Arthroscopic acromioclavicular joint reconstruction using a synthetic ligament device

Jean Kany, Rajkumar S. Amaravathi, Regis Guinand & Philippe Valenti

European Journal of Orthopaedic Surgery & Traumatology

ISSN 1633-8065

Eur J Orthop Surg Traumatol
DOI 10.1007/s00590-011-0856-0

Springer

Eur J Orthop Surg Traumatol
DOI 10.1007/s00590-011-0856-0

ORIGINAL ARTICLE

Arthroscopic acromioclavicular joint reconstruction using a synthetic ligament device

Jean Kany · Rajkumar S. Amaravathi · Regis Guinand · Philippe Valenti

Received: 4 July 2011 / Accepted: 5 August 2011

Abstract
Purpose To describe an all-arthroscopic treatment of acromioclavicular joint (ACJ) dislocation and report the clinical results of the procedure.
Methods This study consisted of 54 patients of whom 49 were men and 5 were women. The age of the patients averaged 39 years (range 16–69 years). All the symptomatic acute and chronic acromioclavicular joint dislocations classified according to Rockwood type III–IV were included in the study. All of them underwent standard clinical and radiological examination.
Result All the patients were regularly followed up at the institute with the average follow-up being 15.09 months (range 5–30 months). The results were assessed using the shoulder subjective value (SSV) and the Modified rating of the University of California Los Angeles (UCLA) for acromioclavicular joint. The mean pre-operative SSV improved from 35.65 to the post-operative value of 88.6. According to the UCLA scale, 40 excellent, 8 good, 4 fair and 2 poor results were achieved. There were few problems encountered with the procedure like failure of ligament, incomplete reduction, capsulitis, and migration of sleeve and fracture clavicle.
Conclusion ACJ dislocations can effectively be treated with arthroscopy-assisted procedure. Since this procedure has given uniformly good to excellent results comparable to open reconstructive procedures, it can be a good treatment option for symptomatic ACJ dislocations.
Level of evidence IV, therapeutic series.

Keywords Arthroscopy · Acromioclavicular joint dislocation · Coracoclavicular ligament · Synthetic ligament

Electronic supplementary material The online version of this article (doi:10.1007/s00590-011-0856-0) contains supplementary material, which is available to authorized users.

J. Kany (✉) · R. Guinand
Clinique De L'Union, Saint Jean 31240, Toulouse, France
e-mail: jean.kany@clinique-union.fr

R. S. Amaravathi
St John's Medical College and Hospital, Bangalore, India

P. Valenti
Clinique Jouvenet, Paris 16, France

Introduction

Acromioclavicular (AC) joint injuries occur most commonly due to direct force on the lateral aspect of the adducted shoulder. This can occur during a sporting activity or a MVA (motor vehicle accident); depending on the force applied, there is complete disruption of the acromioclavicular ligament or coracoclavicular (CC) ligaments [1, 11].

The AC ligament controls the horizontal motion, and the CC ligaments control the vertical motion as they synergistically function to stabilize the AC joint [12]. The conoid ligament controls superior and anterior displacement, whereas the trapezoid ligament controls the posterior displacement, which is the reason for anatomic approach in reconstructing the dislocated AC joint [9].

In Rockwood (RW) type I, II dislocation, nonoperative treatment gives satisfactory result [10]. The treatment for RW III varies widely, depending on the age, physical demand, symptom and cosmesis. An acute RW III injury is an indication for surgery if patient is symptomatic and functionally disabled [10]. Acute RW IV–VI are absolute indications for surgery. Injuries more than 6 weeks are

Published online: 19 August 2011

considered to be chronic, and RW III–VI are stabilized surgically only if pain, paraesthesia and reduced mobility are encountered. Both conservative and operative approaches have their advantage and disadvantage. Conservative treatment can lead to disabling pain, joint osteolysis and cosmetic deformity of the AC joint, while an operative approach can cause joint deformity, osteoarthrosis and failure of hardware [16, 25].

However, newer anatomic techniques are being adopted to reduce complication and improve the outcome by using both biological and non-biological tissue for treatment [21, 23, 29, 31]. Keeping in line with the concept Wolf and Pennington were the first to develop arthroscopic technique to treat AC joint dislocation [33]. The decision to stabilize the dislocated AC joint arthroscopically was undertaken to minimize the soft tissue dissection, scarring, deformity and to have a better functional outcome.

The purpose for this study was to assess whether the usage of synthetic ligament provides results on par with the open procedures and evaluate the outcome with regard to arthroscopic reconstruction of AC joint dislocation.

Materials and methods

In a retrospective study from October 2008 to April 2010, the treatment of 58 patients with symptomatic acromioclavicular (AC) joint dislocation was evaluated following arthroscopic reconstruction of coracoclavicular ligaments. All the patients with symptomatic acute and chronic AC joint dislocation were included in the study. All the cases with associated injuries of the arm and shoulder, those who did not follow up, were excluded from the study. This was done using a synthetic 200-mm-long double-braided polyester tape (polyethylene terephtalate, SEM, SEM LAC 2T, Montrouge, France) with pre-assembled 8-mm-diameter sleeve at one end and polyester traction suture at other end. A stainless steel straight sleeve with a crimping cone is used to secure the other end of the ligament (Fig. 1).

The rationale for using the ligament is to use a tissue close to the failure load of the natural coracoclavicular (CC) ligament. The load to failure of CC ligaments is 589 N, AC joint complex is 815 N, and Weaver–Dunn procedure is 483 N [14, 17]. The load to failure of the ligament SEM LAC 2T is 500 N. It is known that fibrous tissue proliferates between the corocoid and the clavicle once the AC joint complex is stabilized satisfactorily [7]. The ligament SEM LAC 2T can also act like a scaffold for this process while stabilizing the AC joint dislocation.

Of the 58 patients, 2 were lost for follow-up, one died because of natural cause, and another had additional scapula fracture with cervical spine injury. Hence, 54 patients remained for the study of which 49 were men and 5 were women. The average age was 39 years (range 16–69 years). The right-side injuries were seen in 34 patients and left side in 20 patients. The time from injury to treatment averaged 3.8 months (range 0.2–24 months). Most injuries occurred due to rugby ($n = 16$) followed by fall from motorbike ($n = 9$), bicycle ($n = 7$) and others as shown in Table 1. We followed the Rockwood classification for AC joint injury [27] and Rockwood type III injury were seen in 37 patients of whom 22 were acute injuries and 15 chronic injuries. Rockwood type IV injury was seen in 17 patients of whom 6 were acute and 11 were chronic injuries. All the patients with persistent pain, discomfort, functional disability and concerns with cosmesis were only offered surgery. A standard clinical and radiological examination for all patients was done as suggested by Mazzocca et al. [24]. The ACJ was assessed for closed reduction before and under anaesthesia, if the reduction is not possibly a Weaver–Dunn procedure and debridement of AC joint is added in addition to reconstruction of CC ligaments.

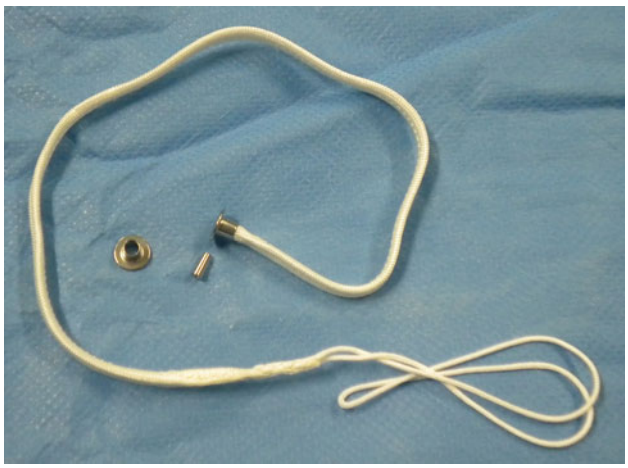

Fig. 1 Ligament SEM LAC 2T. Stainless steel sleeve and crimping cone

All of them were regularly followed up at an average period of 15.09 months (range 5–30 months; Table 1). The local institution review board approved the study, and all the patients had given written informed consent for the study. The ligament SEM LAC 2T was used to reconstruct the CC ligament in all patients. However, 16 chronic injuries (8 RW type III and 8 RW type IV) underwent Weaver–Dunn procedure, and distal clavicle resection was done in 2 patients in addition to CC ligament reconstruction as the reduction of joint pre-operatively was difficult.

Operative technique

The procedure is performed in standard beach chair position with a cushion under the scapula of the affected

Table 1 Patient data

No	Age	Sex	Side	RW	MI type	Time I.T	WD	Mumford	SSV pre-op	SSV post-op	UCLA	RTS	FU months
1	40	F	L	3	Bicycle	12	N	N	50	100	20	Y	25
2	44	M	R	3	Rugby	2	N	N	50	100	20	Y	24
3	45	M	R	3	Rugby	0.2	N	N	20	100	20	Y	24
4	21	M	L	3	Rugby	2	N	N	50	80	16	N	24
5	45	M	R	3	Karate	0.3	N	N	50	90	18	Y	23
6	69	M	R	3	Bicycle	3	Y	N	80	100	20	Y	22
7	19	M	R	3	Rugby	0.2	N	N	50	100	20	Y	21
8	39	M	R	4	Ski	9	Y	N	40	80	15	N	21
9	31	M	R	3	MVA	0.2	N	N	30	80	17	N	22
10	25	M	L	3	Motorbike	0.2	N	N	60	100	20	Y	17
11	49	M	R	3	Ski	6	Y	N	35	100	18	Y	15
12	32	M	R	3	Motorbike	0.2	N	N	40	100	20	Y	14
13	67	M	R	4	Bicycle	8	Y	N	40	100	20	Y	14
14	29	M	R	3	Motorbike	1	N	N	30	100	20	Y	14
15	40	M	R	3	Motorbike	24	Y	N	50	100	20	Y	12
16	37	M	R	3	Rugby	0.2	N	N	40	100	20	Y	12
17	23	M	L	4	Handball	6	N	N	30	80	15	Y	9
18	51	M	R	4	Self fall	5	N	N	50	95	20	Y	8
19	20	M	R	3	Judo	6	Y	N	50	90	20	Y	6
20	33	M	L	4	Rugby	12	Y	N	40	90	18	N	5
21	31	M	R	3	Rugby	2	N	N	40	80	20	Y	24
22	39	M	R	3	Rugby	0.3	N	N	30	90	20	Y	23
23	39	M	L	3	Judo	4	N	N	60	100	18	Y	22
24	25	M	L	3	Rugby	0.2	N	N	60	100	18	Y	21
25	25	M	R	3	Self fall	0.3	N	N	30	100	18	Y	19
26	54	M	L	3	MVA	0.3	Y	N	20	60	13	N	19
27	24	M	L	3	Rugby	0.3	N	N	40	100	20	Y	17
28	45	M	L	3	Rugby	0.3	N	N	40	90	20	Y	15
29	54	M	L	4	Bicycle	0.3	Y	N	40	60	10	N	14
30	46	M	L	3	MVA	0.3	N	N	20	90	18	Y	13
31	45	M	L	4	Street fight	3	Y	N	30	80	15	N	13
32	55	M	L	4	Bicycle	0.6	N	N	20	80	10	N	12
33	24	M	L	3	Self fall	0.6	N	N	20	90	20	Y	12
34	31	M	R	3	Rugby	1	N	N	20	90	20	Y	12
35	48	M	R	3	Bicycle	0.6	N	N	30	75	13	N	11
36	39	M	R	3	Motorbike	4	N	Y	50	90	15	N	8
37	44	M	R	3	Rugby	0.7	N	Y	50	90	20	Y	6
38	43	M	R	4	Rugby	12	Y	N	50	70	14	N	6
39	16	M	R	3	Judo	0.5	N	N	30	100	20	Y	6
40	30	M	R	3	Rugby	0.4	N	N	20	80	17	Y	6
41	24	M	R	3	MVA	0.7	N	N	30	75	14	N	6
42	43	M	L	4	Motorbike	6	Y	Y	20	80	20	Y	6
43	47	F	L	3	Fall	6	Y	Y	20	90	20	Y	7
44	46	M	R	4	Judo	24	Y	Y	30	80	20	Y	8
45	49	F	L	3	Motorbike	6	Y	Y	40	90	20	Y	9
46	54	F	R	3	Fall	12	Y	Y	20	90	20	Y	12
47	40	M	R	4	Motorbike	0.3	N	N	20	70	15	N	16
48	60	M	L	4	Motorbike	0.3	N	N	20	80	18	Y	16

Table 1 continued

No	Age	Sex	Side	RW	MI type	Time I.T	WD	Mumford	SSV pre-op	SSV post-op	UCLA	RTS	FU months
49	30	M	L	4	Ski	0.5	N	N	20	90	20	Y	12
50	37	M	R	3	Horse	6	N	N	30	90	20	Y	18
51	23	M	R	3	Snowboard	5	Y	Y	20	80	20	Y	20
52	32	F	R	4	Rugby	0.3	N	N	20	90	20	Y	20
53	62	M	R	4	Ski	2	N	N	30	90	20	Y	24
54	37	M	R	4	Bicycle	9	Y	Y	20	90	20	Y	30

RW Rockwood type, *MI* mode of injury, *I-T* injury to treatment, *WD* Weaver–Dunn, *SSV* shoulder subjective value, *UCLA* University of Los Angeles, *RTS* return to sports, *FU* follow-up, *MVA* motor vehicle accident, *Y* yes, *N* no

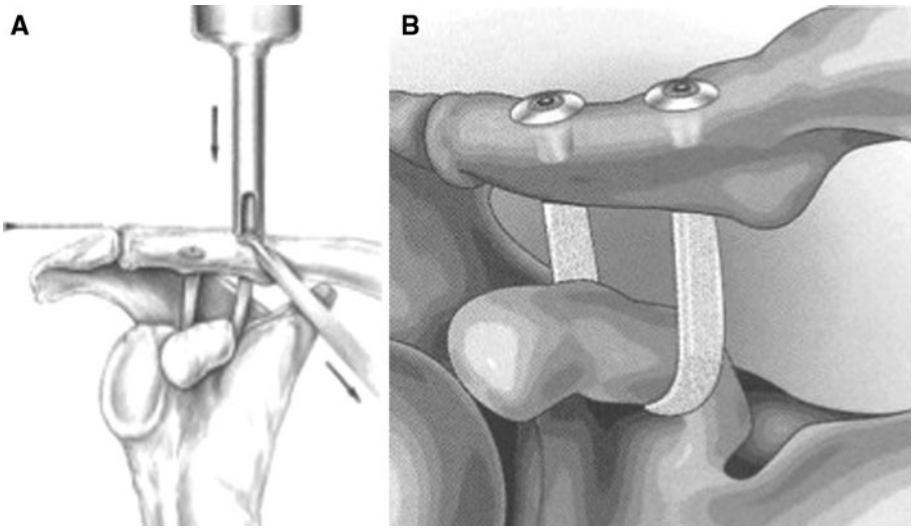

Fig. 2 **a** Figure depicting reduction with sleeve pusher. **b** Final AC joint reduction appearance using Ligament SEM LAC 2T

shoulder. Surgery is performed under controlled hypotension and a combination of regional and general anaesthesia for better visualization and post-operative recovery.

Two stab incisions are made on the superior surface of the clavicle at 2–2.5 cm (A-Fig. 3b) and 4–4.5 cm (B-Fig. 3b) distance from the lateral end of the clavicle. Portals 'C' and 'D' are made inferiorly three to four finger breadth in line with the 'A' and 'B' stab incisions to allow for debridement and managing shuttle relay. The 'E' portal (Fig. 3b) at three to four finger breadths in line with the 'D' portal is the viewing portal. The most medial one (B) is posterior, oblique and the lateral (A) one little anterocentral to simulate the origin of the native CC ligaments. Two drill holes are made using 3.2-mm drill bits, which are left in situ for later identification in the sub-clavicle space. Care is taken to avoid neurovascular injury while clearing the subcorocoid bursa with radio-frequency device and optimizing the lateral edge of corocoid with shaver. A diligent clearance of the soft tissue is done around the corocoid to allow easy passage of graft. The superior hole in the clavicle is enlarged using a sleeve trocar manually. The suture passer and the No 2 monofilament are used to shuttle relay the SEM LAC 2T around the corocoid while viewing from the anterolateral portal. Second sleeve is inserted over the traction suture, and the AC joint is held reduced by pressure on the clavicle with the sleeve pusher and counter on the elbow to lift the shoulder (Fig. 2). It is preferable to use the sleeve pusher on the medial most entry to avoid unexpected failure of clavicle in weak bone. The distance between the inferior aspect of the clavicle and the superior surface of the corocoid is between 3 and 5 mm [3, 18]. Adequate reduction is checked by arthroscopy, when it should be difficult to pass a 5.5-mm shaver between the inferior surface of clavicle and superior surface of coracoid. This technique of assessing the reduction has allowed us to avoid intraoperative X-ray control or use of fluoroscopy. The crimping cone is used to secure the ligament in the sleeve, and excess is cut flush with the sleeve. The portals are closed and dressed. Please note that no dissection of the rotator interval is done to identify the corocoid or of the delto-trapezial fascia (Operative Video).

Post-operative rehabilitation

Post-operatively, the arm is placed in a sling for 3–4 weeks. Passive motion of the shoulder is encouraged

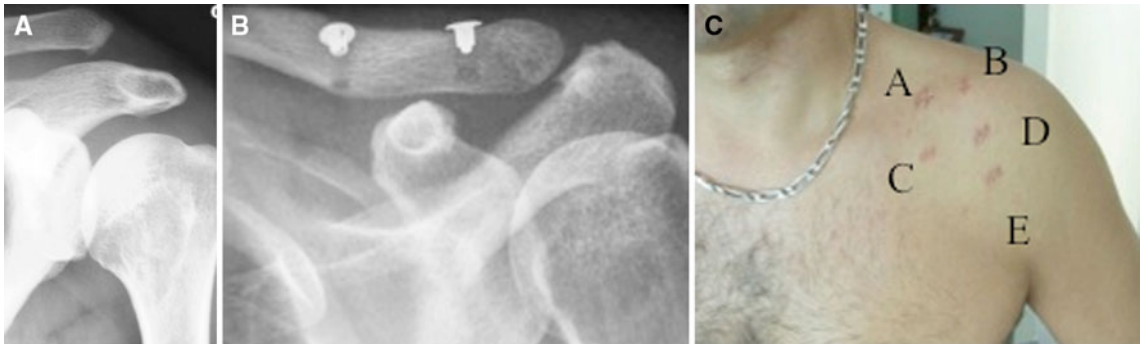

Fig. 3 **a** Rockwood type III AC injury in a left shoulder. **b** Post-surgery follow-up X-ray 9 months. **c** Healed portals (*A*, *B*, *C*, *D* and *E*) and good cosmetic result

from day 1. Over the next 3–4 weeks, they are allowed to do most activities of daily living but without resistance and lifting any heavy object. From 5 to 8 weeks, strengthening exercises and movement against resistance are encouraged. Return to contact sport and overhead activity is allowed by 3–6 months. In those cases where the Weaver–Dunn procedure is done, an additional 3 months is awaited for maturity of the bio-graft for return to sport and overhead activity.

Outcome assessment

All the patients were seen at the institution for regular follow-up, clinical examination with standard radiographs for joint reduction or any other complication. The shoulder subjective value (SSV) is the patients' self-rated subjective assessment of his or her shoulder function as compared to normal shoulder. The SSV is known to correlate well with the Constant score and is expressed as a percentage [13]. A modified scale of University of Los Angeles for AC joint (UCLA) was also used to see the overall function and patient satisfaction which is expressed as a numeric value from 0 to 20 [15].

Result

The patients were regularly followed up with clinical and radiological examination. There was no significant difference in the range of motion pre-operatively or post-operatively. The mean SSV improved from 35.65% (range 20–80%) pre-operatively to 88.6% (range 70–100%) post-operatively. The mean UCLA modified AC rating scale was 18.2 points (range 10–20 points) out of the 20 points. Most patients recovered well from the procedure with the improvement in clinical symptoms, radiological finding and cosmetic appearance (good to excellent 88% approximately) (Fig. 3). However, there were few patients who did not show encouraging results (fair to poor 11% approximately). The complications that were seen during the procedure were night pain and capsulitis ($n = 6$), joint reduction incomplete ($n = 8$) due to soft tissue interposition, failed or torn ligament ($n = 2$) which could possibly be due to the sharp lateral edge of the corocoid or non-anatomic clavicular tunnel placement, migration of sleeve($n = 1$) due to weak bone at the lateral end of clavicle, neuropraxia ($n = 1$) and fracture clavicle($n = 1$) due to multiple entry point for the clavicular tunnels.

The night pain and capsulitis all resolved by medical management. The problem related to the reduction of the joint was due to soft tissue interposition especially in chronic RW type IV injuries. In the case where the sleeve migrated due to weak bone, the procedure was salvaged by converting the technique to open surgery. The case of fracture clavicle was salvaged by adding LCP to treat the fracture. However, at the latest follow-up, both the patients have done well. The UCLA score for 22 acute RW type III injuries was 17 excellent, 2 good and 3 fair, and in 15 chronic RW type III, there were 13 excellent and 2 good results, respectively. The UCLA score in the 6 cases of acute RW type IV was 3 excellent, good in 1 and poor in 2 cases. In 11 chronic RW type IV, the UCLA score was 7 excellent, 3 good and 1 fair result. The overall results for the acute injury out of 28 was 20 excellent, 3 good, 3 fair and 2 poor, and out of 26 chronic injury, it was 20 excellent, 5 good and 1 fair result on the UCLA-modified AC scale, respectively. The Weaver–Dunn procedure for chronic RW type III injury was excellent in all 8 cases, and there were 5 excellent, 2 good and 1 fair result in chronic RW type IV injury. There was one excellent and one good result in the distal clavicle resection cases. The SSV in acute RW injury improved from 38.5% pre-operatively to 91.7% post-operatively, while in RW type IV injuries, the pre-operative value of 30% improved to 82.5% post-operatively. However, when cases ($n = 16$) who underwent Weaver–Dunn procedure were compared to cases ($n = 10$) not undergoing the procedure, no significant difference was

found, probably because of less number of cases and more not so good results with Weaver and Dunn procedure.

The statistical analysis was done using SPSS software version 17 to evaluate the results. The Wilcoxon signed-rank test was used to test the significance of difference in the mean pre-operative and post-operative SSV scores. A statistically significant difference ($P = 0.001$) was observed between the pre-operative and post-operative scores in all patients. While the type of injury did not influence the mean difference, it could be seen that in cases with acute injuries and immediate reconstruction, there is a relatively large significant difference post-operatively ($P = 0.001$). However, the UCLA scores analysed by using Mann–Whitney U test between and across groups did not show any significant results.

Discussion

The AC joint separation is the most common injury accounting for 9% of all shoulder girdle injuries [24]. In Sweden, the incidence of AC joint dislocation regardless of the degree in the age group of 15–64 years is 18/100,000 for men and 1/100,000 for women [26]. Different classification systems are in use for AC joint dislocation like Allman, Tossy and the most widely accepted the Rockwood type, which was used here to identify the injuries [27].

Plain radiographs are thought to be less accurate while evaluating the degree of subluxation especially RW type IV injury [4]. There is also an inverse correlation found between the craniocaudal dislocation and Constant score while analysing the AC joint dislocation by 3D-CT scan [2]. However, we relied on more of intraoperative control for joint reduction and functional outcome for evaluating this injury. Also in most cases, the coracoclavicular distance was within 3–5 mm.

The coracoclavicular sling surgery is known to fare badly due to abrasive wear of the reconstructed ligament under the corocoid process or due to slippage of the graft. In a comparison of synthetic grafts, the load to failure of braided PDS was found to be better than fibre wire or merselene tape. However, in the techniques for AC joint reconstruction where the grafts are used through the tunnels in the clavicle and corocoid have been found to be more anatomic, with less abrasive wear and good outcome [19, 34].

There is no clear consensus on the distal clavicle excision (DCE) in the literature. The AC joint is not a pain generator, and any excess mobility in the antero-posterior direction at the AC joint will lead to clinical failure of DCE and AC joint reconstruction. In cases where the DCE was not done and the AC joint was preserved, there was no arthrosis found, and also in cases where DCE was done, no significant improvement in the outcome was noticed [5, 6].

The coracoacromial (CA) ligament (246 ± 69 N) is not of adequate strength to replace the coracoclavicular (CC) ligaments (621 ± 209 N) [8]. The addition of CA ligament transfer to distal clavicle in AC joint reconstruction with hamstring allograft did not significantly improve the overall biomechanical strength [8]. Although the Weaver–Dunn–Chuinard procedure (CA ligament with a bone piece) with double-button fixation of the chronic AC joint dislocation gave encouraging results, the durability of the reconstruction in a series of 10 cases was unproven [20]. The residual subluxation and dislocation in spite of various Weaver–Dunn procedures for AC joint dislocation are reported to be between 29 and 76% [28, 32]. The CA ligament transfer was not consistently done in all patients in our series and in whom it was done showed excellent result in chronic RW type III injuries and mixed result in chronic RW type IV injuries on the UCLA-modified AC rating scale.

Most failures of the CC ligament reconstruction occur in the first 6 weeks of the reconstruction [20]. In some cases, the mode of failure of the reconstructed graft is through the mid-substance (44%), or through the fracture of the coracoid, and in some it is not clear [8, 9, 23–25]. In some instances, it has been advised to add an additional cerclage suture of high strength around the clavicle and the corocoid to improve the ultimate load to failure and the stiffness of the reconstructed ligament and transfer the mode of failure from the graft to the bone [8]. In this series also, the ligament was found to be torn in mid-substance (2 patients), and one each fracture of clavicle and migration of sleeve was seen respectively.

A rigid fixation of the AC joint or the clavicle to the corocoid will alter the biomechanics of the AC joint complex increasing joint pressure, reducing mobility, pain and ultimately poor outcome of the procedure [4, 18]. Partial loss of joint reduction did not influence the overall outcome but complete loss of reduction in AC joint reconstruction lead to worse results [32]. Anatomic reduction is not absolutely necessary for good functional outcome because even an elongated reconstructed ligament in AC joint disruption is thought to provide enough stability to the clavicle to reduce the symptoms and improve the function [30]. Hence, it is important to assess the reducibility of the dislocated AC joint before surgery to decide on only CC ligament reconstruction or addition of Weaver–Dunn procedure to CC ligament reconstruction in case of irreducibility of AC joint.

The success rate reported in the literature for AC joint surgery in both acute and chronic cases is around 90%, and in late reconstruction, it is around 78% [15, 22, 32]. In our

series also, the good to excellent results were 88%, and the fair to poor results were 11%.

Our series describes an all-arthroscopic technique of anatomic reconstruction of CC ligaments with a synthetic graft without violating the rotator interval and delto-trapezial attachments. There were also no instances of haematoma or infection in our series. The criticism of our series could be to have longer follow-up of patients, to also have normal distribution with uniform data for both the acute and chronic AC dislocation so as to assess the results in a better way and the technical difficulty of the procedure for less experienced surgeons. We also need to sincerely look at reducing the rate of adverse events.

Conclusion

The use of a synthetic ligament gives a safe and viable option for reconstruction of CC ligaments in AC joint dislocation. During the treatment of the AC joint dislocation by experienced surgeons, one can hope to achieve, with less soft tissue dissection good to excellent results that are comparable to open reconstructive procedures. However, separate long-term results of treating acute and chronic AC joint injuries are awaited.

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Bearn JG (1967) Direct observations on the function of the capsule of the sterno-clavicular joint in clavicular support. J Anat 101:159–170 (PMID 6047697)
2. Bezer M, Saygi B, Aydin N, Kukukdurmaz F, Ekuisi G, Guven O (2009) Quantification of acromioclavicular reduction parameters after the Weaver-Dunn procedure. Arch Orthop Trauma Surg 129:1017–1024 (PMID 18719931)
3. Boileau P, Old J, Gastaud O, Brassart N, Roussanne Y (2010) All arthroscopic Weaver-Dunn-Chuinard procedure with double button fixation for chronic acromioclavicular joint dislocation. Arthroscopy 26:149–160 (PMID 20141978)
4. Bostrom Windhamre HA, VonHeideken JP, Une-Larsson VE, Ekelund AL (2010) Surgical treatment of chronic acromioclavicular joint dislocations: comparative studies of Weaver-Dunn augmented with PDS braid or hook plate. J Shoulder Elbow Surg 19:1040–1048 (PMID 20452245)
5. Browne JE, Stanley RF, Tullos HS (1977) Acromioclavicular joint dislocations: comparative results following operative treatment with and without primary distal clavisectomy. Am J Sports Med 5:258–263 (PMID 931040)
6. Carofino BC, Mazzocca AD (2010) The anatomic coracoclavicular ligament reconstruction: surgical technique and indications. J Shoulder Elbow Surg 19:37–46 (PMID 20188267)
7. Clayer M, Slavotinek CJ, Krishnan J (1997) The results of coracoclavicular slings for acromioclavicular dislocation. Aust NZ J Surg 67:343–436 (PMID 9193270)
8. Clavenger T, Vance RE, Bachus KN, Burks RT, Tashjian RZ (2011) Biomechanical comparison of acromioclavicular joint reconstruction using coracoclavicular tendon grafts with or without coracoacromial ligament transfer. Arthroscopy 27:24–30 (PMID 20950988)
9. Costic RS, Labriola JE, Rodosky MW, Debski RE (2004) Biomechanical rationale for development of anatomical reconstructions of coracoclavicular ligaments after complete acromioclavicular dislocations. Am J Sports Med 32:1929–1936 (PMID 15572323)
10. Dias JJ, Steingold RF, Richardson RA, Tesfayohanna B, Gregg PJ (1987) The conservative treatment of acromioclavicular dislocation. Review after 5 years. J Bone Joint Surg Br 69:719–722 (PMID 680330)
11. Fraser-Moodie JA, Shortt NL, Robinson CM (2008) Injuries to the acromioclavicular joint. J Bone Joint Surg Br 90:697–707 (PMID 18539661)
12. Fukuda K, Craig EV, An N, Cofield RH, Chao EY (1986) Biomechanical study of the ligamentous system of the acromioclavicular joint. J Bone Joint Surg Am 68:434–440 (PMID 3949839)
13. Gilbart MK, Gerber C (2007) Comparison of the shoulder subjective value and the constant score. J Shoulder Elbow Surg 16:717–721. doi:10.1016/j.jse.2007.02.123
14. Grutter PW, Petersen SA (2005) Anatomical acromioclavicular ligament reconstruction. A biomechanical comparison of reconstructive techniques of the acromioclavicular joint. Am J Sports Med 33:1723–1728. doi:1177/0363546505275646
15. Guy DK, Wirth MA, Griffin JL, Rockwood CA (1998) Reconstruction of chronic and complete dislocation of the acromioclavicular joint. Clin Orthop Relat Res 347:138–149 (PMID 9520884)
16. Harris RI, Wallace AL, Harper GD, Goldberg JA, Sonnabend DH, Walsh WR (2000) Structural properties of the intact and the reconstructed coracoclavicular ligament complex. Am J Sports Med 28:103–108 (PMID 10653552)
17. Imhoff AB, Chernchujit B (2004) Arthroscopic anatomic stabilization of acromioclavicular joint dislocation. Oper Tech Sports Med 12:43–48. doi:10.1053/j.otsm.2004.04.002
18. Jari R, Costic RS, Rodosky MW, Debski RE (2004) Biomechanical function of surgical procedures for acromioclavicular joint dislocations. Arthroscopy 20:237–245 (PMID 15007312)
19. Kippe MA, Demetropoulos CK, Baker KC, Jurist KA, Guettlier JH (2009) Failure of coracoclavicular artificial graft reconstruction from repetitive rotation. Arthroscopy 25:975–982 (PMID 19732635)
20. Lim YW, Sood A, Van Reit RP, Bain GA (2007) Acromioclavicular joint reduction, repair and reconstruction using metallic buttons (early results and complications). Tech Shoulder Elbow Surg 6:213–221. doi:10/6097/BJE.obo13e3181578965
21. Lim YW (2008) Triple endobutton technique in acromioclavicular joint reduction and reconstruction. Ann Acad Med Singapore 37:294–299 (PMID 18461213)
22. Mathieu L, Rongieras F, Fascia P, Ollat D, Chauvin F, Versier G (2007) Acromioclavicular dislocations treated by synthetic coraco-clavicular ligamentoplasty. Rev Chir Orthop 93:116–125 (French, PMID 17401284)
23. Mazzocca AD, Santangelo SA, Johnson ST, Rios CG, Dumonski ML, Arciero RA (2006) A biomechanical evaluation of an anatomical coracoclavicular ligament reconstruction. Am J Sports Med 34:236–246 (PMID 16282577)
24. Mazzocca AD, Arciero RA, Bicos J (2007) Evaluation and treatment of acromioclavicular injuries. Am J Sports Med 35:316–319 (PMID 17251175)
25. Motamedi AR, Blevin FT, Wills MC, McNally TP, Shahinpoor M (2000) Biomechanics of the coracoclavicular ligament complex and augmentations used in its repair and reconstruction. Am J Sports Med 28:380–384 (PMID 10843132)

26. Nordqvist A, Petersen CJ (1995) Incidence and causes of shoulder girdle injuries in an urban population. J Shoulder Elbow Surg 4:107–112 (PMID 8792740)
27. Rockwood CA Jr, Williams GR, Young DC (1996) Injuries to the acromioclavicular joint. In: Rockwood CA, Green DP, Buchholz RW et al (eds) Fracture in adults, vol 2, 4th edn. Lippincott-Raven, Philadelphia, pp 1341–1413
28. Rolf O, VonWeyhern AH, Ewers A, Boehm TD, Gohlke F (2008) Acromioclavicular dislocation Rockwood III–IV. Results of early versus delayed surgical treatment. Arch Orthop Trauma Surg 128:1153–1157 (PMID 18038141)
29. Shin YJ, Yun YH, Yoo JD (2009) Coracoclavicular ligament reconstruction for acromioclavicular dislocation using 2 suture anchors and coracoacromial ligament transfer. Am J Sports Med 37:346–351 (PMID 19022989)
30. Tauber M, Gordon K, Koller H, Fox M, Resch H (2009) Semitendinous tendon graft versus a modified Weaver-Dunn procedure for acromioclavicular joint reconstruction in chronic cases. A prospective comparative study. Am J Sports Med 37:181–190 (PMID 18818433)
31. Wellmann M, Zantop T, Wellmann A, Raschke MJ, Petersen W (2007) Biomechanical evaluation of minimally invasive repairs for complete acromioclavicular joint dislocation. Am J Sports Med 35:955–961 (PMID 17322128)
32. Weinstein DM, McCann PD, McIlveen SJ, Flatow EL, Bigliani LU (1995) Surgical treatment of complete acromioclavicular dislocations. Am J Sports Med 23:324–331 (PMID 7661261)
33. Wolf EM, Pennington WT (2001) Arthroscopic reconstruction for acromioclavicular joint dislocation. Arthroscopy 17:558–563 (PMID 11337730)
34. Yoo YS, Tsai AG, Ranawat AS, Bansal M, Fu F, Rodosky MW, Smolinski P (2010) A biomechanical analysis of the native coracoclavicular ligaments and their influence on a new reconstruction using a coracoid tunnel and free tendon graft. Arthroscopy 26:1153–1161 (PMID 20810076)