



# High Early-onset acromioclavicular secondary pathologies after acute arthroscopic joint reduction: a cohort study

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## Abstract

**Purpose** The research aim was to determine the prevalence and risk factors of early secondary acromioclavicular (AC) joint disease in patients undergoing acute arthroscopic AC joint reduction and fixation and early complications of acute surgical treatment in patients with high-grade AC joint dislocation.

**Methods** Overall, 102 patients diagnosed with Rockwood type V AC joint dislocation and undergoing arthroscopic coracoclavicular fixation were included. Early clinical and radiological complications were evaluated, as well as risk factors of secondary AC joint pathology.

**Results** Twenty-nine patients (28%) presented with a secondary AC joint pathology, with 24 and 5 cases of osteolysis and osteoarthritis, respectively. The main complication was a loss of reduction of  $\geq 1$  mm (78%). Patients aged  $> 55$  years were more likely to develop a secondary AC joint disease (odds ratios (OR) = 10.1, 95% confidence interval (CI): 1.42 – 72.55,  $p=0.021$ ). Patients with osteolysis (OR = 3.2, 95% CI 1.16 – 9.27,  $p=0.025$ ) or loss of reduction of  $> 5$  mm (OR = 7.4, 95% CI 2.31 – 24.08,  $p=0.001$ ) were more likely to develop AC joint pain. Patients with an initial over-reduction were less likely to develop a subluxated AC joint (OR = 0.033, 95% CI 0.0021–0.134,  $p=0.001$ )

**Conclusion** Age  $> 55$  years and female sex were identified as risk factors of early-onset secondary AC joint disease. Osteolysis and a loss of reduction of  $> 5$  mm were risk factors of AC joint pain but not of revision surgery. The main early complication was a loss of reduction of  $\geq 1$  mm. An initial over-reduction of the distal clavicle was a protective factor to avoid AC joint subluxation.

**Level of evidence** 2.

**Keywords** Acromioclavicular joint dislocation · Acromioclavicular joint injuries · AC joint osteolysis · AC joint osteoarthritis · Acromioclavicular joint pathologies

## Introduction

Acromioclavicular (AC) joint dislocations correspond to 30–50% of shoulder injuries in athletes and 9% of those in the general population [27, 33]. It usually occurs in the third decade of life and is five times more frequent in men [22, 27, 28, 31]. The management of high-grade lesions remains

controversial in the acute setting, and there is no consensus on the most appropriate technique and fixation method for high-grade lesions in the acute stage.

Multiple surgical techniques have been described to treat AC joint dislocations, including open or arthroscopic approaches [28, 33], as well as different types of fixation methods to achieve stable constructs that allow the healing of the AC and coracoclavicular (CC) ligaments [18, 31]. Currently, the frequency of treatment of this type of injury with arthroscopic assistance has increased [2, 7, 13, 15, 16, 29, 30]. However, a wide failure rate (8.5–80%) [7, 28] has been reported, and evidence supporting one technique over the other is limited [5, 37].

As in any other joint, achieving stability and congruency is crucial for cartilage viability. Failing to achieve these goals may lead to cartilage degeneration and worse

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clinical outcomes. Studies on early complications associated with early AC joint dislocation surgery are scarce, especially with regard to postoperative secondary AC joint disease after an acute dislocation. Distal clavicle osteolysis and AC joint arthritis may develop after acute AC joint trauma and are well-known causes of shoulder pain [38]. Werder first described post-traumatic osteolysis in 1950 [36], and only a few case series have been reported since [1, 17, 19, 25, 26]. Early postoperative complications should not be overlooked because they may directly affect discharge timeframes. Early development of acromioclavicular disease after an acute arthroscopic joint reduction may lead to an increased time to return to work and sports, shoulder pain, early revision surgery, and ultimately increased treatment costs. Knowledge of this complication, risk factors, and consequences is needed for proper management and prevention of this condition.

We hypothesized that there is a high early-onset acromioclavicular secondary pathologies after acute arthroscopic joint reduction. The primary objective of this study was to determine the prevalence and risk factors of early-onset secondary AC joint disease in patients undergoing acute arthroscopic AC joint reduction and fixation. The secondary objective was to determine other early clinical and radiological complications in patients surgically treated with a high-grade AC joint dislocation.

## Methods

Analytical observational cohort study.

### Patients

One-hundred and seventeen patients initially underwent acute arthroscopic AC joint reduction and fixation from March 2016 to November 2018 in the same trauma center. All patients were covered by the workers' accident compensation insurance law. The study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments. Ethical approval was waived by the local Ethics Committee in view of the retrospective nature of the study and all the procedures being performed were part of the routine care. The inclusion criteria were as follows: age >18 years, Rockwood type V [27] AC joint dislocation, surgery within the first 3 weeks of the initial trauma, and clinical and imaging follow-up conducted at least 8 weeks after surgery and up to 1 year. We excluded patients who presented signs of AC joint pathology on initial radiographs.

## Surgical technique and postoperative rehabilitation

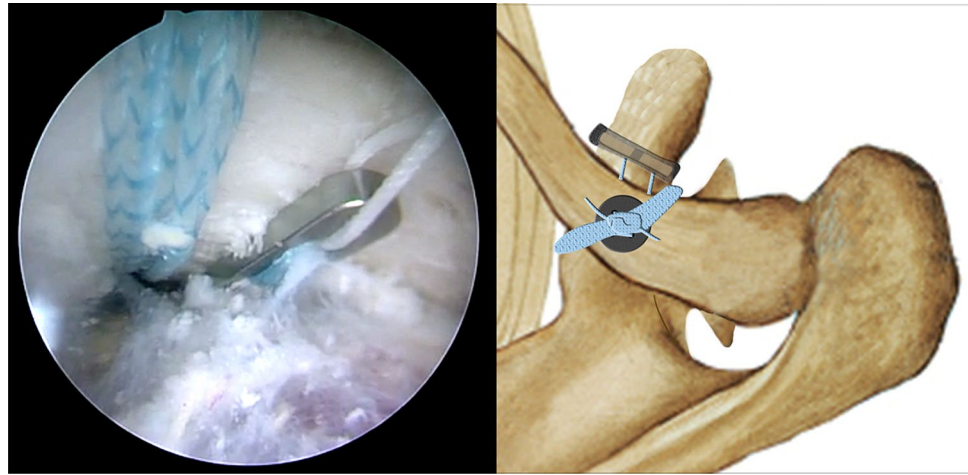
The surgical technique and postoperative care of these patients were described previously in detail by the senior author [20]. A team of five shoulder surgeons with previously fellowship training participated in this study. The surgery started with a diagnostic arthroscopy. The coracoid was located with the shaver until the base of the coracoid was reached. Then, the scope was switched to the anterior portal to have a clear vision of the base of the coracoid. The coracoclavicular guide was introduced through the anterolateral portal, and the exit point of the guide was held under the center of the coracoid base. A small incision over the clavicle was performed, and the center spot on the superior cortex was located to drill with a 2.4-mm guide pin through the clavicle and, simultaneously, the exit point under the center of the coracoid's base. Using a power drill, a 4-mm cannulated drill was advanced over the pin through the clavicle and the coracoid. A Nitinol wire was passed through the cannulated drill, leaving the loop superiorly, and the tip was grabbed with the grasper through the anterolateral portal. One white traction suture from the oblong button of the TightRope® (Arthrex, Naples, USA) was inserted through the wire loop of the Nitinol suture-passing wire. The suture-passing wire was pulled to retrieve the white traction suture. The oblong button was advanced until the coracoid base. Once the security of the oblong button was confirmed, the clavicle was reduced under fluoroscopy. Both the blue TightRope® suture tails were pulled to advance the round button down to the surface of the clavicle and then tied over the clavicle button. We added a double FiberTape® (Arthrex, Naples, USA) loop around the clavicle and under the coracoid tied with a Nice-Knot to enhance the stability of the fixation (Fig. 1).

After surgery, all patients underwent standard shoulder immobilization in internal rotation for 6 weeks. Active motion of the elbow and passive external rotation of the shoulder were encouraged immediately, but with an elbow support to neutralize gravity force on the construct. Passive glenohumeral elevation up to 90° was allowed under supervision from week 4, and an unrestrictive active motion was started after week 6. Strengthening was allowed between weeks 8 and 12.

### Data collection

We collected the following demographic and clinical variables from patients' clinical records: age in years, sex (male or female), days until surgery, discharge period (weeks), weight in kilograms (kg), tobacco use as a dichotomous

**Fig. 1** Arthroscopic coracoclavicular joint fixation with the TightRope® and FiberTape® loop (Arthrex, Naples, USA)



variable (yes/no), body mass index (BMI) in  $\text{kg}/\text{m}^2$ , and associated arthroscopic injuries, which were described in surgical records at the time of the surgery.

Clinical complications were recorded every 2 weeks during medical follow-up by each surgeon until discharge, within the described follow-up period (between 8 weeks to 1 year) according to the following criteria: (1) re-interventions, defined as a new surgical intervention related to the previously intervened injury; (2) wound infection or any infection associated with the surgical procedure, diagnosed by clinical signs and elevated inflammatory blood parameters; (3) acromioclavicular joint pain, evaluated using Paxino's test; (4) unstable cross-body adduction test; (5) pain in relation to the clavicle button (yes/no), evaluated by palpation of the implant; (6) neurological and vascular injuries, evaluated by clinical examination; and (7) AC joint static deformity, evaluated by clinical frontal inspection compared to the contralateral side.

### Radiological evaluation

Postoperative standing anteroposterior (AP) bilateral non-stress AC joint radiographs were requested immediately after surgery and every month during medical follow-up.

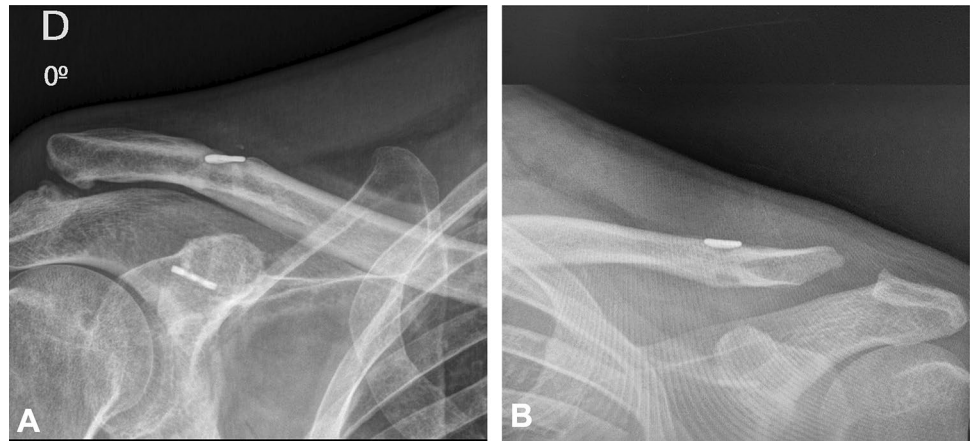
All radiographs were taken in the same trauma center, and the Xero® Viewer by Agfa Healthcare (Mortsel, Belgium) was used as the DICOM viewer. The radiographs were reviewed by a single-blinded musculoskeletal radiologist. The variables analyzed from the X-rays were as follows: coracoclavicular distance (CCD) was measured drawing a perpendicular line from the inferior cortex of the clavicle to the apex of the coracoid in millimeters (mm) and CCD difference between the injured and non-injured sides. An immediate postoperative positive CCD difference was considered an under-reduction of the AC joint, while a negative value indicated an over-reduction. A CCD difference of zero was considered an anatomical reduction. A positive change ( $\geq 1$  mm) in the CCD difference during follow-up was considered a loss of reduction, while a change of  $>5$  mm was considered as a significant loss of reduction (Fig. 2). A positive CCD difference ( $\geq 1$  mm) in the final follow-up was considered subluxation. AC osteoarthritis was defined as the appearance of osteophytes associated with



**Fig. 2** Postoperative AC joint bilateral AP X-ray. The CCD of both shoulders was measured in millimeters to calculate the difference between the injured and non-injured sides (CCD difference=CCD of the injured side–CCD of the normal side). A CCD difference was

considered as under-reduction of the AC joint, while a negative CCD difference was considered as over-reduction. In this case, over-reduction of the AC joint was observed (CCD=−3). AC acromioclavicular, AP anteroposterior, CCD coracoclavicular distance

**Fig. 3** **a** Postoperative radiograph of the right shoulder joint where the presence of osteophytes associated with bone cysts and decreased AC joint space (osteoarthritis) was appreciated. **b** Osteolysis showed the presence of increased AC joint space associated with distal clavicular bone resorption and subchondral bone cysts, predominantly in the inferior border. AC acromioclavicular



bone cysts in the distal clavicle and decreased AC joint space, and osteolysis was defined as the appearance of an increased AC joint space associated with distal clavicle bone resorption and subchondral bone cysts (Fig. 3). Other radiological complications, such as implant migration, clavicular button subsidence, and clavicle or coracoid fractures, were also observed.

### Statistical analyses

Categorical variables were compared using the Chi-square test, while continuous variables were compared using the Student's *t* test. The risk factors were evaluated using univariate logistic regression models and expressed as odds ratios (OR) and 95% confidence intervals (95% CI). The dichotomous variable "AC secondary disease" was determined as the primary outcome (the dependent variable), while the risk factors (sex, age, an initial reduction of the AC joint, postoperative CCD difference, over-reduction and under-reduction, weight, and nicotine consumption) were independent variables. For other types of complications as secondary outcomes (infection, pain in relation to the implant, AC deformity, neurological injury, vascular injury, clavicle or coracoid fracture, migration of the coracoid implant, subsidence of the clavicular implant, and re-interventions), the variable "AC secondary disease" was considered as an independent variable. Finally, complications were also evaluated as risk factors for a loss of reduction of >5 mm. All statistical analyses were performed using STATA version 14.2 (Copyright 1985–2019 StataCorp LLC, StataCorp). Statistical significance was set at  $p < 0.05$ .

## Results

### Study population

Of the 117 patients with Rockwood type V AC joint dislocation surgically treated within the first 3 weeks, a total of 102

**Table 1** Descriptive analysis of the study population and complications

Parameters	All mean/count	Range/percentages
Age [years]	37,3	18–63
Sex [Males]	97	95%
Sex [Females]	5	4,9%
Days until surgery	11,4	2–32
Tobacco	30	29%
Weight [Kg]	82,1	61–100
Discharged [weeks]	16,1	5–41
IMC [Kg/m <sup>2</sup> ]	32,3	27,8–37
Undercorrected	28	27%
Overcorrected	62	61%
AC subluxation	59	58%
Assymetry > 5 mm	13	13%
Loss of reduction	80	78%
Loss of reduction > 5 mm	12	12%
CCD Post Op difference [mm]	1,2	-6–9
Associated injuries	11	11%
Rx follow-up [w]	18,2	2–65
Clinical follow-up [w]	20,8	8–68
Re-intervention	7	7%
Infection	1	1%
Acromioclavicular pain	19	19%
Pain in relation to implant	9	9%
Neurologic injury	1	1%
Vascular injury	0	0%
Clavicle fracture	1	1%
Clavicular subsidence	17	17%
Implant migration	4	4%
Clinical deformity	7	7%
Unstable cross arm test	4	4%

Cualitative variables are described with absolute frequencies and percentages, otherwise, they are described with mean and range

fulfilled the inclusion criteria. Fifteen patients who had AC joint osteoarthritis on initial radiographs were excluded. The characteristics of the 102 studied patients are summarized in Table 1.

## Radiological and clinical findings

Immediate postoperative radiographs showed that 12 (12%) patients had an anatomically reduced AC joint, 62 (61%) had an over-reduction of the distal clavicle, and 28 (27%) had an under-reduction. The postoperative mean CCD difference was  $-0.8$  mm, and at the final follow-up, the mean CCD difference was 1.2 mm. Eighty patients (78%) had a loss of reduction of at least 1 mm, while 12 (12%) had a loss of reduction of  $>5$  mm. The mean loss of reduction was by 2.7 mm. Table 1 summarizes the clinical and radiological complications.

There was no association between the time to surgery (days) and loss of reduction of  $\geq 1$  mm (OR 1.08, 95% CI 0.98–1.18,  $p=0.126$ ) and loss of reduction of  $>5$  mm

(OR 0.97, 95% CI 0.88–1.08,  $p=0.615$ ) within the first 21 days. Evidence of early-acquired secondary AC pathology at the end of follow-up was present in 29 (28%) patients. Of them, 24 had distal clavicle osteolysis (24%) and 5 had AC joint osteoarthritis (5%). Table 2 shows the descriptive analysis of patients with and without secondary AC disease.

## Complications requiring revision surgery

Seven patients (7%) required revision surgery. There were three cases of AC joint instability treated by a new AC joint reconstruction with autograft, two cases of residual AC joint pain treated by distal clavicle excision, one case of clavicle fracture at the bone tunnel after a new trauma that required fixation with a plate, and one case of acute infection requiring surgical drainage of the wound and treatment with intravenous antibiotics.

**Table 2** Descriptive analysis of patients with and without secondary AC joint disease

Parameters	AC disease present (n=29)	AC disease absent (n=73)	P value
Age (years; mean) (SD)	41 (11.77)	36 (11.28)	0.032
Sex (M: F)	25: 4	72: 1	0.009
Days until surgery (mean) (SD)	13 (6.64)	11 (4.87)	0.048
Tobacco	12 (41%)	18 (25%)	0.103
Weight (kg; mean) (SD)	79 (10.32)	83 (13.40)	0.277
Discharged (weeks; mean) (SD)	19 (9.88)	15 (6.00)	0.014
BMI (mean) (SD)	32	32	
Associated injuries	3 (10%)	8 (11%)	0.928
Clinical follow-up (w; mean) (SD)	24 (13.26)	20 (10.81)	0.054
<b>Radiological complications</b>			
Postoperative AC under-reduction	7 (25%)	21 (29%)	0.677
Postoperative AC over-reduction	17 (61%)	45 (63%)	0.869
Final AC subluxation (CCD difference $\geq 1$ mm)	17 (61%)	42 (59%)	0.887
Final AC subluxation (CCD difference $> 5$ mm)	5 (18%)	8 (11%)	0.382
Loss of reduction ( $\geq 1$ mm)	25 (89%)	55 (77%)	0.179
Loss of reduction ( $> 5$ mm)	5 (18%)	7 (10%)	0.272
CCD postoperative difference (mm; mean)(SD)	1.7 (1.93)	1.01 (2.91)	0.304
Clavicular subsidence	8 (29%)	9 (13%)	0.055
Coracoid implant migration	3 (10%)	1 (1%)	0.035
<b>Clinical complications</b>			
Acromioclavicular pain	8 (29%)	11 (15%)	0.120
Pain in relation to implant	4 (14%)	5 (7%)	0.274
Re-intervention	3 (10%)	4 (5%)	0.381
AC deformity	4 (14%)	3 (4%)	0.093
Positive cross-body adduction test	2 (7%)	2 (3%)	0.227
Infection	0	1 (100%)	0.531
Clavicle fracture	1 (100%)	0	0.526

BMI: body mass index, AC: acromioclavicular, CCD: coracoclavicular distance

## Factors influencing radiological and clinical outcomes

Post hoc analysis showed that age >55 years (OR 7.23; 95% CI 1.65–62.7,  $p=0.033$ ) had a positive association with early-acquired AC disease, and male sex was a protective factor (OR 0.8; 95% CI 0.009–0.81,  $p=0.03$ ). Acquired AC joint disease was also associated with coracoid button implant migration (OR 4.49; 95% CI 1.02–41.38,  $p=0.04$ ). No other risk factor was found for early-acquired AC joint disease (Table 3). Although there was no association between secondary AC joint disease and AC joint pain in the overall population (OR 2.30; 95% CI 0.84–6.33,  $p=0.10$ ) (Table 4), a positive association was found only when patients with distal clavicle osteolysis were included (OR 3.28, 95% CI 1.61–9.27;  $p=0.025$ ).

A loss of reduction of >5 mm was associated with AC joint pain (OR 7.4, 95% CI 2.31–24.08,  $p=0.001$ ), but it was not a risk factor for re-intervention (Table 5). Patients with an initial over-reduction were 33.3 times less likely to develop a subluxated AC joint during follow-up (OR 0.033, 95% CI 0.0021–0.134,  $p=0.001$ ).

## Discussion

We found a high prevalence of early-acquired AC joint disease in patients undergoing arthroscopic AC joint reduction and stabilization after an acute Rockwood type V AC joint injury. To the best of our knowledge, this is the first study that focused directly on analyzing the prevalence, risk factors, and consequences of AC joint secondary disease.

**Table 3** Univariate logistic regression analysis evaluating factors associated with secondary AC joint disease

Factors	Regression coefficient	P value	95% CI
Age > 55 years	7.23	0.033	1.65 – 62.7
Sex (M: F)	0.08	0.03	0.009 – 0.81
Weight	0.97	0.53	0.89 – 1.05
Tobacco consumption	2.11	0.11	0.85 – 5.26
Under-reduction	0.80	0.67	0.29 – 2.18
Over-reduction	0.92	0.87	0.37 – 2.27
AC subluxation	1.06	0.88	0.43 – 2.60
Loss of reduction ( $\geq 1$ mm)	2.42	0.18	0.58 – 5.02
Loss of reduction (> 5 mm)	1.98	0.27	0.57 – 6.88
CCD postoperative difference (mm; mean)	0.95	0.60	0.81 – 1.13
Associated injuries	0.93	0.92	0.23 – 3.81

AC joint disease was considered a dependent variable, and risk factors were considered independent variables

AC acromioclavicular, CCD coracoclavicular distance

**Table 4** Univariate logistic regression analysis of secondary AC joint disease as a factor associated with outcomes

Outcome	Regression coefficient	P value	95% CI
Re-intervention	1.57	0.53	0.36 – 6.75
Acromioclavicular pain	2.30	0.10	0.84 – 6.33
Pain in relation to implant	1.80	0.37	0.48 – 6.68
Clavicular subsidence	2.5	0.07	0.90 – 6.94
Coracoid implant migration	4.49	0.04	1.02 – 41.38
Clinical deformity	1.78	0.38	0.48 – 6.59

AC acromioclavicular

The main etiology of early-acquired AC secondary diseases in this cohort was distal clavicle osteolysis (86%). Post-traumatic osteolysis of the distal clavicle is uncommon; however, it occurs more often than is generally recognized, and many cases may be overlooked or misdiagnosed [1]. The earliest signs of distal clavicle osteolysis were observed at 8 weeks after surgery in one patient. There is no clear cause described and the pathogenesis is poorly understood. We had two hypotheses. First, the initial trauma and AC joint dislocation may trigger a chain of events that could end in chondrolysis and osteolysis and it cannot be reversed by early reduction and stabilization. This may be supported by the fact that radiological signs were seen during the early stages of follow-up despite early surgery. Synovial overgrowth, nervous system dysfunctions, vascular compromise, and microfracture have been hypothesized as the causes of osteolysis [17, 19, 26]. Asano et al found synovial overgrowth, destruction of the cartilage layer, invasion of the fibrous tissue with vascular proliferation, and occasional multinuclear giant cells in a histological evaluation of a 25-year-old man with post-traumatic osteolysis of the distal clavicle. Consequently, a compression force through the joint may cause microfractures of the distal clavicle [1]. The second hypothesis was that despite early reduction and stabilization, the residual AC instability could still trigger inflammatory and degenerative changes. However, according to our results, postoperative under-reduction, loss of reduction, and final subluxation were not found to be a risk factor for early secondary AC disease.

**Table 5** Multivariable logistic regression analysis of the loss of reduction of > 5 mm as a factor associated with outcomes

Outcome	Regression coefficient	P value	95% CI
Re-intervention	3.87	0.075	0.85 – 17.55
Acromioclavicular pain	7.47	0.001	2.31 – 24.08

The main complication found in our study was a loss of reduction of  $\geq 1$  mm in nearly 80% of the cases, of which, only 12 were considered significant ( $> 5$  mm). There is still no consensus where loss of reduction begins and 1mm CCD difference between radiographs could also be caused by measurement inaccuracy. Therefore, these results have to be clinically interpreted with caution. The final follow-up radiographs showed that the mean CCD difference was 1.2 mm; 13% of the patients had an AC subluxation with a CCD difference of  $> 5$  mm. These results are similar to those of a systematic review that showed that the mean postoperative side-to-side CCD ranged from 1.1 to 2.8 mm on a non-stress radiograph [23]. Although most of the patients showed loss of reduction in radiographic measurements, a clinical AC joint deformity and positive cross-body adduction test were only exhibited in 7% and 4% of the patients, respectively, and only three patients required revision surgery because of symptomatic instability. Over-reduction of the AC joint was a protective factor against AC joint subluxation (CCD difference,  $\geq 1$  mm) in the final follow-up radiographs. Surgeons should consider over-reduction of the AC joint during surgery because it may lead to favorable radiological results [21].

Like Maziak et al., our study did not find any significant relationship between body weight and postoperative loss or reduction [21]. In contrast, Barth et al. [3] reported significantly poorer radiological results in overweight patients, as the weight of the upper limb may compromise final joint reduction. This may be because, we emphasized shoulder immobilization for 6 weeks after surgery, allowing active motion of the elbow and passive external rotation of the shoulder, but with an elbow support to neutralize free arm weight on the AC joint fixation.

The use of the TightRope® system as an isolated technique for CC ligament reconstruction has shown to provide only superior-inferior stability, which could lead to residual horizontal instability and loss of reduction [4]. Radiological results have shown that patients treated only with TightRope® or a similar double-button device without any augmentation have presented a significant loss of reduction in 17–25% of the patients at medium term follow-up [24] [34] [39]. In general, we believe that isolated use of a TightRope® system for Rockwood type V AC joint dislocations is insufficient, and the use of an augmentation method is necessary to increase stability, allowing adequate healing of AC joint and CC ligaments in the acute setting [20].

Our results are comparable to those of studies that reported using a double-button device with augmentation. Hann et al. [10] reviewed 59 patients with a double CC TightRope® and added an AC cerclage for Rockwood type V injuries with 2 years of follow-up. The modified Alexander X-ray showed a partial dynamic posterior translation in 41.1% of the patients and a complete posterior

translation in 5.8% of the patients. The revision rate was 11.7%, and only one patient required revision owing to recurrent instability. In a retrospective analysis of 104 patients with an acute high-grade AC joint dislocation, half with CC fixation and half with a combined CC and AC stabilization, Maziak et al. [21] described a radiologically complete dynamic posterior translation in 11% of the patients, and over-reduction was the main protective factor. However, questions on the techniques still arise. It is not clear whether in an acute setting after injury, we need a technique that recreates native CC ligament and AC joint biomechanics or a technique that is sufficient to maintain AC joint reduction until ligament healing [9]. To date, double implant suspensory CC ligament fixations, augmentation with AC cerclages, and hook plates after removal have reported a similar loss of reduction as measured by the CCD distance in comparative X-rays [35]. However, the loss of reduction does not necessarily lead to poor functional outcomes [10, 11, 21, 30, 32].

In a recent systematic review, suspensory devices showed a postoperative complication rate of 6.2% and an unplanned reoperation rate of 2.7% in 435 patients [23]. The most frequent clinical complication in our study was residual AC pain with Paxino's test. According to our findings, both early osteolysis and a loss of reduction of  $> 5$  mm were associated with AC pain on physical examination. Most of these patients could be treated with conservative treatment and partially improved, but two cases (10%) needed revision surgery with an isolated distal clavicle resection. In addition, it should be considered that all patients in our series were covered by the workers' compensation insurance law, which has been described as a prognostic factor for poorer results in other shoulder surgeries [14].

Age  $> 55$  years was found to be the main risk factor for early-acquired AC disease. The incidence of degenerative AC joint disease in the normal population is high in patients over 50 years [6]. The mean age of our cohort was 37 years, which was slightly higher in patients with an early AC disease. We excluded all patients with signs of degenerative AC joint disease in initial radiographs to avoid this bias. Although no radiographic signs of degenerative disease were found in the initial imaging, the chondral extracellular matrix may be compromised in older patients, which could lead to early signs of secondary pathology after a shoulder trauma and AC joint dislocation. We strongly believe that the prevalence of post-traumatic AC joint osteoarthritis has been undervalued in this study and may be higher with longer follow-ups [6]. Eschler et al. [8] showed a 12% incidence of AC joint osteoarthritis with a minimum of 9 months of follow-up and Issa et al. [12] reported a 26% incidence with a minimum of 5 years of follow-up. However, we demonstrated that early signs can be found during the first few months after surgery.

Eighty percent of the female patients (4/5) developed early signs of AC joint secondary disease, which was a significant risk factor. In addition, acquired AC disease was associated with coracoid implant migration due to a lateral wall fracture. Two patients did not have a loss of reduction and the other two had a loss of reduction of <5 mm, probably due to the independent FiberTape® loop fixation. Both factors should be explored in the future due to the low frequency of these cases in this study.

Our study has some limitations. The retrospective design and short follow-up period are considered as limitations. Radiography for the evaluation of early secondary AC disease may also be considered as a diagnostic limitation. However, as in our study, X-rays are mostly used for imaging during routine follow-up after this type of surgery, and more advanced techniques are used only in special cases. Other limitations include the lack of a nonsurgical control group and multiple surgeons involved in the surgical treatment of these patients. Nonetheless, we focused mainly on the early findings, which are not abundant in the literature, and provided information regarding the most immediate complications of this surgical intervention and its consequences. Only patients with a Rockwood type V AC joint dislocation were included, while those with other high-grade injuries (Rockwood type III–IV) were excluded, as initial trauma energy through the joint and type of ligament injuries may be different. In addition, in our study, all patients underwent the same type of surgery using a standardized technique [20] by trained shoulder surgeons.

## Conclusions

The prevalence and risk factors of early-onset secondary AC disease in patients undergoing acute arthroscopic AC joint reduction and fixation were high. The main cause of secondary AC joint pathology was distal clavicle osteolysis. The risk factors were age over 55 years and female sex. Patients who developed early-onset distal clavicle osteolysis were associated with AC joint pain at the final follow-up and had a later discharge than those who did not have secondary AC joint disease. The main early complication was the loss of reduction, and a significant loss of reduction was associated with AC joint pain. The main protective factor of radiological subluxation at the final follow-up was an initial over-reduction of the distal clavicle. The main clinical complication was residual AC joint pain during physical examination. Comparative studies are needed to determine the best approach, prognostic factors, and surgical technique in Rockwood type V AC joint dislocations.

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## Declarations

**Conflict of interest** The authors have no relevant financial or non-financial interests to disclose.

**Ethical approval** This study was approved by the Hospital's Ethics Committee.

**Informed consent** All study participants provided informed consent to participate in this study.

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