

## Original article

## Surgical treatment of acromioclavicular dislocation with minimally invasive surgery

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**ABSTRACT. *Introduction:*** Treatment of grade III Rockwood acromioclavicular lesions continues to be controversial. A new surgical technique for reduction using minimally invasive surgery provides good results. The purpose of this paper is to present the short and medium term results of a series of patients with grade III acromioclavicular dislocations who underwent surgery. ***Methods:*** Prospective assessment of a series of 14 patients with acromioclavicular dislocation who underwent surgery from May 2009 to June 2010 consisting of open reduction and synthesis with coracoclavicular fixation with a double anchor. Radiologic, functional and personal satisfaction parameters were assessed. ***Results:*** Statistically significant radiologic results were obtained, which reflect a correct reduction. An «excellent» mean score was obtained in the functional assessment using the Imatani test. Patients reported subjective satisfaction during the interviews at the outpatient visits. ***Conclusions:*** There are only a few papers reporting postoperative results with this surgical technique. Without a control group it is not possible to make a comparison with orthopedic treatment, so comparisons were made with published series using classical techniques. The surgical technique provides similar results; it is simple, inexpensive

**RESUMEN. *Introducción:*** El tratamiento de las lesiones acromioclaviculares grado III de Rockwood es aún motivo de controversia. Una nueva técnica quirúrgica de reducción mediante cirugía mínimamente invasiva permite obtener buenos resultados. El objetivo del presente trabajo consiste en presentar los resultados a corto y mediano plazo de una serie de pacientes intervenidos por luxaciones acromioclaviculares grado III. ***Métodos:*** Se evalúa de manera prospectiva una serie de 14 pacientes con luxaciones acromioclaviculares intervenidos entre Mayo 2009 y Junio 2010 mediante reducción abierta y síntesis con una doble ancla de fijación coracoclavicular. Se evalúan parámetros radiológicos, funcionales y de satisfacción personal. ***Resultados:*** Se han obtenido resultados estadísticamente significativos desde el punto de vista radiológico que hablan a favor de una correcta reducción. Se ha obtenido una puntuación media «excelente» en la valoración funcional mediante el test de Imatani. Los pacientes se han mostrado subjetivamente satisfechos a la entrevistas en consultas externas. ***Conclusiones:*** Existen pocos artículos publicados que muestren resultados postoperatorios con esta misma técnica quirúrgica. Al carecer de grupo control no es posible establecer una comparativa frente al tratamiento ortopédico, recurriendo a la compa-

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and has not shown to have any postoperative complications during a mean follow-up of 13.7 months. Surgical treatment of grade III acromioclavicular lesions using this surgical technique has provided appropriate results in this group of patients.

**Key words:** dislocation, shoulder, acromioclavicular, joint, surgery.

ración con series publicadas con técnicas clásicas. La técnica quirúrgica ofrece resultados similares, es sencilla, barata y no ha mostrado complicaciones postoperatorias a un seguimiento medio de 13.7 meses. El tratamiento quirúrgico de las lesiones acromioclaviculares grado III mediante esta técnica quirúrgica ha obtenido resultados satisfactorios en este grupo de pacientes.

**Palabras clave:** dislocación, hombro, acromioclavicular, articulación, cirugía.

## Introduction

Acromioclavicular joint injuries represent a frequent entity in the field of traumatology; their estimated incidence is 10% of all dislocations around the shoulder, with a large percent of undiagnosed cases.<sup>1</sup>

Depending on the energy of the injury the latter may be from a simple sprain all the way to complete joint dislocation, with the possibility of associated clavicular or scapular bone fractures. Moreover, neighboring structures like the clavicular attachments of the deltoid muscles, the trapezium and the acromioclavicular fibrocartilage itself may be injured.

The treatment of acromioclavicular joint injuries has always been controversial. The true debate takes place when deciding which is the best therapeutic option for grade III injuries, according to the Rockwood classification, which involve complete dislocation with moderate displacement of the distal end of the clavicle on a vertical plane. It is possible to prove that both the conservative and the surgical options have been popular recently. This paper shows the short and medium term results of a group of patients with Rockwood grade III acute acromioclavicular dislocations that underwent a novel surgical procedure. The main hypothesis of this study is: are the postoperative results of the patients undergoing this procedure satisfactory from the radiological, functional and esthetic point of view? Secondly, the results of other surgical techniques and orthopedic treatment are compared.

## Material and methods

This paper presents a prospective study conducted at the Orthopedic Surgery and Traumatology Service at our hospital. It assessed the postoperative results of a series of 14 patients with acute acromioclavicular dislocations operated between May 2009 and June 2010.

All patients had a history of trauma and presented at the Emergency Department in this center on the day of the injury. There were then diagnosed and immobilized with a sling. All patients were offered the possibility of undergoing

surgery versus conservative treatment; the risks and benefits of each option were explained to them. They were also informed about this study. All of them signed an informed consent authorizing the surgery.

The series was composed of 14 patients, 13 males and one female, ages 18-53 years; mean age was 31.6 years. Eleven patients had Rockwood grade III pure acromioclavicular dislocations. Three of the patients had Neer IIB distal clavicular fractures, with a vertical and oblique fracture line between the clavicular attachments of the conoid and trapezoid ligaments. From a mechanical perspective this fracture is considered as an «acromioclavicular equivalent», as the conoid ligament is torn and this produces a vertical displacement of the most medial clavicular fragment, which causes the highest risk of fracture pseudoarthrosis.<sup>2</sup> All patients were working and some of them had an associated condition at the time of the diagnosis.

Surgery was performed within 3 days of the injury after the anesthetic assessment. All patients were operated by the same physician, with one exception.

The implant used was the MINAR<sup>®</sup> system (Minimal Invasive Reconstruction of the Acromioclavicular Joint) developed by Karl Storz GmbH<sup>®</sup> (Dr. Karl-Storz-Str. 34, 78532 Tuttlingen, Deutschland - 07461 7080) in collaboration with surgeons Prof. Wolf Petersen (Trauma Surgery, Martin Luther Hospital, Berlin, Germany) and Dr. Thore Zantop (Trauma, Hand and Reconstructive Surgery, University Hospital, Münster, Germany). This system produces coracoclavicular stabilization by combining a thread loop with a fixation double anchor or FLIPPTACK<sup>®</sup>: one of the two anchors is placed under the lower aspect of the coracoid process, while the other one is placed on a vertical plane on the upper aspect of the clavicle, and both are joined with a double knot of the non-absorbable suture.

The surgical technique involves a single longitudinal 3-5 cm skin incision, 3 cm medial from the acromioclavicular joint. Protected drilling of a bone tunnel is performed on the clavicle and the coracoid process and the anchors are passed through it. Once tied, they secure the position of the clavicle when the dislocation is manually reduced.

Besides the placement of the implant, soft tissue repair is also performed trying to suture the coracoclavicular ligament bundles with absorbable sutures and repair the delto-trapezoid fascia reanchoring it to the clavicle. The last step consists of suturing the subcutaneous plane and the skin without an aspiration drain.

The technique used in the three patients with clavicular fracture was similar in everything. The fixation anchor was placed in the most medial clavicular fragment, with the exception that an 8-shaped transosseous absorbable suture was used to reinforce stability in the anteroposterior plane.

After a control X-ray within the first 24-48 hours, and in the absence of medical complications, patients were discharged.

The operated limb was immobilized for two weeks with a sling; then specific rehabilitation was started. Patients were then asked to come to the outpatient service at six weeks, four months and one year after surgery.

Mean follow-up was 13.7 months. All the visits and questionnaire filling-out took place in the outpatient service.

Three types of criteria were used for the evaluation of results: radiological, functional and esthetic, and those related with personal satisfaction.

Anteroposterior and lateral axillary X-rays were performed in all patients including both the injured limb and the contralateral one, considered as a reference pattern (*Figure 1*).

The following parameters of the anteroposterior X-rays were measured for the radiological study:

- Width of the injured acromioclavicular (AC) joint, measured in millimeters, before and after surgery.
- Coracoclavicular (CC) distance, measured in millimeters, of the injured joint, understood as the closest distance between these two structures, both before and after surgery.
- The vertical clavicular displacement, measured in millimeters, of the injured joint, with respect to the tangent line of the lower border of the acromioclavicular joint, both before and after surgery (*Figure 2*).
- The presence of calcifications in acromioclavicular or coracoclavicular ligaments, clavicular or acromial osteolysis, and changes in the fracture line in the three cases with clavicular fracture.



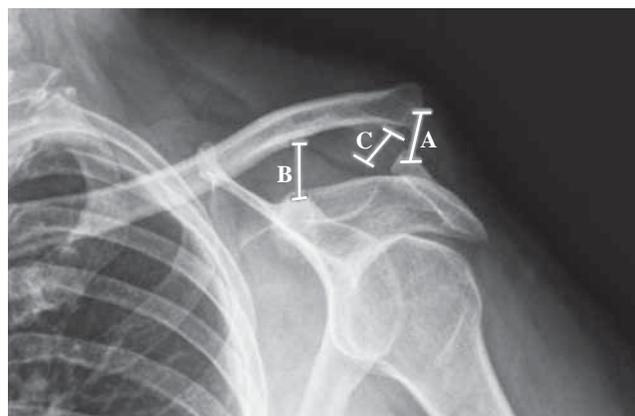
**Figure 1.** Anteroposterior X-ray of both shoulders showing a Rockwood grade III right acromioclavicular dislocation, with vertical shift of the clavicle and a certain drop of the scapulohumeral region compared with the contralateral shoulder.

- The acromioclavicular width and the coracoclavicular distance were measured in the non-injured limb X-rays and were considered as reference measures.

The statistical study was conducted by the Preventive Medicine Service using the parametric or Student «t» test and calculating the statistically significant confidence intervals.

Functional criteria were assessed using the Imatani test, shown in *table 1*, at the outpatient service between 6 weeks and 6 months after surgery.

The esthetic result and personal satisfaction were assessed considering clavicular prominence as well as the surgical scar and its possible complications (infection, hy-



**Figure 2.** Parameters used for the radiographic assessment. A: Width of the acromioclavicular joint. B: Coracoclavicular distance. C: Vertical shift of the clavicle.

**Table 1. Imatani Test.**

Total score	Distribution	
Pain		
40	None	
25	Mild, occasional	
10	Moderate, tolerable, limits activities	
0	Serious, ongoing, disabling	
Function		
20	Weakness (percentage compared to prior status)	
5	Shoulder use	
5	Modification of activities	
Mobility		
10	Adduction	
10	Flexion	
10	Adduction	
Assessment of results		
Score 90-100	Excellent	Appropriate
Score 80-89	Good	Appropriate
Score 70-79	Acceptable	Not appropriate
< 70 points	Poor	Not appropriate

peritrophy, keloid, hyperalgesia) and the psychologic aspects having to do with patients' personal satisfaction and their perception of the result achieved.

**Results**

Acromioclavicular joint width, coracoclavicular distance and clavicular vertical displacement were all reduced in patients' postoperative X-rays and approached the values measured in the contralateral shoulder, considered as a reference pattern. Assuming a normal distribution, applying the parametric Student «t» test, and calculating the confidence interval, we may say that there are no statistically significant differences in the coracoclavicular distance between the postoperative results and the contralateral shoulder, with  $p \leq 0.05$ , which leads to assume that this distance was fully corrected. There were, in turn, statistically significant differences for the measurements of acromioclavicular width and vertical clavicular displacement between the postoperative results and the contralateral shoulder, with  $p \leq 0.05$ , which leads to assume that these distances were not completely

corrected as there was a mean difference of 1 and 1.6 millimeters, respectively.

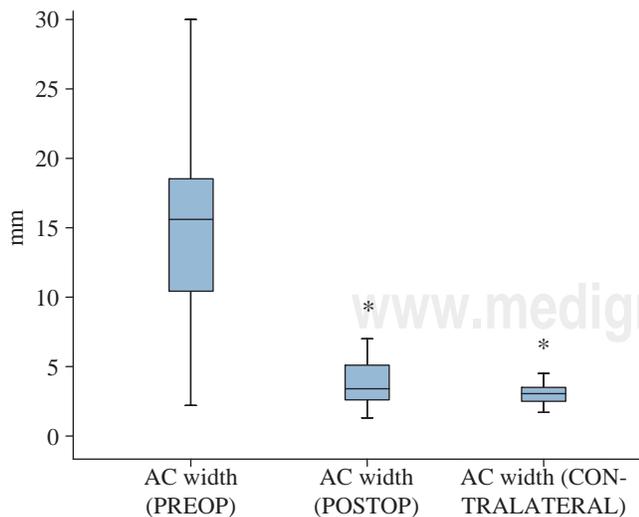
The statistical results and the value distribution charts are shown in *table 2* and *charts 1, 2 and 3*. They show that one of the patients had comparatively higher postoperative values than the rest of the series; he was the only patient in the series with surgical technique failure and with clinical and radiological reproduction of the articular dislocation. This failure was due to a failed surgical indication, as the patient was diagnosed with a grade III acromioclavicular dislocation without noticing that he also had fracture of the coracoid process and the scapular body, and coracoclavicular fixation is not effective for this problem. This patient required a second surgery based on rigid acromioclavicular fixation, in this case using Phemister's technique.

No cases of peri-implant osteolysis have been documented; but 3 cases of coracoclavicular ligament ossification without clinical repercussions have been reported. Postoperative changes may be seen in the control X-ray in *figure 3*.

Functionality was assessed with the Imatani test, applied during a visit at the outpatient service after postoperative

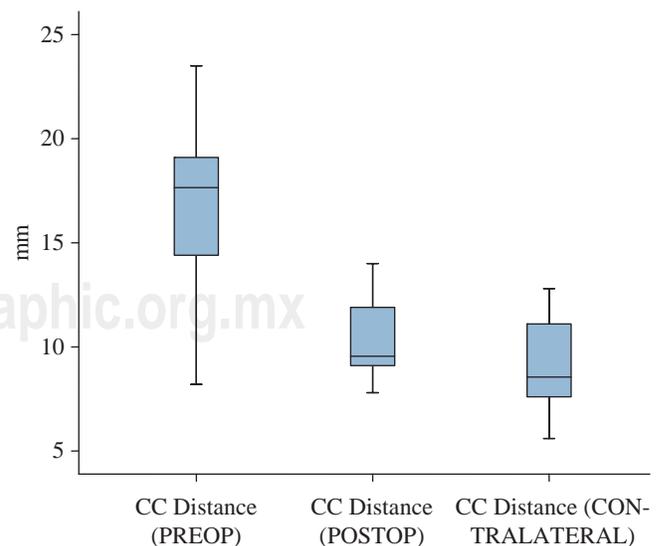
**Table 2. Comparison between postoperative results and the contralateral shoulder.**

		Related differences					t	gl	Sig. (bilateral)
		Mean	Std. deviation	Std. error of the mean	95% Confidence interval for the difference				
					Upper	Lower		Std. deviation	Std. error of the mean
Pair 1	AC width (Post) - AC width (Contra) -	.9929	1.9793	.5290	-.1500	2.1357	1.877	13	.083
Pair 2	CC Distance (Post) - CC Distance (Contra) -	1.3643	1.9492	.5209	.2388	2.4897	2.619	13	.021
Pair 3	Clavicular vertical shift (Post) - Clavicular vertical shift (Contra) -	.7714	2.0345	.5437	-.4032	1.9461	1.419	13	.179



\*Patient with technique failure.

**Chart 1.** Box diagram representing the evolution of acromioclavicular width and how it compares with the contralateral shoulder.



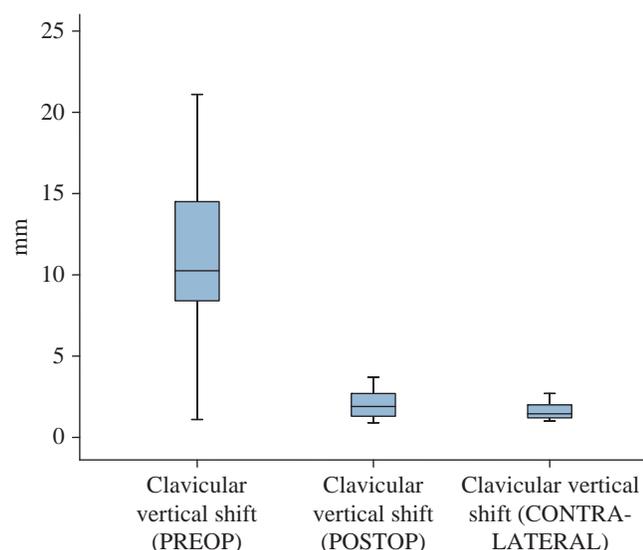
**Chart 2.** Box diagram representing the evolution of the coracoclavicular distance and how it compares with the contralateral shoulder.

week six. Three of the patients did not undergo the test because they were seen by a different surgeon, so only the results of the 11 remaining patients are included.

The results obtained are shown in *table 3*. The mean total score was 90.18, which represents an overall «excellent» result. Eight of the patients achieved «excellent» results (accounting for 72%), 2 «good» results, and one patient had an «acceptable» result due to a poor score in the «pain» item. The only patient with surgical technique failure was not interviewed because he was reoperated on, but including him in the study may represent a decrease in the overall mean score.

The highest score was obtained in the «mobility» item, as all patients interviewed had the same score of 30 points, which corresponds to full range of motion.

Concerning the degree of personal satisfaction and esthetic results, there was a single case of clavicular prominence seen at the outpatient visits, without clinical or radiological correlation. There were no cases of infection,



\* Patient with technique failure.

**Chart 3.** Box diagram representing the evolution of the vertical shift of the clavicle and how it compares with the contralateral shoulder.



**Figure 3.** Appropriate result in a postoperative control X-ray.

hypertrophic scar, hyperalgesia or keloid. All patients were satisfied with the results obtained. In all cases patients returned to work within less than two months. Since we did not use an analog scale to measure the patients' degree of satisfaction, we cannot draw further conclusions.

## Discussion

Based on the above mentioned data, the short and medium term results are satisfactory for this group of patients, both from the radiological and the functional and esthetic standpoints. There was one case of technique failure, which supposes a 7% that could have been avoided with the right diagnosis. From the radiological standpoint, statistically significant results were obtained. Moreover, 90% of functional results were satisfactory, which coincides with the data of other bibliographic series.

There are, however, several limitations that prevent us from extending the conclusions of the study. There is no control group or comparative patient cohort to assess post-operative results versus conservative treatment. This limits the discussion and forces us to turn to historical cohorts. Imatani's functional test and the radiological measures used in this study may not apply to other papers addressing this pathology, which would make it difficult to compare results. We may not conclude if surgical treatment is the best option for this group of patients; we may only point out that the results obtained with this surgical technique have been satisfactory. There is also the need to prolong the follow-up to assess the long-term results. Even though statistically significant results were obtained, the patient number in this series should increase to draw more consistent conclusions.

The surgical technique used has a series of advantages compared to other types of acromioclavicular reduction techniques.

First of all, it produces an anatomical stabilization that could contribute to better long-term results. It also involves a temporary stabilization, as the implant exerts its role until the capsular and ligament healing process begins, which is estimated to occur at around four weeks. This could produce a long-term benefit compared to other replacement techniques. Since no implant failure occurs during the first weeks, it is likely that it will not occur later on. The surgery is affordable and simple; it does not require neither fancy instruments nor a long operative time, which is estimated between 30 and 45 minutes. As this is an open reduction technique it does not require arthroscopic assistance. The surgical incision is small, same as the implant, so the need to remove it has not been described, and this avoids a second surgery. No fixation material intolerance or fatigue has occurred. The only case where the fixation failed resulted from not making a correct diagnosis of the patient's injuries. Had the diagnosis been correct, this type of surgery would not have been indicated.

Given that the surgical technique described herein was introduced only recently (less than five years ago), there are

Table 3. Results of Imatani test.

Patient	Pain	Weakness	Use shoulder	Change in activities	Abduction	Flexion	Adduction	Total
1	30	20	5	5	10	10	10	90
2	35	20	5	5	10	10	10	95
3	10	20	5	5	10	10	10	70
4	35	15	5	4	10	10	10	89
5	40	20	5	5	10	10	10	100
6	29	15	4	5	10	10	10	83
7	35	20	5	5	10	10	10	95
8	35	18	4	5	10	10	10	92
9	35	15	5	5	10	10	10	90
10	33	18	5	5	10	10	10	91
11	37	20	5	5	10	10	10	97
Mean	32.18	18.27	4.818	4.90	10	10	10	90.18

no prospective trials including a long-term follow-up of patients operated with this surgical technique.

Other studies provide information on arthroscopic fixation with a very similar implant, with good clinical and radiological results at the 2-year follow-up in a 20-patient series.<sup>3,4</sup> However, despite the larger surgical approach used when performing reduction with an open technique, the latter is technically less difficult, the operative time is shorter, the cost is less and reconstruction is more anatomical. With the open technique it is possible to also repair the ligament complex which is sacrificed with the arthroscopic technique in order to achieve a better vision of the field (particularly the coracoclavicular and the upper and mid glenohumeral ligaments).

A similar surgical technique consists of reduction under a coracoclavicular cerclage with either absorbable or non-absorbable sutures. However, since this is a less strong fixation, complications may occur, like anterior clavicular subluxation or suture rupture as a result of the arm's rotation movements.

The classic Bosworth<sup>6</sup> coracoclavicular fixation technique has certain inconveniences such as the difficulty to control anteroposterior clavicular displacement or the impossibility of repairing the ligament complex. There are technique modifications that use absorbable materials with similar results.

One of the most widely used techniques is acromioclavicular rigid fixation using Steinmann pins, Kirschner nails or the more recent hook plate.

Phemister's technique<sup>7</sup> is technically simple and little invasive; however, it does not allow achieving an anatomical stabilization or soft tissue reconstruction. To do this, an italic «S»-shaped broad incision is required, which could increase the risk of complications.

The hook plate has been related with a higher complication rate and does not represent an advantage over other implants from this group.

There are no comparisons in the literature between acromioclavicular fixation techniques and the coracoclavicular fixation technique described herein.

Other types of surgical techniques based on ligament reconstruction, such as coracoacromial ligament transfer or the Weaver-Dunn technique,<sup>8</sup> involve little acceptance as isolated techniques and should be associated with other techniques like acromioclavicular or coracoclavicular fixation.<sup>9</sup>

In this paper it was not possible to assess postoperative results related with the orthopedic treatment, as there was no control group.

## Conclusions

Several conclusions may be drawn as an answer to the questions posed at the beginning of this paper. Surgical treatment of Rockwood grade III acromioclavicular dislocations using this surgical technique has provided appropriate results in this group of patients. The surgical technique has proven to be simple, brief and effective. During the follow-up no infectious or other type of complications have been described that result in implant removal.

However, a treatment algorithm cannot be established because both conservative treatment and the different surgical techniques have yielded good results according to the literature. New studies and meta-analyses are necessary to draw additional conclusions.

Since this is a prospective study, additional conclusions are expected when the number of patients is increased and the follow-up period is prolonged, as we intend to do.

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