction does not place the joint in the native position. In the same line, the Breuer et al.'s study [16] did not show any dif-

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ferences between clinical outcomes and reduction loss.

Regarding factors associated with reduction loss, a delayed time to surgery was the most common [10,16]. Breuer et al. [16] reported greater reduction loss with a delay of 10 days. In the present study, even a 7-day delay in surgery was associated with worst radiological final AC reduction, which suggests the importance of early surgery in patients with indications. It should be noted that only six patients (7%) underwent surgery after 7 days compared to 77 (93%) before 7 days. This asymmetry in group size could have weakened the results of the comparative analysis. Additionally, in this study, age greater than 40 years was also associated with worse final AC reduction, similar to other published articles [10,16].

Other studies evaluating flexible CC fixations report similar functional outcomes in either single or double [3,15,17] clavicular tunnels. Despite similar functional outcomes, compared to a single tunnel, double clavicular tunnels show less postoperative reduction loss in comparative clinical studies [21]. One advantage of the double clavicular tunnel with the three flip-button technique is that this configuration is between two and seven times cheaper than other commercially available options such as ZipTight, Dog Bone, TightRope, or Twin Tail.

A direct comparison of complication rates between different studies is not possible, because the criteria utilized are usually different or not clearly described [16,18,25,29,35]. In general, complication rates have been reported to range between 22.4% [29] and 44% [25], with the most frequent complications being reduction loss, clavicular osteolysis and osteoarthritis, hardware failure, and coracoid fractures. The present study showed a global complication rate of 19.3% with AC joint osteoarthritis being the most common (10.8%), similar to what was described by Breuer et al. [16] (8%). Some studies showed a correlation between the presence of complications and worst functional outcomes. Martetschläger et al. [18] revealed a reduced satisfaction and Clavert et al. [29] demonstrated significant lower Constant scores in patients with complications. The present study showed that the presence of complications was correlated with worse SSV, VAS, and DASH assessment, independent of the final reduction of the AC joint.

The findings of the present study should be interpreted with the following limitations in mind. First, this is a retrospective case series study with a mid-term follow-up period. Second, we observed 25.9% loss to follow-up, which could have affected the final results. Third, we did not include postoperative radiographic stress views (Alexander X-rays view) when assessing final radiographic horizontal stability [31,32,36], we only assessed vertical instability. This could underestimate the remaining postoperative instability of the AC joint [31,32]. This was because at the beginning of this study, there were no conclusive data on the use of this projection. Fourth, only the preoperative and final AC reduction was analyzed and loss of reduction was not calculated.

CONCLUSIONS

Anatomic CC fixation with a double clavicular tunnel and three flip-buttons leads to good functional outcomes, low complication rates, and high rates of optimal AC reduction. Functional outcomes were worse in patients who had complications and were not associated with AC reduction. A suboptimal final AC reduction was more common in patients older than 40 years and in those with a surgery delay of more than 7 days. Further studies should be conducted to analyze the cost-benefit of using double versus single clavicular tunnels.

NOTES

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Conflict of interest

None.

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Data availability

Contact the corresponding author for data availability.

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