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Chronic acromioclavicular dislocations: multidirectional stabilization without grafting

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Objective: Clinical and radiological evaluation of the surgical treatment of chronic acromioclavicular (AC) dislocations with triple button device and AC joint augmentation.
Materials and Methods: This retrospective study included 21 patients with chronic AC dislocations. All patients underwent bilateral-weighted Zanca and Alexander views as well as the Constant score (CS) and Acromioclavicular Joint Instability Scoring System (ACJI).
Results: A total of 21 patients (19 men and 2 women) with the mean age of 30.7 ± 11.7 years (range, 19-62 years) were able to participate in clinical and radiographic follow-up. After a mean follow-up of 49.7 ± 17.1 months (range, 13-60 months), the results of the CS were 95.2 ± 5.5 (range, 85-100) and ACJI test 89.7 ± 7.9 (range, 75-100), showing no significant differences with the uninjured shoulder (CS, 96.2 ± 3.9; range, 85-100; ACJI, 95.7 ± 4.1; range, 85-100). At the final review, we observed that the preoperative coracoclavicular distance (Zanca view) improved from 12.8 ± 1.5 mm to 8.5 ± 1.3 mm and the AC distance (Alexander view) from 7.8 ± 2.3 mm to 0.99 ± 0.91 mm. Compared with healthy shoulder, these differences were not significant. Osteoarthritis or radiological calcifications were not associated with worse clinical outcomes.
Conclusion: The triple button device is an acceptable alternative surgical method for chronic AC joint dislocations. The surgical technique is simple; it does not need a graft, nor does it present major complications, and material extraction is unnecessary.

Acromioclavicular (AC) dislocations represent 9% of shoulder girdle injuries. Most AC joint injuries occur in the third decade of life as a result of contact sports (rugby, cycling, football, martial arts, etc.) or traffic accidents. The main mechanism is usually a direct blow to the shoulder with the arm in adduction.[35,57]

The original classification of Tossy et al,[76] with 3 main types of injuries, was later extended by Rockwood[13] to 6 injury types, which is the most used today. Conservative treatment has been nominated for types I and II (low grade), and surgical treatment for types IV, V and VI (high grade). The treatment for type III injuries remains controversial, and patients are usually treated nonoperatively, except for patients with physically demanding occupations or sporting activities.[37,74] Between 20% and 40% of type III[79] or higher AC dislocations that are treated orthopedically as well as those that are operated, regardless of the technique, do not obtain good clinical results because patients complain of pain, fatigue and muscle weakness, paresthesias, or an unsightly bulge at the level of the joint.[34,39] In addition, vertical instability due to coracoclavicular (CC) ligament injury[18] and horizontal instability due to insufficient healing of AC ligaments produce functional shoulder impairment and chronic pain.

The treatment of chronic acromioclavicular dislocations remains a therapeutic challenge nowadays.[16,30] It has evolved from the original open techniques until the most recent arthroscopic advances, since Lafosse et al[46] treated the first case, in an attempt to get a better treatment with fewer complications. Rigid techniques (plate or screws) that do not allow normal mobility of the clavicle have been shown to be ineffective and have many complications.[59] The Weaver-Dunn procedure has been used with several modifications over time.[30,48] The latest trends advocate the need to use an autograft associated with a fixation system to solve these lesions, given the poor healing capacity of the native ligaments, especially when the injury has long time of evolution.[3,20]

This study was approved under protocol from the Murcia University (HGU Los Arcos Institutional Review Board) and found to be exempt (HULAMM-CE-IRB/01.03/2017).

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The aim of this article is to describe the treatment of chronic acromioclavicular dislocations with a triple-button device with an AC reinforcement in a series of cases and compare it with the results published in the literature. We want to know if this system achieves a stable reduction in time without the need to use a graft, either natural or artificial, thus avoiding the clinical complications, facilitating the surgical technique, and reducing the morbidity associated with these processes.

Materials and methods

Patient selection

A retrospective evaluation was performed on the outcomes of 21 patients (19 men and 2 women aged between 19 and 62 years) treated between January 2012 and January 2018 for chronic AC joint dislocation. All the patients presented pain and discomfort with limitation of their daily and sports activity.

The inclusion criteria were: (1) chronic AC joint dislocation (more than 6 weeks from injury), (2) primary treatment failure (it is defined as the presence of pain and/or instability 6 weeks after injury; except for 3 patients who were initially operated, in the rest of the cases, the initial treatment was conservative: shoulder in a sling and analgesia for 10-15 days followed by rehabilitation), (3) patients with closed physis, (4) unilateral injury, (5) written consent of patients, and (6) minimum 1 year of follow-up. The exclusion criteria were: (1) prior disease (glenohumeral arthritis, fracture, or rotator cuff pathology) or surgery of the injured shoulder before acromioclavicular dislocation (or the uninjured shoulder used as control), (2) patients lost to follow-up, and (3) the presence of fracture or associated lesions of girdle shoulder at the time of the study. No patients were lost during the follow-up.

Radiographic and clinical evaluations

Preoperative projections included a bilateral Zanca view with 10 kg to assess vertical stability and a bilateral Alexander view with 10 kg to assess horizontal stability.[66] Preoperative values were taken, and each patient was followed up every 3 months for a year and annually thereafter. In all cases, the CC distance (distance between the superior surface of the coracoid process and the inferior cortex of the clavicula) on the Zanca view and the acromioclavicular distance (distance between the articular medial edge of the acromion and the articular lateral edge of the clavicle) on the Alexander view were evaluated. Horizontal instability is defined according to Tauber.[72] The articulation is considered stable if the anteroposterior displacement compared with the uninjured side is less than 50%, subluxated (between 50% and 100% with respect to the healthy side), and dislocated (more than 100% with respect to the healthy side).

Vertical instability (radiological recurrence) is defined as an increase in the CC distance greater than 25% with respect to the healthy side (type 3 of Rockwood at least) (Fig. 1). These measurements were performed using the computer program Syngo (Siemens AG, Erlangen, Germany). The clinical follow-up included Constant score (CS: 0-100)[14] and acromioclavicular joint instability test (ACJI: 0-100)[66] with the same temporal sequence as radiological measurements. Patient age, gender, injured side, correlation between clinical tests and radiological measures, primary treatment, delay to surgery, mechanism of injury, and ACJ separation grade were assessed (according to the Rockwood classification).[13]

Surgical technique

The surgical procedures were performed by a single orthopedic surgeon. With the patient in the beach-chair position, the procedure was performed under general anesthesia in combination with an interscalene block. Preoperative endovenous antibiotic prophylaxis was provided with 2 g cefazolin. The injured shoulder was prepared and draped free. A pad was placed beneath the scapula. A saber cut incision[61,72,78] was made in line from the coracoid process to the medial AC joint.

First step: vertical stabilization

The deltotrapezial fascia is taken down subperiosteally, exposing the base of the coracoid avoiding muscle detachment of the clavicle. We place blunt retractors medially and laterally under the coracoid process to protect the neurovascular structures. At this time, we center a 2.4-mm drill tip guide pin on top of the coracoid and drill through both cortices. Next, we advance a 4.5-mm cannulated screw, and a drill hole is then made with care, making sure not to plunge the drill bit or fracture the coracoid process. A malleable retractor can also be placed inferior to the coracoid process to ensure that the drill bit does not plunge too deep below the coracoid process. The guide pin and the drill are removed. We access the CC space and remove the scar tissue and a few millimeters of the inferior border of the clavicle. We always remove the AC capsule, disc, and 5 mm of distal clavicle. Two more drill holes are then made using a 2.4-mm drill tip guide pin at 15 mm anterior to the midline and 40 mm posterior to the midline from the distal end of the clavicle. This corresponds to the anatomic attachment of CC ligaments. We advance a 4-mm cannulated drill over the guide pin and ream through both cortices to complete the clavicle tunnels. The guide pin and the drill are removed. The Twin Tail TightRope features 2 independent clavicle button tails. Each clavicle button is independently joined to the coracoid button with a continuous loop of #5 FiberWire. The 3 buttons on the device have white traction sutures to help pass them through the bone and blue sutures to tie. We introduce the coracoid button through the coracoid tunnel using the Button Inserter. The button must be flipped beneath the coracoid undersurface. At this time, a nitinol suture is passed through the clavicle tunnel using a SutureLasso. Now we load all sutures from 1 clavicle button into the loop of the suture passing wire. The wire is pulled to retrieve the sutures through the clavicle tunnel. This last step is repeated with the second clavicle button. The clavicle must be manually reduced by direct pressure of our thumb. The fiberwires are then individually tied to each of their endobuttons from medial to lateral. Tension on the sutures should be aimed at achieving and maintaining adequate reduction, while allowing motion as physiological as possible. The white traction suture is removed from the 3 buttons.

Second step: horizontal stabilization

For the internal brace, we use two 4.5-mm SwiveLock and 1 FiberTape (#5 non-reabsorbable suture). Two anteroposterior 3.75-mm holes are made 5 mm from the lateral end of the clavicle and 5 mm from the medial end of the acromion. Then we must pass 1 end of the FiberTape through the eyelet of the first 4.5-mm SwiveLock. The SwiveLock is pushed into the acromial socket until the eyelet is fully seated. We need to maintain tension on each end of the FiberTape turning the driver clockwise to screw the anchor. We need to ensure that the anchor is seated flush with the cortices before removing the driver. At this time, we pass both free limbs of the FiberTape through the eyelet of the second 4.5-mm SwiveLock. The next step is to place the AC joint reduced in the horizontal plane before inserting the second anchor. Now we have to maintain tension on each end of the FiberTape and screw the anchor into the clavicle. This step occasionally requires a gentle tap with the mallet. Now the free ends of the FiberTape are cut. The internal brace provides posterior and rotational stabilization of the

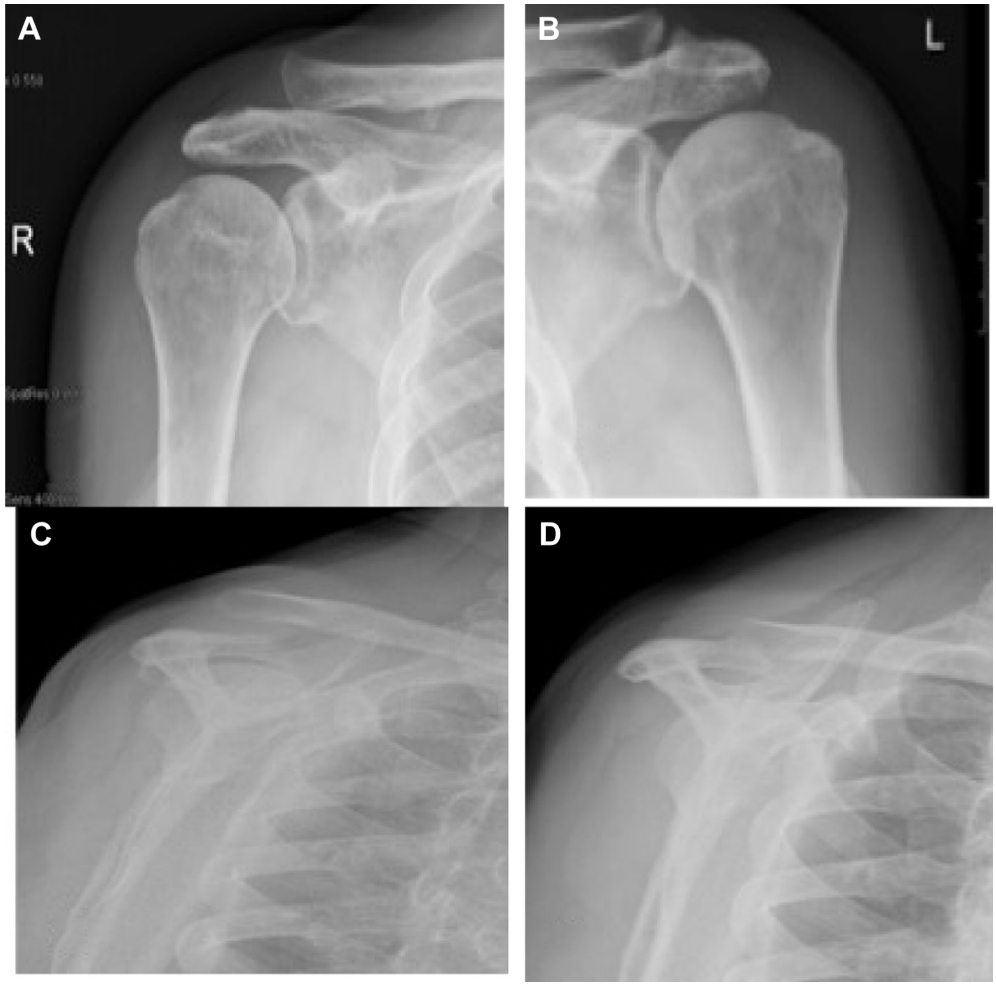

Figure 1 Case number 8. Preoperative stress radiographs of a chronic acromioclavicular joint separation demonstrated in both planes (**A**: Zanca view; **C**: Alexander view) compared with the healthy side (**B**: Zanca view; **D**: Alexander view). *R*, right; *L*, left.

AC joint (Figs. 2 and 3). The trapezius and deltoid with their fascia must be repaired and the wound must close with sutures. A sling is worn in the postoperative period.

Clinical note

We started to reinforce the acromioclavicular joint in 2012, using knotless implants that we used in the rotator cuff repair. In January 2017, the use of a specific system that reproduced almost exactly what we were doing in chronic AC dislocations and called InternalBrace was published on Arthrex's website. This reinforcement has also been used in other joints such as the ankle and/or the hand, among others.

Postoperative care

After surgery the arm is supported with a sling for 4 weeks. During this time only passive abduction and flexion are allowed (3 times a day for 10 minutes each time). After removal of the sling, actively assisted exercises (up to 90°) are begun. During weeks 6-12 a full range of motion is allowed as well as isometric muscle strengthening. Exercises against resistance are added from week 12. Sports or activities that stress the AC joint (heavy manual labor for example) are not allowed until the sixth month.

Statistical analysis

A descriptive analysis of each variable was performed, showing the data as arithmetic mean ± standard deviation with the range in parentheses. To analyze the relationship between 2 categorical variables, Fisher's exact test was used. To test if there was any difference between the means of dichotomous qualitative variables, the Mann-Whitney *U* test was used. To test the equality between means of nondichotomous variables, the Kruskal-Wallis test was used. The SPSS version 19.0 system (IBM Corp., Armonk, NY, USA) was used for the statistical analysis. A level of statistical significance of $P < .05$ was considered.

Results

The average follow-up for the 21 patients was 49.7 ± 17.1 months (range, 13-60 months). There were 19 men (90.4%) and 2 women (4.7%). The mean age of the entire study population was 30.7 ± 11.7 years (range, 19-62 years). The time elapsed between injury or prior surgery and last surgery ranged from 6 to 31 weeks (average, 11.8 ± 5.9 weeks). The right side was affected in 15 cases (71.4%). The mechanism of injury included a sport in 12 cases (57.1%; bike, football, or martial arts), traffic accidents in 6 cases (28.5%), and a fall in 3 patients (14.2%). The surgery had an average duration including skin closure of 51.5 ± 8.9 minutes

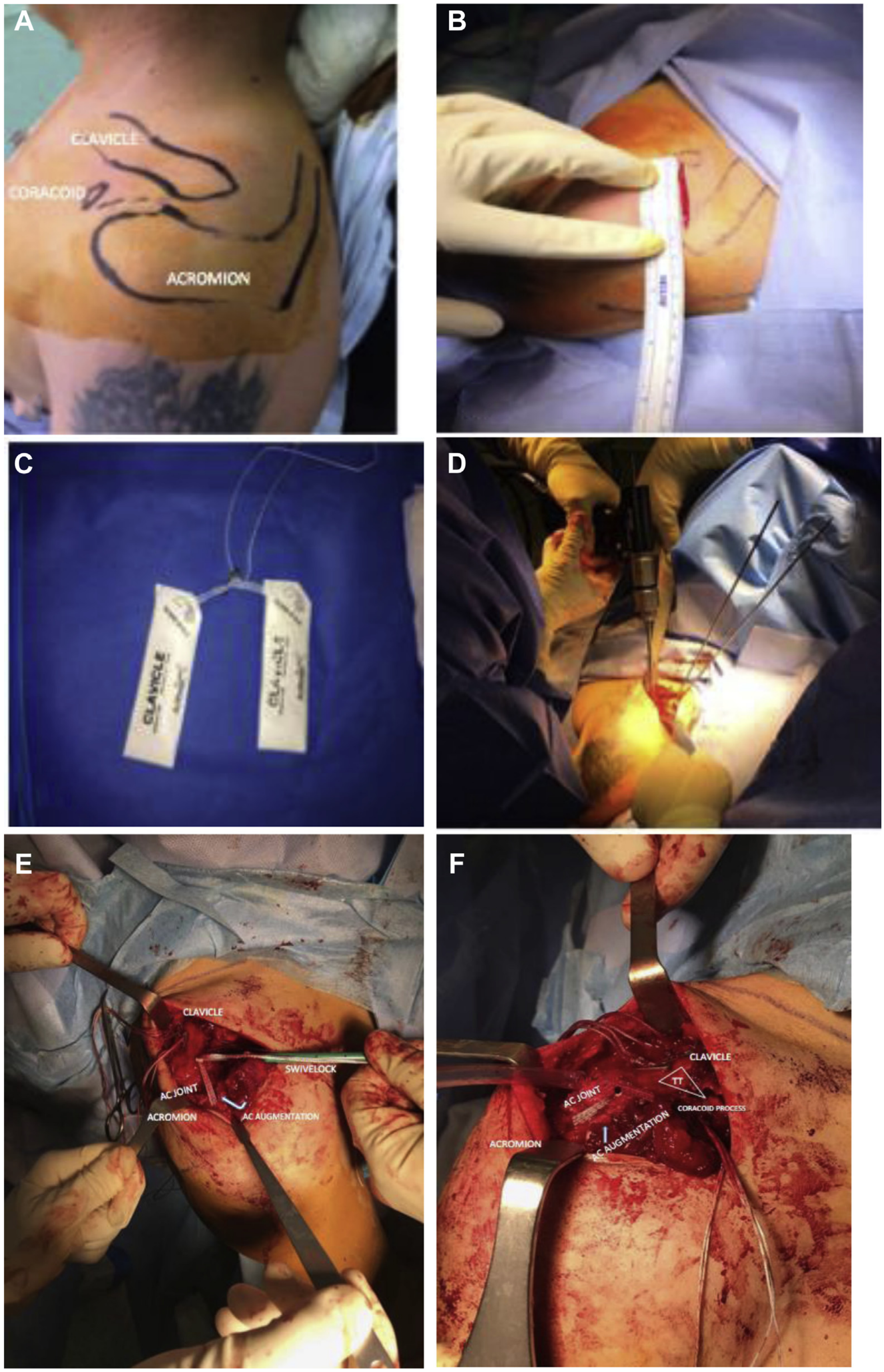

Figure 2 Case number 10. (**A**) Patient in a beach chair with anatomic references marked on the skin. (**B**) MINAR (cutaneous incision no greater than 5 cm). (**C**) Twin Tail prepared on the operating table. (**D**) Performing a hole in the coracoid, having marked the anatomic points of the coracoclavicular ligaments in the clavicle with needles. (**E**) The triple-button device implanted and knotted in its definitive position can be observed while preparing the insertion of the implants for the AC joint. (**F**) Final aspect of the joint with the Twin Tail + AC augmentation. *AC*, acromioclavicular; *MINAR*, mini-invasive acromioclavicular joint reconstruction; *TT*, Twin Tail (triangular disposition).

(range, 43-73 minutes). A total of 19 of 21 patients presented a type 3 of Rockwood, one of them a type IV and another a type V. Three patients had been previously operated (1 with the technique of Weaver-Dunn and another 2 with GraftRope). There were no intraoperative complications. The demographic data are shown in Table I.

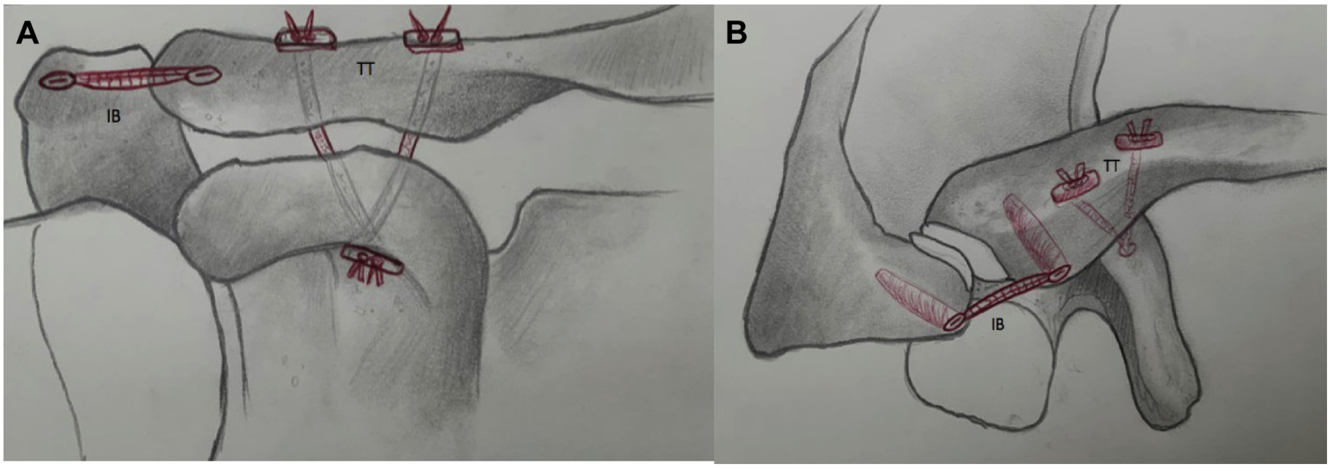

Figure 3 Schematic diagram of the final construct. (**A**) Frontal view; (**B**) axial view. *IB*, internal brace; *TT*, Twin Tail TightRope.

Clinical results

The values of the preoperative CS on the injured side were 75.3 ± 9.4 (range, 50-85). At the last follow-up, the CS of the injured side averaged 95.2 ± 5.5 points (range, 85-100 points), and the healthy side presented a mean value of 96.2 ± 3.9 points (range, 85-100 points). This difference was not statistically significant (*P* > .05) (Fig. 4).

The mean preoperative ACJI rating score was 52.7 ± 11.3 on the injured side (range, 35-75) and 95.7 ± 4.1 on the healthy side (range, 85-100). At the last follow-up, the ACJI of the affected side was 89.7 ± 7.9 (range, 75-100). This difference with the healthy side was not statistically significant (*P* > .05) (Fig. 5).

There were no major complications such as fractures around the implant or deep infections. There were minor complications: 5 patients who presented a hypertrophic scar (23.8%) and who were successfully treated with topical treatment, 1 patient who presented subcutaneous discomfort with the clavicular buttons (4.7%) that improved with nonsteroidal anti-inflammatory drugs, and another patient who suffered a superficial infection (4.7%) that was treated with oral antibiotic. Also, neither sex nor age had any statistically significant correlation with the clinical scores. The patients were reincorporated to their usual activity at 12.5 ± 3.1 weeks (range, 5-18 weeks).

Radiological results

Preoperatively, the mean CC distance was 12.8 ± 1.5 mm (range, 11.3-16.4 mm) on the injured side and 7.9 ± 0.6 mm (range, 7-9.1 mm) on the uninjured side. Postoperatively, the mean CC distance was 8.2 ± 0.9 mm (range, 7.1-13.2 mm), and at the last follow-up, the mean CC distance was 8.5 ± 1.3 mm (range, 7.3-13.9 mm). There was no statistical difference between the injured and uninjured side (*P* > .05) (Fig. 6).

Preoperatively, the mean AC distance (horizontal plane) was 7.8 ± 2.3 mm (range, 4.2-12.1 mm) on the injured side and 0.41 ± 0.65 mm (range, 0-2.9 mm) on the uninjured side. Postoperatively, the mean AC distance was 0.78 ± 0.88 mm (range, 0-2.1 mm) and increased up to 0.99 ± 0.91 mm (range, 0.3-3.8 mm) in the last review. There was no statistical difference between the injured and uninjured side (*P* > .05) (Fig. 7).

There were 1 recurrence in the Alexander view and 1 recurrence in the Zanca view (4.7%): both in the same patient (case number 2 in the current study). This case averaged a lower score in the ACJI

Table I
Demographic data

Patient no.	Age	Injured side	Etiology	Rockwood	Time evolution since injury (weeks)	Follow-up (mo)	Primary treatment
1	35	L	Sport	III	22	80	Weaver-Dunn
2	43	R	Fall	V	8	76	GraftRope
3	26	R	Sport	III	16	71	Conservative
4	24	R	Sport	III	11	70	Conservative
5	19	R	Sport	III	5	68	Conservative
6	21	R	Sport	III	12	63	Conservative
7	59	L	Traffic accident	III	17	61	GraftRope
8	21	L	Sport	III	10	59	Conservative
9	37	R	Sport	III	13	58	Conservative
10	28	R	Sport	III	14	53	Conservative
11	24	L	Traffic accident	IV	11	48	Conservative
12	62	L	Fall	III	31	41	Conservative
13	31	R	Traffic accident	III	6	38	Conservative
14	23	R	Sport	III	8	37	Conservative
15	23	L	Sport	III	8	36	Conservative
16	30	R	Sport	III	7	34	Conservative
17	24	R	Traffic accident	III	6	30	Conservative
18	38	R	Fall	III	8	29	Conservative
19	19	R	Sport	III	8	27	Conservative
20	23	R	Traffic accident		8	25	Conservative
21	21	R	Traffic accident	III	8	25	Conservative

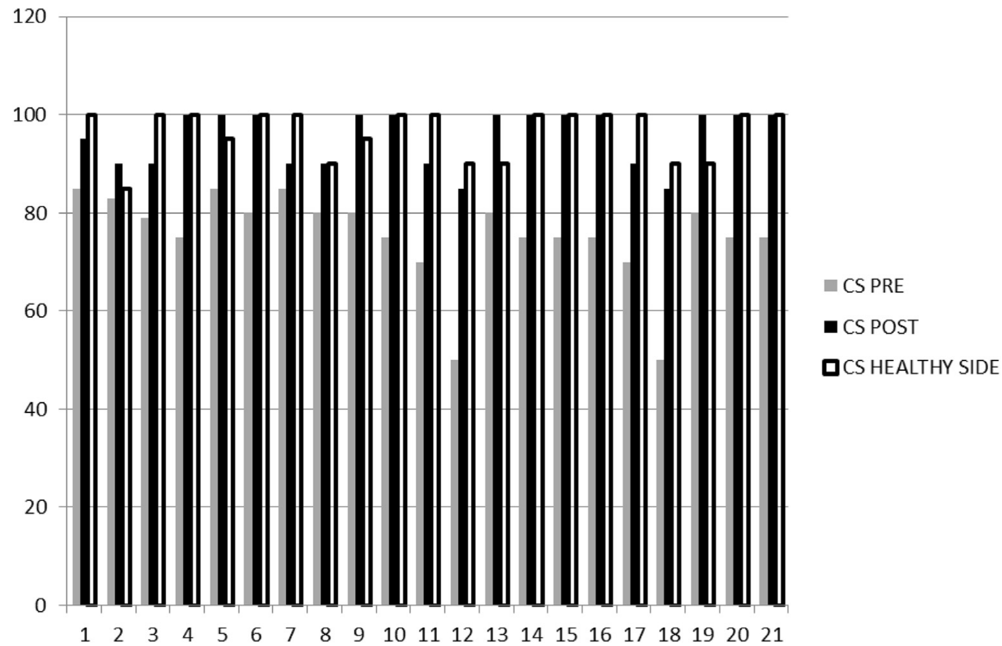

Figure 4 Constant score. It is appreciated how the preoperative values are not as low as in the ACJI test. Even the postoperative values of the injured shoulder exceed those of the noninjured shoulder in some cases, which indicates that a generic test omits information regarding the state of the acromioclavicular joint. *ACJI*, Acromioclavicular Joint Instability Scoring System; *CS*, Constant score.

test (75) at the last follow-up. In 3 patients (14.2%), radiological signs of osteoarthritis of the AC joint occurred at the time of follow-up. Four patients (19%) revealed calcification between the coracoid process and the inferior border of the distal clavicle. There was no hardware failure, implant migration (at the clavicular site), or fracture in our study. We detected a lateral mobilization of the coracoid button in 4 patients (19%) without clinically worse results (Table II).

There was a statistically significant association (0.02) between the evolution time of the lesion and the clinical and radiological results. There was a high correlation between the Alexander view and the ACJI test (r: 0.86). There was an intermediate correlation between the Zanca view and the ACJI test (r: 0.57). There was a slight correlation between CS with the Alexander view (0.24) and Zanca view (0.30). No significant differences were found regarding the duration of the surgery, or the cause of the accident with the radiological or clinical findings. No patient had to be reoperated to remove the implant.

Discussion

Chronic AC dislocations remain a therapeutic challenge today. No single procedure has proven to be superior to another, and the techniques developed to date still present a considerable failure rate.[3,13,67] The AC joint is the part of the shoulder girdle that transfers the load of the upper extremity to the core of the body. The CC ligaments are the main ligaments responsible for vertical stability (2 strong connections between the clavicle and the coracoid),[18] whereas the AC ligaments are responsible for horizontal stability (AC joint has 4 thin capsular ligaments all around, the

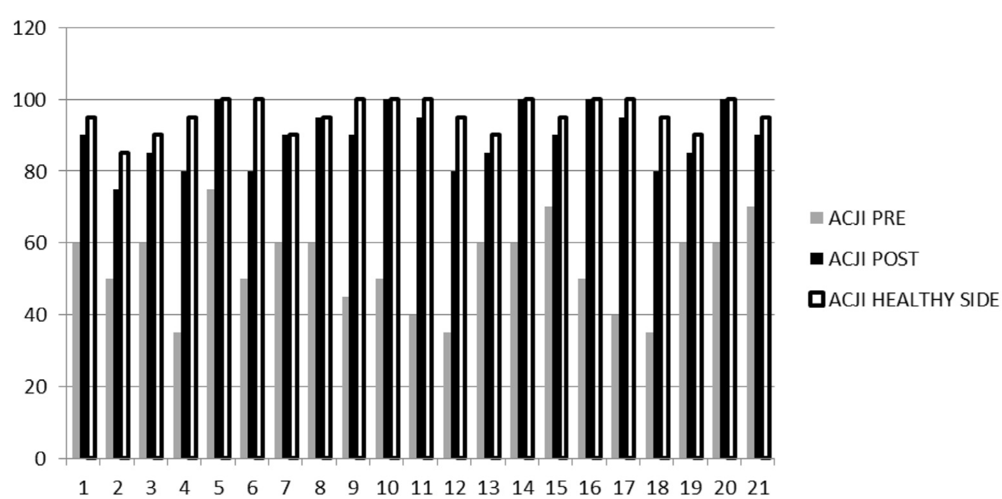

Figure 5 ACJI test. We can observe the low values that the patients have before the surgery and how they approach the values of the healthy side after the surgery. *ACJI*, Acromioclavicular Joint Instability Scoring System.

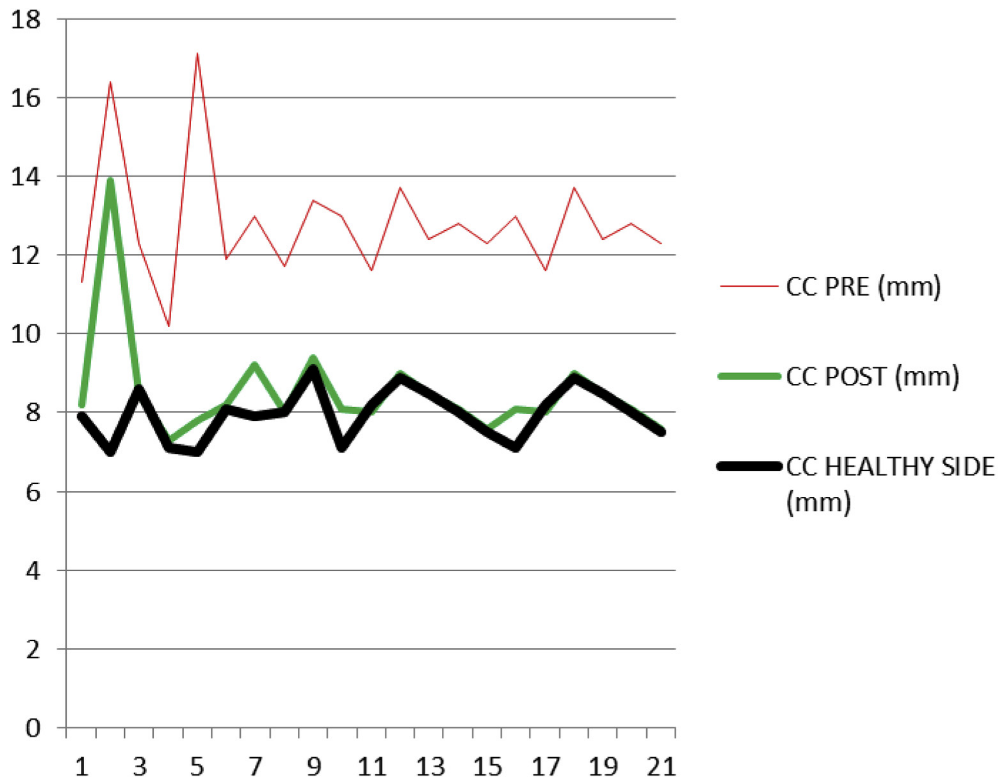

Figure 6 Coracoclavicular distance in the Zanca view. The vertical displacement is reduced to a position similar to that of the healthy shoulder after surgery, except in case number 2. *CC*, coracoclavicular distance; *PRE*, preoperatory; *POST*, last follow-up.

superior and posterior parts being the most important).[26,53] Restoration of the anatomy is the key to success and good functional outcome after any treatment.[16,41] Otherwise, patients may develop symptoms (weakness, pain, dyskinesia, and even neurologic symptoms).[81]

Management of chronic AC lesions has evolved from Mumford's procedure, nonanatomic techniques like Weaver-Dunn, and now anatomic reconstruction of CC ligaments. Cadenat[8] and Neviaser[60] were the first to transfer the coracoacromial ligament to the distal end of the clavicle. This technique, the benchmark for many years,

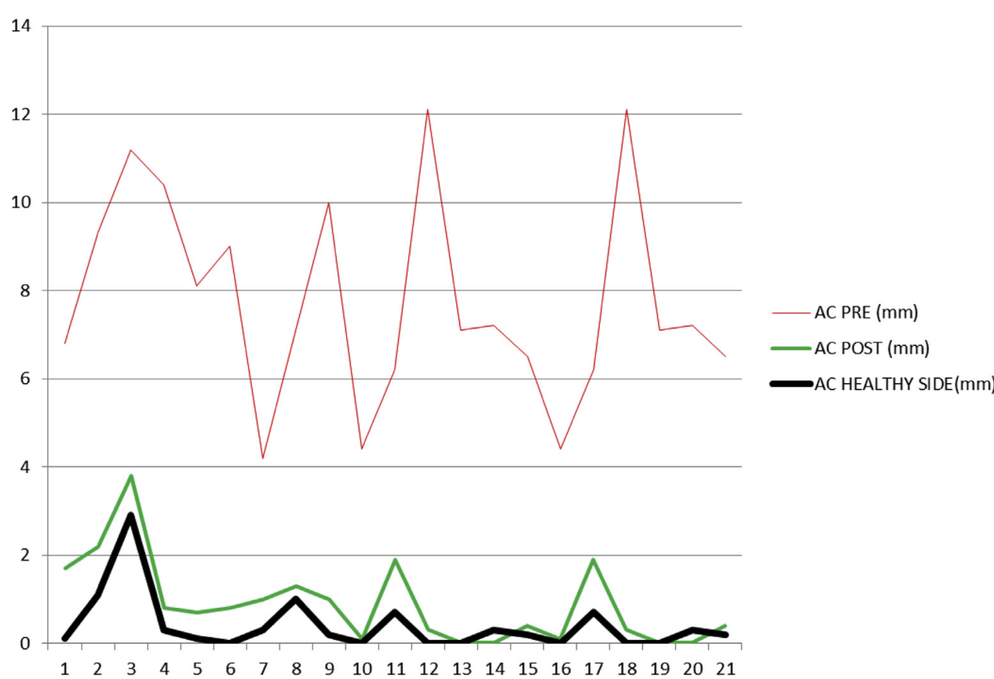

Figure 7 Acromioclavicular distance in the Alexander view. It is observed how the horizontal displacement before surgery returns to an almost anatomic position after surgery, except for case number 2 (recurrence). *AC*, acromioclavicular distance; *PRE*, preoperatory; *POST*, last follow-up.

Table II
Clinical and radiological complications–associated treatment

Patient no.	Clinical complications	Radiological complications	Treatment
1	–	–	–
2	Discomfort with implants	Recurrence (vertical + horizontal)	NSAIDs
3	Hypertrophic scar Wound infection	Degenerative changes	Antibiotics
4	–	–	–
5	Hypertrophic scar	–	–
6	–	Degenerative changes	–
7	–	–	–
8	–	Calcifications	–
9		LMBA	–
10	Hypertrophic scar	LMBA	–
11	–	–	–
12	–	Degenerative changes LMBA	–
13	–	Calcifications	–
14	–	Calcifications	–
15	–	–	–
16	Hypertrophic scar	LMBA	–
17	–	–	–
18	–	–	–
19	Hypertrophic scar	–	–
20	–	–	–
21	–	–	–

–, None; *LMBA*, lateral mobilization of coracoid button; *NSAID*, nonsteroidal anti-inflammatory drug.

was modified by Weaver-Dunn resecting the distal end of the clavicle.[80] Although it has had acceptable results, it also has biomechanical disadvantages because the ligament transferred does not have the strength of the native ligaments; also, it is a nonanatomic technique that presents approximately 30% loss of reduction and horizontal instability. In addition, the coracoacromial ligament is a secondary stabilizer of the shoulder, so in the long term, it can lead to vertical instability of the shoulder joint.[5] Thus, alternative techniques have been developed in which the transferred coracoacromial ligament is augmented with cerclage, sutures, or tight ropes.[6,54] These methods have demonstrated recurrences as well as risk of bone fracture due to the effect of the sutures.

Rigid devices such as CC screws[7] or transarticular AC fixation transmit significant forces including some rotations that may lead to complications such as loosening, breakage, and migration.[9,27,29] The hook plate[2] allows early mobilization; however, it causes high contact stress and predisposes to acromial fracture during loading. The major disadvantage is that it must be removed, which results in an extra surgical procedure.[19]

Jones et al[36] first described the use of an autogenous semitendinosus tendon for reconstructing the CC ligaments. Afterward, other natural tendons were also used, such as palmaris longus[51] or lateral half of the conjoined tendon.[40] The use of a graft has the advantages such as biological integration, no loosening, and no need for implant removal.[20,33,44] They have proven to be superior biomechanically compared with more conventional methods in lab tests.[49,73] Despite good clinical results, complications related to hardware failure,[52] stabilization failures,[77] coracoid and clavicle fractures,[56] or hyperesthesia of the infrapatellar branch of the saphenous nerve (at the region of tendon harvesting in case of using hamstrings)[38] have been reported. Also, we must consider the need for an extra process, technically demanding, to take the graft, with the time it entails. In the same way, the use of allografts[11,20,21] provides sufficient strength to start early mobilization and allows not to sacrifice a native tendon. The concern about its use is the transmission of diseases, osteolysis,[65] and the risk of infection.[25] We also have to take into account the associated economic cost.

Some of these techniques have been performed by arthroscopy, communicating good results and few complications.[46] The problem with arthroscopic techniques is that they are technically very demanding, requiring a steep learning curve.[17] Besides, the position of the coracoid tunnel will determine the position of the tunnels in the clavicle, it being very difficult to be able to respect the native anatomic insertions of the CC ligaments,[12] so, the graft behaves biomechanically as a single large diameter ligament, which causes the risk of fracture of the coracoid.[15] Nordin et al[62] had to suspend their prospective study on the GraftRope system for this reason. Lastly, the arthroscopy-assisted procedure may increase costs over the open procedure alone.[10]

Although the Rockwood classification is the most used, it provides only static information; the fact of not understanding dynamic injury forms favors a loss of information, because not all injuries can be included in this classification.[73,75] Another problem that we find is that by not making adequate axial radiological projections up to 20% of type IV dislocations are misdiagnosed as type III, which explains their poor clinical evolution because so many of them develop scapular dyskinesis (70%).[28]

The triple button device used in the current study is a nonrigid fixation. We are based on 2 facts:

Clinical and laboratory studies show that the Twin Tail TightRope used in this work has a stiffness closer to the native joint than devices that block it, such as plates. Consequently, the degrees of freedom of movement will be very close to normal function.[45,50]

The clinical experience itself: when we use plate and screw systems and mobilize the arm neither visually nor pressing with the thumb, we are able to mobilize the joint. However, when we use our device and mobilize the arm both visually and pressing with the thumb, we observe mobility, small but existing.

The arrangement in "V" with the base in the coracoid process and 2 independent clavicular buttons respects the insertions of the CC ligaments, allowing them to work biomechanically as 2 different but synergistic structures. The 2 buttons of the clavicle spread the pressure over a larger area so that the chances of cut-through of bone are reduced. The fact that the drilling holes are only 4.5 mm (compared to the 6-7 mm that are required to pass certain grafts or devices such as GraftRope)[62] allows the coracoid process not to be excessively weakened and fractured. The presence of lysis, bone resorption, and risk of bone fracture has been related to larger bone tunnels, in an eccentric position or in distal portion of the coracoid process.[44,69] As the average width of the coracoid is approximately 15 mm, accurate coracoid tunnel placement particularly in the center-center or medial-center position minimizes bony failure risk (open surgery makes this step easier).[68] More force was required to cause fractures in models with smaller tunnels, and cadaveric specimens were more prone to fracture when tunnels were placed in the distal coracoid compared with the base.[22] These results suggest that the technique must include using tunnels closer to 4.5 mm than 6 mm and tunnels closer to the base of the coracoid because they are more forgiving regarding bony failure risk than those placed in the distal coracoid.[43]

We remove the distal end of the clavicle (no more than 5 mm) and the disc in order to prevent AC joint osteoarthrosis[81] and a potential pain generator.[4] We must take care and not resect too much distal clavicle to avoid horizontal instability.[68] The time of evolution produces scarring and fibrosis that of the soft tissues often makes adequate reduction difficult, hence the importance of adding a reinforcement for the AC joint that allows us to control the horizontal displacement of the same. We must be careful in this step, because an excess of tension can cause an anterior displacement of the clavicle that is also the cause of poor clinical evolution.[66] It is known that the CC ligaments have poor intrinsic healing capacity but not the bone or the surrounding soft tissues such as

Table III
Comparative table with other results described for the treatment of chronic AC dislocations

Author	Year	Technique	N	FU	HI	VI	Clinical test		
Tauber et al[74]	2009	WD vs. ST	24	38	WD (1/12): 8.3%	0%		MWD	STG
					ST (0-12): 0%		CS	81	93
							ASES	86	96
Boström-Windhamre et al[6]	2010	WD-P vs. WD-H	45	45-100	–	WD-P (3/18): 16%		WD-P	WD-H
						WD-H (4/17): 23.5%	CS	85	75
							Q-DASH	16	20
							SSV(%)	80	70
Boileau et al[5]	2010	WDC	10	12.9	–	–	SSV(%)	82	
							UCLA	16.5	
Kim et al[40]	2012	WD-CT	12	31.2	–	–	UCLA	18.5	
Chouhan et al[11]	2013	LARS	8	46	–	–	CS	91	
							ASES	93	
Fauci et al[21]	2013	ST vs. LARS	40	48	–	ST(5/20): 25%		ST	LARS
						LARS (6/20): 33%	CS	94.2	85.9
							UCLA	18.2	15.4
Virtanen et al[77]	2014	BTD/TSA	25	50	6/25: 24%	12/25: 48%	CS	83	
							DASH	14	
Saccomanno et al[63]	2014	ST	18	26		11%	CS	90.3	
							DASH	6.6	
Lee et al[49]	2015	WD-CT	18	35	–	11.1%	CS	90.7	
							UCLA	18.1	
Barth et al[3]	2015	DBG	24	12	4.1%	–	Q-DASH	9	
Tauber et al[71]	2015	TB vs. DB	26	24	TB: 25%	TB: 8%		TB	DB
					DB: 71%	DB: 21%	CS	88.8	82.6
							ASES	95.3	88
							TS	10.9	9.0
							ACJI	84.7	58.4
Hegazy et al[33]	2016	WD vs. ST	20	27.8	–	WD (3/10): 30%		WD	ST
						ST (0/10): 0%	NCS	84	95
Current study	2019	MINAR	21	49	1/21: 4.7%	1/21: 4.7%	CS	95.3	
							ACJI	89	

AC, acromioclavicular; *WD*, modified Weaver-Dunn; *ST*, semitendinous tendon; *WD-P*, Weaver-Dunn augmented with PDS-braid; *WD-H*, Weaver-Dunn augmented with hook plate; *WDC*, Weaver-Dunn-Chuinard procedure; *WD-CT*, Weaver-Dunn + conjoined tendon; *LARS*, ligament augmentation and reconstruction system; *BTD/TSA*, Biotenodesis/titanium suture anchor + hamstrings; *DBG*, double button + graft; *TB*, triple-bundle; *DB*, double-Bundle; *MINAR*, mini-invasive acromioclavicular joint reconstruction; *N*, included patients; *FU*, follow-up average in months; *HI*, horizontal instability; *VI*, vertical instability; *CS*, Constant score test (0-100); *ASES*, American Shoulder and Elbow Surgeon assessment (0-100); *Q-DASH*, Quick disability of the arm, shoulder, and hand score (100-0); *SSV*, Subjective Shoulder Value (0-100); *Modified UCLA*, University of California at Los Angeles Shoulder Score (0-20); *TS*, Taft score (0-12); *ACJI*, acromioclavicular joint instability score (0-100); *NCS*, Nottingham Clavicle score (0-100); *MWD*, modified Weaver-Dunn technique; *STG*, semitendinous tendon graft.

the muscle or fascia that depend on the suprascapular artery.[23,31] During surgery, we stimulate the edges of these tissues without using an electrocautery to allow an extra blood supply to aid healing. The device used stabilizes the joint long enough for this extrinsic healing[30] to take place and thus avoids the use of a graft. For this purpose, delicate soft tissue management is essential, which must be accompanied by a solid repair of the deltoid muscle and trapezius fascia.

When we compare our results with those published for chronic AC dislocations, our results clearly improve techniques such as the Weaver-Dunn and the hook plate and equalize at least the results of the different techniques that use grafts (Table III). We have in this study one of the clinical series with the longest follow-up time for those reported today. In fact, to our knowledge, only published works regarding chronic AC dislocations of Tauber et al,[71] Hegazy et al,[33] and the current study use a specific AC test such as the ACJI, Nottingham scale, or the Taft score. General clinical shoulder scores such as the Constant, ASES, or others scores do not reflect AC-related daily problems. This system overestimates the rate of success after any kind of AC joint stabilization, and also other relevant aspects of the joint are lacking.[70] Usually, patients suffering from chronic AC instability have moderate pain levels and good range of motion with only limited impairment in daily living. Nevertheless, uncomfortable instability of the shoulder has disabling consequences such as periscapular muscle fatigue and scapular dyskinesia. When scores take into consideration AC-related complaints and are applied to these same patients, the values are lower and in accordance with the clinical reality of the patient. Also, the studies show a significant correlation of persistent horizontal AC instability and lower outcomes according to the AC specific scores.[66,75] This fact explains why the results of the general clinical shoulder scores show neither the degree of initial disability of these lesions on the one hand nor the functional and radiological improvement after the surgery on the other hand that can be seen with more specific tests such as the ACJI. The most frequent clinical complication we found were hypertrophic scars. Although none of them has required surgery, it has negatively rated in ACJI, reducing scores despite the minimally invasive approach. The radiological complications (calcification, coracoid button mobilization, or osteoarthritis) had no clinical repercussion.

When we try to compare studies, we encounter 2 main problems: first, the definitions for determining a loss of reduction are not unified among studies. Some research shows percentages, like Tauber,[72] and others use relations of width and length between clavicle and coracoides or acromion. This inconsistency makes it difficult to compare outcomes between studies objectively.[52] Second, the time that must pass to consider an AC dislocation as chronic: the studies include AC dislocations of 3 weeks,[19,55,81] 6 weeks,[24] 8 weeks,[63]12 weeks,[1] and even 6 months.[62] We have used a 6-week interval as chronic because in our experience it is the minimum time that has to pass to consider that the injury of the AC joint has not healed properly in a primary way. In any case, what is clear is that the longer the evolution, the more difficult it is to achieve good clinical and radiological results as we have seen in this study.

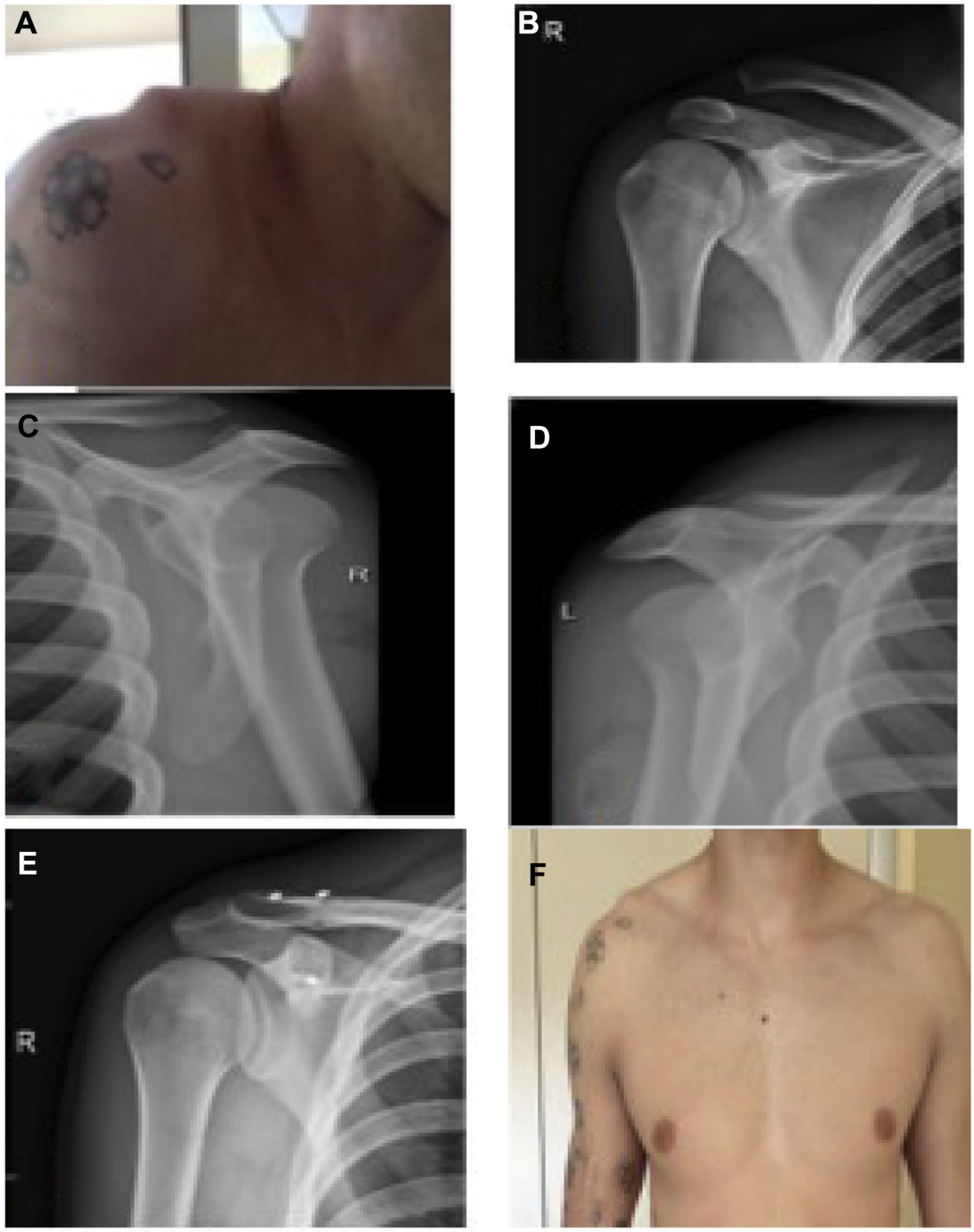

Figure 8 Case number 3. (**A**) Clinical deformity in the right AC joint (before surgery). (**B**) Zanca view showing complete chronic dislocation of the AC joint. (**C**, **D**) Alexander view of both joints, marked with R (right) and L (left) on the figure; horizontal displacement of the right AC joint is observed compared with the left side (healthy). (**E**) Zanca view at 4-year follow-up showing anatomic reduction. (**F**) Clinical aspect after 4 years of follow-up. The scar is not appreciated. *AC*, acromioclavicular.

An ideal repair should, biomechanically, have a similar compliance as that of native ligaments. The triple button device and AC augmentation reduce the dislocation, stabilize the joint, protect them, and ensure a correct restoration of the muscular fascia[66] (Fig. 8). Other strengths of the triple button device are the low profile of the implants, time of surgery (less than 1 hour on average), its technical simplicity (little learning curve), and no need to remove the implants. A particular strength of this study is that all surgeries were performed by a single surgeon, thereby decreasing the variability of the surgical practice as a bias.

In the last 10 years, several articles have been published stressing the importance of instability in the horizontal plane of the AC joint.[30] Current classifications such Rockwood's are static and do not allow categorization of dynamic or multidirectional instabilities, so much information is lacking with them.[73,75] Another problem that we find is that by not making adequate axial radiological projections up to 20% of type IV dislocations are misdiagnosed as type III, which explains their poor clinical evolution because so many of them develop scapular dyskinesis (70%).[28] It has been shown that there is an association of dynamic posterior instability and inferior clinical results in AC scores.[32,66]

The horizontal component of instability is justified mostly by injury to the AC ligaments, so to reproduce its effect on the joint, a system that mimics its function must be added, especially when the injury is chronic. In the direction of posterior displacement of the clavicle, the AC ligament contributed approximately 90% of the ligamentous constraint.[18,26] Klimkiewicz et al[41] demonstrated on a capsuloligamentous model that more than 80% of the horizontal stability was provided by an intact superior posterior capsuloligamentous joint complex. The majority of accepted techniques

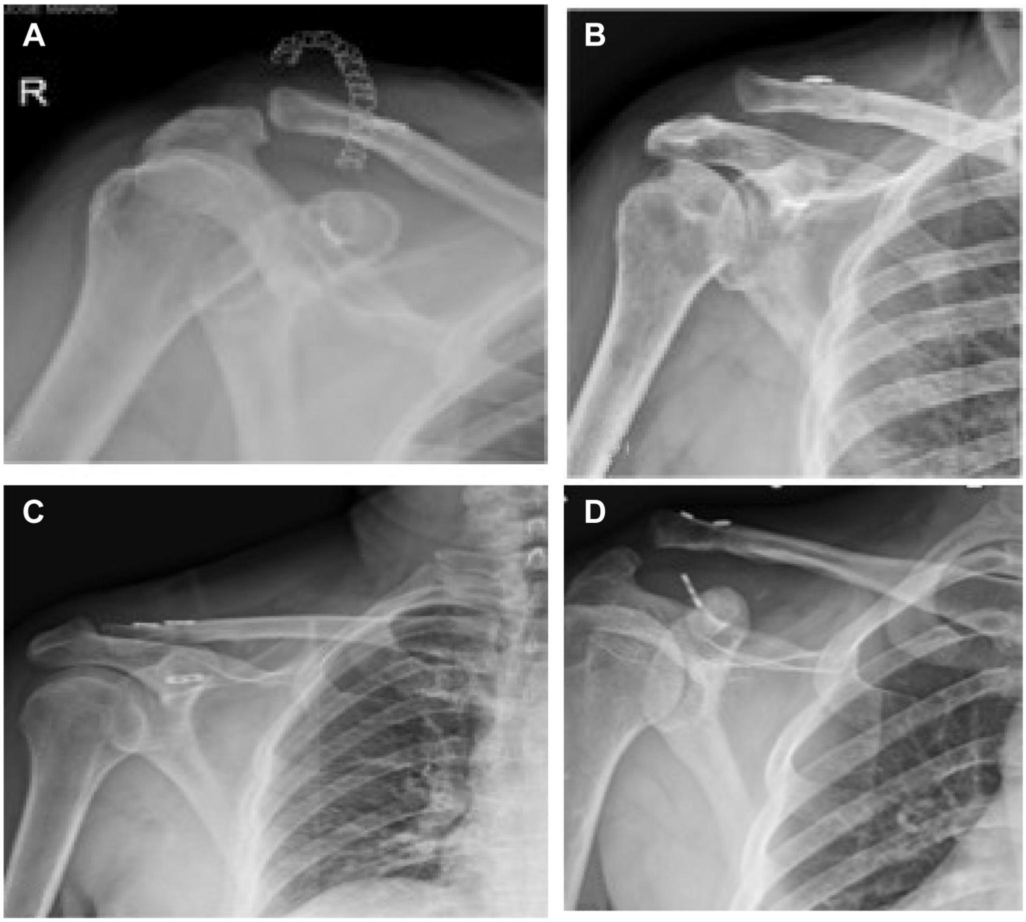

Figure 9 Case number 2. (**A**) GraftRope; Zanca view after first surgery. (**B**) Lost of reduction of GraftRope after 6 weeks. (**C**) Twin-Tail; Zanca view showing good reduction. (**D**) Zanca view, 6 weeks after the surgery. Significant loss of reduction is shown. *R*, right.

do not reconstruct the AC ligaments in an anatomic manner, and an unacceptable high rate of persistent posterior instability in 43% of cases has been described.[58,72] The studies support the notion that reconstruction procedures should treat AC ligaments as separate structures.[64]

The Twin Tail TightRope get mainly vertical stability and that is related to its construction that fixes the S-shaped clavicle at 2 points like CC ligaments. Residual horizontal instability can lead to pain and disability with lesser grade AC injuries, and also horizontal AC joint instability may occur independent of vertical instability. So, addressing horizontal instability is of utmost importance in reconstruction surgery of the ACJ in both the acute and chronic settings.[43,50,82] That is why the internal brace is used. The clinical results obtained in this study support its use.

In our series, we have had 1 recurrence in the vertical and horizontal plane in the same patient, and although the literature shows that a certain amount of vertical loss of reduction is usually well tolerated by the patient, from a clinical point of view,[42,71] the same does not happen with horizontal instability, because even lower degrees of recurrence are associated with poorer results, as we can see in our case number 2 (Fig. 9). This patient, already intervened by a failure of the graft-rope system, failed to comply with the immobilization protocol and participated in a martial arts championship a month after surgery. Despite the radiological displacement and clinical discomfort, the patient was able to develop his sporting activity without demanding a new surgical process. Regarding the rehabilitation protocol, it is important not to start the strength exercises before 3 months to avoid the failure of the technique,[47] as we have explained previously.

This study has several limitations. First, it was a retrospective study without a control group that limits the extrapolation of data. Being a not very frequent pathology, it is not easy to find a long series of cases to establish such control groups, at least in the short and medium term. Secondly, the follow-up time is relatively short and the number of patients included is limited. Thirdly, another confounding factor to consider is that 3 of the 21 patients (14.2%) have been previously operated and this fact could bias the results. Although it has not been the subject of this study, it would be interesting to study the economic cost associated with the use of this device, compared with the implants and/or allografts used in other techniques.

The preliminary results with the triple button device and AC augmentation in chronic AC injuries are promising, but in any case, prospective, randomized studies with longer-term and multicenter control groups will be necessary to be able to draw more definitive conclusions. First impressions indicate that with these systems and this technique, the use of grafts may not be necessary for the management of this pathology.

Conclusion

Twin Tail TightRope with AC augmentation is an acceptable alternative surgical method for chronic AC joint dislocations. It achieves an anatomic reduction and an AC joint function close to the natural one according to the clinical results obtained. The surgical technique is simple; it does not need a graft, nor does it present major complications, and material extraction is unnecessary.

Disclaimer

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