Sling reconstruction of acromioclavicular joint dislocation: is screw fixation necessary?

Mohamed M.F. Sharaby, Mohamed F. Mostafa

Department of Orthopedic Surgery, Mansoura University Hospital, Mansoura, Egypt

Correspondence to Mohamed M.F. Sharaby, MD, Mansoura University Hospital, Orthopaedic Department, Mansoura, Egypt; Mansoura university hospital, orthopedic department, Mansoura, 35511, Egypt; Mobile: 01001926343 – 0112821188;
e-mail: sharaby_mmf@yahoo.com, sharaby_mmf@hotmail.com

Received 1 March 2014
Accepted 6 April 2014

The Egyptian Orthopaedic Journal
2016, 51:339–346

Background
Acromioclavicular joint injuries have been in much controversy with regard to the ideal method of treatment. The loop technique has been successfully used to stabilize this joint with variable success. Adding a Bosworth screw to the loop fixation may improve its efficacy and decrease the incidence of postoperative subluxation. This comparative study evaluates the efficacy of loop fixation for both acromioclavicular and coracoclavicular ligament reconstruction versus a loop combined with Bosworth screw with regard to function, radiology, and fixation-related complications.

Patient and methods
Over a 5-year period, we treated 50 patients with acute acromioclavicular joint dislocations with two methods of fixation. Only 47 patients continued follow-up. Group I (*N*=24) was managed with reconstruction of the coracoclavicular and acromioclavicular ligaments by means of loop fixation. In group II (*N*=23), a Bosworth screw was added to the loop fixation.

Results
The mean follow-up period was 24.2±5.9 months (range: 15–34 months) for the first group and 23.3±6.5 months (range: 13–36 months) for the second group. The mean postoperative pain score (visual analog scale) was 1.38±1.7 for group I and 1.35±1.27 for group II. The mean Constant score was 90.2±8.1 for group I and 92.2±5.5 for group II. The mean Taft score was 10.6±1.4 and 10.9±1.3 in the first and second groups, respectively. Recurrence was detected in four patients, two in each group. There was no statistically significant difference in results between the two groups.

Conclusion
Sling technique was found efficient enough to maintain stability of the acutely dislocated acromioclavicular joint without the need to augment this reconstruction with a screw.

Keywords:
acromioclavicular dislocation, coracoclavicular ligament, nonabsorbable tape, screw fixation, sling technique

Egypt Orthop J 51:339–346

1110-1148

Introduction

The acromioclavicular (AC) and coracoclavicular (CC) ligaments are prone to injuries with subsequent dislocation of the AC joint. This represents the second most common type of dislocation to occur around the shoulder girdle [1]. The mechanism of injury usually involves a direct trauma to the superior aspect of the acromion with inferior and anterior translation of the acromion in relation to the distal aspect of the clavicle [2,3]. Indirect trauma, such as a fall on an outstretched hand or flexed elbow, forces the humeral head proximally into the acromion [3]. Most of these injuries are incomplete, involving only the AC ligaments. The magnitude of the applied force determines the degree of injury with the AC ligaments involved initially, followed by the CC ligaments, and finally the deltoid and the trapezius muscle insertions into the clavicle [3].

Some authors consider conservative treatment for Rockwood type I, II, and III AC joint dislocations [4,5]. Others prefer to manage Rockwood type III with operative methods. Type IV–VI dislocations are usually the result of a very high-energy injury, which needs surgical repair. However, standard method for treating this common injury is still lacking [6,7]. Commonly used reconstructive methods include the Weaver–Dunn procedure [8] and the modified Bosworth technique [9], with the use of devices such as pins [10], plates [11] or loops [1,12].

The Weaver–Dunn technique involves nonanatomical reconstruction of the CC ligament with transfer of the

 DOI: 10.4103/eoj.eoj_88_16

CA ligament. The biomechanical properties of this reconstruction are markedly different from those of the intact CC ligaments with possible failure of reconstruction [13]. Anatomic CC ligament reconstructions were found to avoid the mechanical disadvantage of the Weaver–Dunn technique [2].

A number of different surgical techniques were described to treat acute AC joint dislocations with anatomic reconstruction of both AC and CC ligaments. Loop fixation was used to achieve this value, including sutures with and without anchors and tapes [2,12]. Additional metal fixation may add stability to the AC joint and protect against late displacement. A question was evoked about the value of additional screw fixation with loop fixation in acute AC dislocations. A comparison was made between a technique to treat this injury using reconstruction of the AC and CC ligaments with loop fixation with and without Bosworth screw. The aim of this study was to evaluate the efficacy of loop fixation for both ac and CC ligaments and to evaluate whether the added CC screw fixation will improve results with regard to function and fixation-related complications.

Patients and methods

In this study, a prospective randomized evaluation was carried out to compare between two methods for reconstruction of acute AC dislocations. This study approved by the Ethical committee of Mansoura University Hospital, Mansoura, Egypt. The first group was managed with suture loop fixation (Dacron tape and No. 5 Ethibond suture). The second group was managed with suture loop fixation in addition to CC screw fixation. Inclusion criteria were Rockwood type IV and V AC dislocations, cases of type III ac dislocation in high-demand patients and in polytrauma patients, acute cases (within 3 weeks of the event of trauma), no preceding history of AC joint pain, and not associated with injury of the upper limb that may interfere with rehabilitation. This study was started with 50 patients (25 in each group). Patients were randomly distributed among the two groups with blocked randomization technique (Table 1).

The operative procedure was started in both groups with general anesthesia with the patient seated in beach chair position and the involved arm hanging freely by the side. A 10 cm vertical skin incision in the direction of Langer's lines was made 2–3 cm medial to the AC joint, starting posterior to the clavicle and extended anteriorly. An evaluation was carried out for the AC

Table 1 Patients' demographics

	Age		Sex [*n* (%)]		Arm dominance [*n* (%)]		Duration until surgery (days)		Duration of follow-up (months)		Injury mechanism [*n* (%)]		Fracture classification [*n* (%)]		
	Mean±SD	Range	Male	Female	Dominant	Nondominant	Mean±SD (median)	Range	Mean±SD	Range	RTA	Fall	Group III	Group IV	Group V
Group A	36.8±11	19–56	18 (75)	6 (25)	15 (62.5)	9 (37.5)	5.4±3.1 (5)	1–14	24.2±5.9	15–34	13 (54.2)	11 (45.8)	3 (12.5)	5 (20.8)	16 (66.7)
Group B	35.8±8.5	21–51	18 (78.3)	5 (21.7)	16 (69.6)	7 (30.4)	5.8±3.2 (4)	1–15	23.3±6.5	13–36	12 (52.2)	11 (47.8)	3 (13)	4 (17.4)	16 (69.6)

joint ligaments and disc, CC ligament, and Deltoid and Trapezius insertions to the clavicle. The distal clavicle was then exposed – if not already peeled off the surrounding tissues – in a subperiosteal manner. The coracoid base was then exposed by deepening the incision at the deltoid insertion. The subcoracoid passage was developed and the sutures were passed under the coracoid base using a Satinsky vascular clamp passing from medial to lateral direction. Clavicular preparation included identification of the anatomical attachment of the conoid and trapezoid ligaments to the undersurface of the clavicle and making a drill hole with a 2.5 mm drill pit. The conoid hole was placed 45 mm medial to the AC joint and at the posterior aspect of the clavicle. In addition, the conoid tubercle can be palpated on the undersurface of the clavicle. The trapezoid hole was placed about 20–25 mm lateral to the center of the conoid hole. The holes were positioned at least 15 mm away from the anterior and posterior borders of the clavicle (Fig. 1).

The loop was then passed through the holes in the clavicle with the anterior limb of the loop directed to the lateral hole and the posterior one directed medially and both were tied with the knot under the clavicle. In the first group, this sling was the only fixation material used. In one case of this group, the suture knot was tied superior to the clavicle. In the second group, the clavicle was drilled down to the base of the coracoid between the conoid and trapezoid holes, and a 3.5 mm cortical screw was inserted transfixing the clavicle to the base of coracoid. A minimum distance of 10 mm was left between adjacent holes to avoid weakening of the clavicle. In addition, in both groups, the ruptured AC ligament was reconstructed with Ethibond No. 5 suture through intraosseous suture about 10 mm from the edges of the joint. The suture was passed in the horizontal plane from anterior to posterior in the lateral clavicle and in the acromion to control anteroposterior displacement (Fig. 2).

The AC joint reconstruction sutures were tied first as this resulted in resuming the anteroposterior relation of the clavicle to the coracoid. In the second group, the screw was tightened first followed by the AC joint suture and the CC loop. The deltoid and trapezius insertions were restored through intraosseous sutures with closure in a layered manner.

Postoperatively, rehabilitation was started from the first postoperative day with passive shoulder exercise without elevation for the first 3 weeks. Abduction, external rotation, and internal rotation were started by the fourth week for the next 3 weeks. Adduction was prohibited for the first 6 weeks. Sling was worn for 6 weeks (the protective phase). Basic strengthening (6–12 weeks) included active range-of-motion exercises of the shoulder with slow progressive strengthening. This was followed by the advanced strengthening phase (3–5 months).

Both Constant–Murley score [14] and Taft score [15] were used for the evaluation of clinical results, neither of which was validated for AC joint evaluation. However, the Constant score was the most widely used tool for evaluation of the AC joint as a part of the shoulder girdle. Pain was also evaluated separately on a visual analog scale from 0 to 10. Preoperative and

Figure 1

Superior surface of the clavicle showing sites of drilling for insertion of the coniod (point C) and trapezoid (point T) ligaments: aT=20–25 mm, cT=15 mm, bC=45 mm, dC=15 mm.

Figure 2

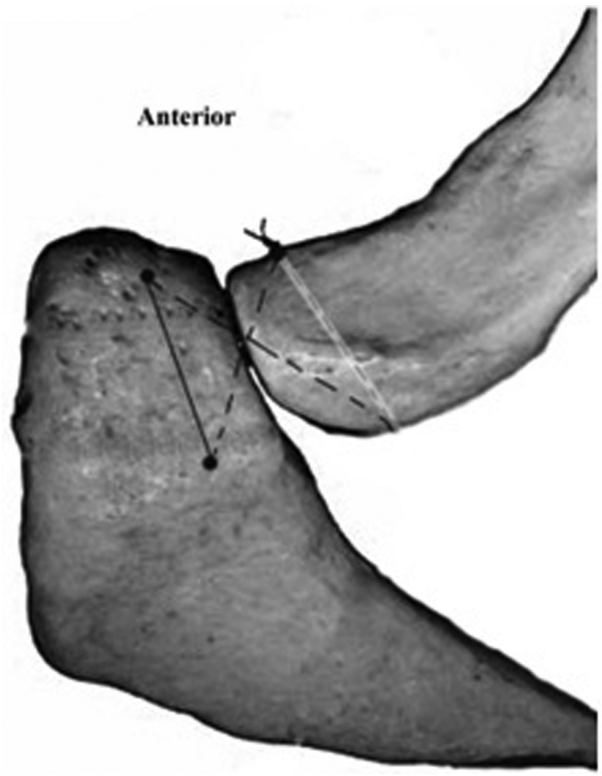


Diagram showing reconstruction of the acromioclavicular ligament with figure-of-eight Ethibond suture.

postoperative radiographs of the AC joint in two planes were taken as anteroposterior and axillary views. In the axillary view, the position of the clavicle relative to the end of the acromion in the horizontal plane was assessed. In postoperative radiographs, distances between the coracoid process and the clavicle were measured in anteroposterior views of both shoulders (CC distance) and the difference was estimated. The elevation of the clavicle from the inferior end of the acromion (CL) to the width of acromion (AC) ratio (CL/AC ratio%) was also estimated (Fig. 3).

Results

This study was continued with 47 patients; one case was lost to follow-up in group I (n=24), and two patients were lost to follow-up in group II (n=23). The mean follow-up period was 24.2±5.9 months (range: 15–34 months) for the first group and 23.3±6.5 months (range: 13–36 months) for the second group. The results are presented in Tables 2 and 3 (Figs 4 and 5).

No statistically significant difference was found between the results of the two groups (Table 4).

Four patients showed evidence of recurrence; in the first group, two (9.5%) patients showed CC distance of 14 and 15 mm (CC difference between the two sides of 6 and 7 mm), with moderate degree of pain that interfered with some daily activities. In the second group, the two (8.7%) patients started activity earlier than recommended, with packing out of the screw off the coracoid base. Seven (14.9%) cases in our series showed osteolysis of the clavicle at the site of the sling. In one patient, the suture tape was tied superior to the clavicle with subsequent tenderness at the suture knot for nearly 4 weeks and resolved spontaneously with residual mild tenderness. Screws were removed within 3–6 months postoperatively.

Figure 3

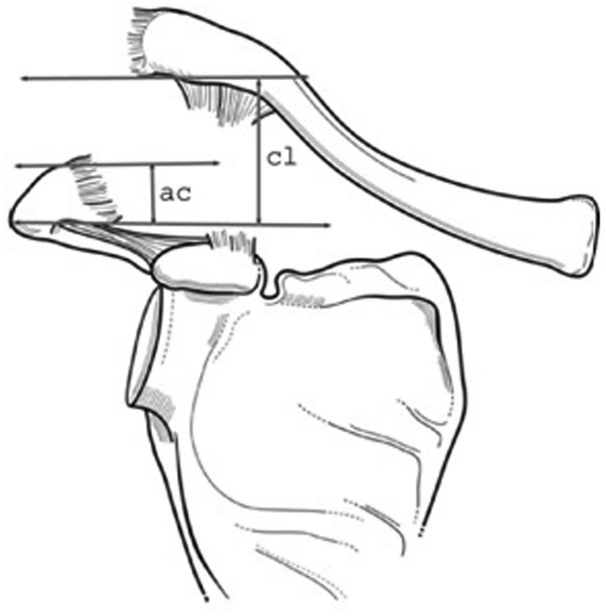


Diagram showing radiological measurement of the CL/AC ratio. Ac, acromion; CL, clavicle.

Statistical analysis

The results were presented as the mean and ranges for parametric data and medians for nonparametric data.

Table 2 Clinical and radiological results of group I

	Mean±SD	Range
Constant score	90.2±8.1	74–99
Taft score	10.6±1.4	8–12
Clinical Taft	6.7±1.3	4–8
Radiological Taft	3.9±0.3	3–4
Pain (visual analog scale)	1.38±1.7	0–5 (median=1)
CL/AC ratio	22.9±10.9	9.1–58.3 (median=22.2)
Coracoclavicular distance (mm)	11.7±1.5	9–14
Coracoclavicular distance difference	2.17±1.3	1–6 (median=2)

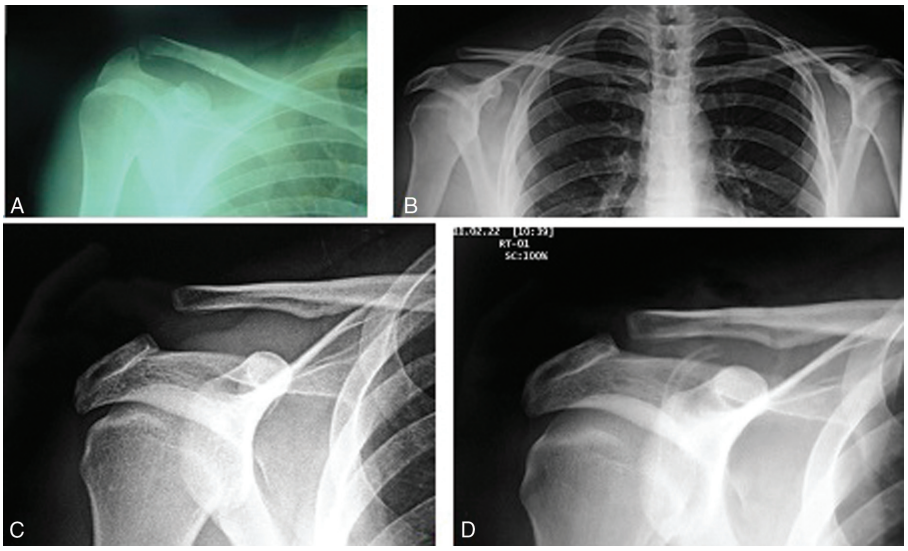
Table 3 Clinical and radiological results of group II

	Mean±SD	Range
Constant score	92.2±5.5	76–98
Taft score	10.9±1.3	7–12
Clinical Taft	7±1.15	4–8
Radiological Taft	3.9±0.3	3–4
Pain (visual analog scale)	1.35±1.27	0–4 (median=1)
CL/AC ratio	20.9±18.7	0–81.8 (median=15.4)
Coracoclavicular distance (mm)	12.04±1.5	9–15
Coracoclavicular distance difference	1.7±1.5	0–6 (median=1)

Table 4 Comparison of the results in groups I and II

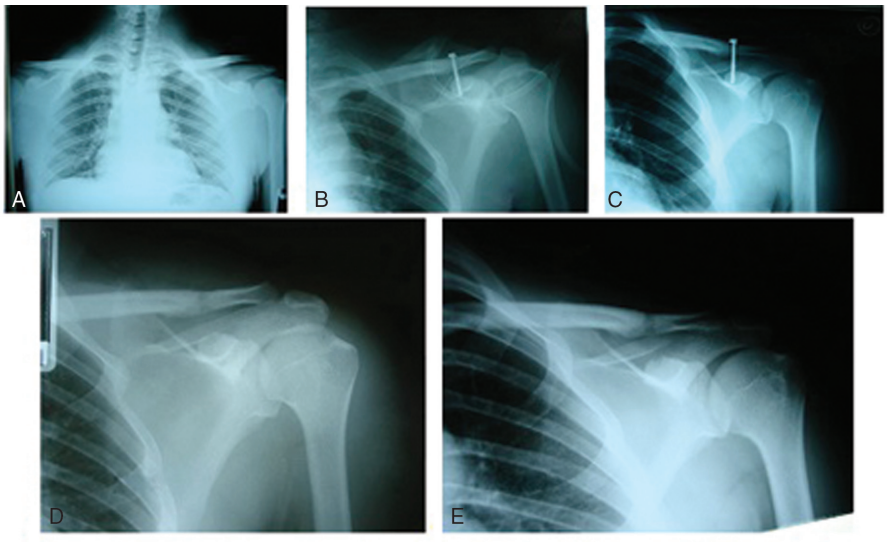
	Group I	Group II	*P*
Constant			
Mean±SD	90.2±8.1	92.2±5.5	0.3
Range	74–99	76–98	
Taft			
Mean±SD	10.6±1.4	10.9±1.3	0.5
Range	8–12	7–12	
Pain			
Mean±SD	1.38±1.7	1.35±1.27	0.7
Range	0–5	0–4	
Coracoclavicular difference (mm)			
Mean±SD	2.17±1.3	1.7±1.5	0.07
Range	1–6	0–6	
CL/AC ratio			
Mean±SD	22.9±10.9	20.9±18.7	0.16
Range	9.1–58.3	0–81.8	

Figure 4



(a, b) Preoperative anteroposterior view radiograph of a type V acromioclavicular dislocation. (c) Postoperative anteroposterior view shows anatomical reduction of the acromioclavicular joint using sling technique. (d) A 24-month follow-up anteroposterior radiograph showing good reduction of the acromioclavicular joint.

Figure 5



(a) Preoperative anteroposterior view radiograph of a type V acromioclavicular dislocation. (b) Postoperative anteroposterior view shows anatomical reduction of the acromioclavicular joint using both the sling and screw fixation. (c, d) Four months postoperatively before and after removal of the screw. (e) A 24-month follow-up anteroposterior radiograph. Reduction of the acromioclavicular joint is maintained with no signs of acromioclavicular joint arthritis.

Independent sample *t*-test was used to test significance between means for parametric data, whereas the Mann–Whitney *U*-test was used for nonparametric variables. The correlation between variables was tested using Pearson's correlation test ($P \leq 0.05$ was considered significant). The SPSS, version 17.0 was used.

Discussion

The principle of operative management of a dislocated AC joint is anatomical reduction of the injured joint and maintenance of this reduction until injured soft tissue heals and stabilizes the distal clavicle [16].

CC screw fixation was initially described by Bosworth and introduced in 1941. It provides both vertical and horizontal stability [17]. This firm fixation was thought to enable early shoulder joint motion. However, this metal work insertion carried several disadvantages, including screw backing out, loosening, and breakage with early motion, the difficulty of the procedure, and the need for a

second operation for screw removal [16]. CC slings between the distal clavicle and the coracoid are one of the widely used extra-articular nonrigid techniques nowadays [18]. Synthetic loops (composed of wires, sutures such as Dacron or Mersilene tape, or other absorbable and nonabsorbable materials) have been used [19].

In this study, two techniques were used to fix the AC joint. In the first group, the sling technique was adopted using Dacron tape and Ethibond suture to fix both the AC joint and reconstruct the CC ligaments at their former anatomical position. In the second group, a Bosworth screw was used in addition to the sling technique. The absence of statistically significantly better values in the second group with added screw fixation indicates the efficiency of the sling technique in stabilizing the acutely dislocated AC joint.

Although it may appear that screw fixation has maintained better reduction radiologically, some authors consider it a nonanatomical form of fixation. The AC joint was described as a nonrigid joint. This means that it moves with full overhead elevation. The clavicle rises by up to 35° and rotates on its long axis by 45°. With adduction and extension, it displaces up to 35° anteriorly and posteriorly [20]. Therefore, any form of rigid fixation will inevitably impair AC joint motion. Moreover, nonremoval of the implant will carry the risk for excessive torque on the screw with the possibility of screw failure [21].

Anatomical studies have shown that the conoid ligament is directed medially and attached to the clavicle posterior to midline. The trapezoid ligament, by comparison, is directed laterally and attached to the clavicle anterior to the midline [22]. Experimental studies have revealed that the two components of the CC ligaments have different functions according to the direction and magnitude of forces applied [23,24]. The trapezoid ligament provides the major support against compressive loads applied along the axis of the clavicle and acts as a secondary restraint to superior translation. The conoid ligament contributes to both superior and anterior stability [2,12]. Wei *et al.* [21] suggested that the ideal surgical treatment for complete AC dislocation would be restoring each ligament separately to achieve functionally optimal outcomes.

As regards the technique of operation, reconstruction of both AC and CC ligaments was essential in every case. Dacron tape was inserted in a position similar to the former conoid and trapezoid ligaments. Reconstruction of the AC joint with Ethibond and repair of the superior ligament whenever possible seemed to play a role in improving the results in the group fixed with the sling only. This sling technique carried several advantages. The suspension suture used in this technique was No. 5 Ethibond suture and the Dacron tape. This is a cost-effective and simple technique. The idea of using both Ethibond suture and the Dacron was two-fold: first, the Ethibond is easy to be tightened without relaxation, and, second, using the two suture materials allowed a stronger sling that has the joined properties of both materials. We chose nonresorbable sutures instead of biodegradable ones to maintain the augmentation for longer time than that provided with such sutures.

In addition, the absence of a drill hole in the base of the coracoid played a role in minimizing the risk for subsequent coracoid fracture. Although screw fixation carries more biomechanical stability, especially at the start of fixation, it carries the complications of screw cut out, infection, irritation under the head of the screw, and the need for another surgery for removal and implant failure. Although neither coracoid nor clavicular fracture was reported in our series, they were clearly described in the literature as a complication with Bosworth screw insertion. Bannister and colleagues stated that early removal of the screw to avoid breakage and the risk for recurrent deformity due to early removal should be very well balanced; otherwise, deformity may recur, which has been reported to have a rate as high as 35%. Recommended screw removal is at 8 weeks [6]. In this study, screw removal was performed after a minimum of 3 months after fixation.

In this study, the rate of recurrence at final follow-up was 8.3% in group I (N=2) compared with 8.7% (N=2) in group II. With nonanatomic reconstructive techniques, Weaver and Dunn's originally reported 20% recurrence rate [8]. This rate varied in the literature between 15 and 25% [19,25]. However, Millet *et al.* [26] reported better results with lower rates of recurrence (6%) using the docking technique. Lower rates of recurrence were observed with the use of hook plate fixation. Recurrence rate of 3.2% was reported following plate removal and about 1.8% of cases showed broken hook [27]. Anatomic reconstructive techniques showed improved results with lower rates of recurrence. Moustafa *et al.* [28] using synthetic loops reported nearly similar rates of redisplacement (8.7%). Verhaven *et al.* [29] reported 10.7% reoperation in their series using double Dacron loop for fixation. Although screw fixation is more biomechanically superior to sling alone, the

possibility for redisplacement is still present with it, possibly due to screw rigidity that may limit clavicular motion resulting in screw failure. Verhaven *et al.* [29] also noticed erosion of the clavicle with the Dacron tape used for fixation of the CC ligament in 21.4% of cases. Erosion was detected in our study in 14.9% of cases, although with minimal clinical significance.

Clinical results of cases with subluxation in this study found were satisfactory with no or mild pain. None of them needed reoperation for refixation of the AC joint. Moreover, poor clinical correlation was detected between radiological results, including both CC difference and CL/AC ratio on one hand and pain as measured on visual analog scale and Constant score on the other hand and was found nonsignificantly related (Table 5). Poor correlation between clinical and radiological results was reported by other authors as well [11,15]. Taft *et al.* [15] commented that AC joint subluxation does not affect the overall result. Sundaram and colleagues reported that a number of patients who underwent a modified Bosworth procedure had subluxation but that was not associated with functional disability of the shoulder joint. They concluded that elevation of the lateral clavicle of up to half the shaft thickness does not influence the clinical results [30]. Broos *et al.* [31] also reported that joint redislocation was the only factor that may influence the end results ($P<0.05$).

The question of an age limit for the surgical treatment of dislocations of the AC joint should be further evaluated. Larsen *et al.* [5] recommended conservative management of patients over 45 years of age, due to a high rate of poor results following surgical intervention in this group. Krueger-Franke and colleagues in their study on acute AC joint reconstruction using PDS cord for repair of the CC ligament reported good-to-excellent results in four of their five patients older than 45 years of age. They concluded that surgical management should be considered for athletically active patient of 45 years and older and that a generalized age limit does not seem to be appropriate [32]. In this study, we had 12 (25.5%) patients older than 45 years. Statistically better results were found in the younger age group (Table 6). This is similar to the findings of Taft *et al.* [15].

Table 5 Correlation between clinical and radiological results

	Pain		Constant score	
	r	*P*	*r*	*P*
Coracoclavicular difference	0.26	0.07	–0.2	0.1
CL/AC ratio	0.2	0.1	–0.2	0.1

Table 6 The effect of age on clinical results

	<45 (*N*=35)	≥45 (*N*=12)	*t*	*P*
Pain	0.77±1.05	3.1±1.24	6.2	0.00
Constant	93.9±4.7	83.25±6.5	6.1	0.00
Taft	11.34±0.76	9±1.27	7.6	0.00

Conclusion

The sling technique was found to be efficient enough to maintain stability of the acutely dislocated AC joint with proper follow-up and without the need to augment this reconstruction with a screw. Metal use will add stability but will affect AC joint mobility and will need another surgery for removal. Surgery is better reserved for active patients with intact nonarthritic AC joints. Moreover, the decision of reoperation for either refixing the AC joint or excision of the distal clavicle should be taken mainly according to a thorough clinical evaluation and not depending only on radiological evaluation.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Lemos MJ. The evaluation and treatment of the injured acromioclavicular joint in athletes. Am J Sports Med 1998; 26:137–144.

2 Baldwin K, Namdari S, Andersen JR, Lee B, Itamura JM, Huffman GR. Luggage tag technique of anatomic fixation of displaced acromioclavicular joint separations. Clin Orthop Relat Res 2010; 468:259–265.

3 Rokito AS, Oh YH, Zuckerman JD. Modified Weaver-Dunn procedure for acromioclavicular joint dislocations. Orthopedics 2004; 27:21–28.

4 Gstettner C, Tauber M, Hitzl W, Resch H. Rockwood type III acromioclavicular dislocation: surgical versus conservative treatment. J Shoulder Elbow Surg 2008; 17:220–225.

5 Larsen E, Bjerg-Nielsen A, Christensen P. Conservative or surgical treatment of acromioclavicular dislocation. A prospective, controlled, randomized study. J Bone Joint Surg Am 1986; 68:552–555.

6 Bannister GC, Wallace WA, Stableforth PG, Hutson MA. The management of acute acromioclavicular dislocation: a randomized prospective controlled trial. J Bone Joint Surg Br 1989; 71:848–850.

7 Spencer EE Jr. Treatment of grade III acromioclavicular joint injuries: a systematic review. Clin Orthop Relat Res 2007; 455:38–44.

8 Weaver JK, Dunn HK. Treatment of acromioclavicular injuries, especially complete acromioclavicular separation. J Bone Joint Surg Am 1972; 54:1187–1194.

9 Weitzman G. Treatment of acute acromioclavicular joint dislocation by a modified Bosworth method. Report on twenty-four cases. J Bone Joint Surg Am 1967; 49:1167–1178.

10 Leidel BA, Braunstein V, Kirchhoff C, Pilotto S, Mutschler W, Biberthaler P. Consistency of long-term outcome of acute Rockwood grade III acromioclavicular joint separations after K-wire transfixation. J Trauma 2009; 66:1666–1671.

11 De Baets T, Truijen J, Driesen R, Pittevils T. The treatment of acromioclavicular joint dislocation Tossy grade III with a clavicle hook plate. Acta Orthop Belg 2004; 70:515–519.

12 Huang TW, Hsieh PH, Huang KC, Huang KC. Suspension suture augmentation for repair of coracoclavicular ligament disruptions. Clin Orthop Relat Res 2009; 467:2142–2148.

13 Mazzocca AD, Santangelo SA, Johnson ST, Rios CG, Dumonski ML, Arciero RA. A biomechanical evaluation of an anatomical coracoclavicular ligament reconstruction. Am J Sports Med 2006; 34:236–246.

14 Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. Clin Orthop Relat Res 1987; 214:160–164.

15 Taft TN, Wilson FC, Oglesby JW. Dislocation of the acromioclavicular joint: end-result study. J Bone Joint Surg Am 1987; 69:1045–1051.

16 Choi SW, Lee TJ, Moon KH, Cho KJ, Lee SY. Minimally invasive coracoclavicular stabilization with suture anchors for acute acromioclavicular dislocation. Am J Sports Med 2008; 36:961–965.

17 Bargren JH, Erlanger S, Dick HM. Biomechanics and comparison of two operative methods of treatment of complete acromioclavicular separation. Clin Orthop Relat Res 1978; 130:267–272.

18 Trikha SP, Acton D, Wilson AJ, Curtis MJ. A new method of arthroscopic reconstruction of the dislocated acromio-clavicular joint. Ann R Coll Surg Engl 2004; 86:161–164.

19 Weinstein DM, McCann PD, McIlveen SJ. Surgical treatment of complete acromioclavicular dislocation. Am J Sports Med 1995; 23:324–331.

20 Lim YW. Triple endobutton technique in acromioclavicular joint reduction and reconstruction. Ann Acad Med Singapore 2008; 37:294–299.

21 Wei HF, Chen YF, Zeng BF, Zhang CQ, Chai YM, Wang HM, Lu Y. Triple endobuttton technique for the treatment of acute complete acromioclavicular joint dislocations: preliminary results. Int Orthop 2011; 35:555–559.

22 Rios CG, Arciero RA, Mazzocca AD. Anatomy of the clavicle and coracoid process for reconstruction of the coracoclavicular ligaments. Am J Sports Med 2007; 35:811–817.

23 Debski RE, Parsons IM 3rd, Fenwick J, Vangura A. Ligament mechanics during three degree-of-freedom motion at the acromioclavicular joint. Ann Biomed Eng 2000; 28:612–618.

24 Lee SJ, Nicholas SJ, Akizuki KH, McHugh MP, Kremenic IJ, Ben-Avi S. Reconstruction of the coracoclavicular ligaments with tendon grafts: a comparative biomechanical study. Am J Sports Med 2003; 31: 648–655.

25 Tienen TG, Oyen JF, Eggen PJ. A modified technique of reconstruction for complete acromioclavicular dislocation: a prospective study. Am J Sports Med 2003; 31:655–659.

26 Millett PJ, Braun S, Gobezie R, Pacheco IH. Acromioclavicular joint reconstruction with coracoacromial ligament transfer using the docking technique. BMC Musculoskelet Disord 2009; 10:6.

27 Kienast B, Thietje R, Queitsch C, Gille J, Schulz AP, Meiners J. Mid-term results after operative treatment of Rockwood grade III-V acromioclavicular joint dislocations with an AC-hook-plate. Eur J Med Res 2011; 16: 52–56.

28 Moustafa AM, Ragab RK, Shoukry FA. Surgical repair of complete acromioclavicular dislocation augmented with PDS bands. Technique and results. Pan Arab J Orth Trauma 2003; 7:21–32.

29 Verhaven E, Casteleyn PP, de Boeck H, Handelberg F, Haentjens P, Opdecam P. Surgical treatment of acute type V acromioclavicular injuries. A prospective study. Acta Orthop Belg 1992; 58:176–182.

30 Sundaram N, Patel DV, Porter DS. Stabilization of acute acromioclavicular dislocation by a modified Bosworth technique: a long-term follow-up study. Injury 1992; 23:189–193.

31 Broos P, Stoffelen D, van de Sijpe K, Fourneau I. Surgical management of complete Tossy III acromioclavicular joint dislocation with the Bosworth screw or the Wolter plate. A critical evaluation. Unfallchirurgie 1997; 23:153–159.

32 Krueger-Franke M, Siebert CH, Rosemeyer B. Surgical treatment of dislocations of the acromioclavicular joint in the athlete. Br J Sports Med 1993; 27:121–124.