Triple endobutton technique for the treatment of acute complete acromioclavicular joint dislocations: preliminary results

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Abstract Numerous procedures have been described for the operative management of acromioclavicular (AC) joint injuries. Some of these techniques, including hardware fixation and non-anatomical reconstructions, are associated with serious complications and high failure rates. Recently, AC joint reconstruction techniques have focused on anatomical restoration of the coracoclavicular ligaments to achieve optimal clinical outcomes. We used a triple endobutton technique to separately reconstruct the trapezoid and the coronoid portions of the coracoclavicular ligament. We evaluated the preliminary clinical and radiological results of this technique in patients with acute complete dislocation of the AC joint. All patients achieved a significant improvement in the pain and function of shoulder at a mean follow-up interval of 12 months (range, 8–14 months). Excellent reduction of the AC joint was maintained. The triple endobutton technique may be safe and effective for the treatment of acute complete AC joint dislocations.

Introduction

Traumatic separation of the acromioclavicular (AC) joint is common, particularly in active or athletic young adults.

Nonoperative treatments are recommended for Rockwood I and II separations, while the management of Rockwood III dislocations still remains controversial [22]. Rockwood IV and above injuries require operative intervention for adequate reduction and stabilisation [2].

Many techniques are used to treat AC joint dislocations. Techniques using various forms of hardware fixation, such as the Bosworth screw and hook plate, have fallen out of favour because of problems with hardware failure and the need for a second procedure to remove the hardware. In traditional procedures, such as the Weaver-Dunn procedure, the reconstructed coracoclavicular ligament may be much weaker and much more compliant than the native ligament, leading to the reported high failure rate [24].

More recently, the triple endobutton technique has been described for the treatment of complete AC joint dislocations [16]. This technique allows reconstruction of the coracoclavicular ligament in as an anatomical position as possible. The theoretical strength of the fixation is also superior to the original strength of the coracoclavicular ligaments. Our study introduces a novel surgical technique for reconstruction of coracoclavicular ligaments using three endobuttons (Acufex; Smith & Nephew, Andover, MA), closed loop (CL) and five strands of #2 Ethibond suture. We present here the preliminary clinical and radiological results of this technique in patients with acute complete dislocation of the AC joint.

Materials and methods

Fifteen consecutive cases of patients with acute AC dislocation who had undergone surgical management were reviewed retrospectively from December 2008 to July

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2009. All patients had been treated by coracoclavicular reconstruction technique using three endobuttons, CL and five strands of #2 Ethibond sutures. According to the classification of Rockwood et al. [21], there were two grade III, six grade IV and seven grade V separations. Both patients with grade III dislocations were manual labourers. There were two women and 13 men with a mean age of 42.8 years (range, 25–66 years). The dominant shoulder was involved in six patients. The patients underwent surgery with a mean time from injury to reconstruction of 6.5 days (range, 3–14 days). No prior shoulder complaints were reported before the injury.

The diagnosis of complete AC dislocation was made based on clinical and radiographic assessments. Clinical diagnoses were based on the presence of painful and palpable step-off of the AC joint following the traumatic episode. Preoperative radiological evaluations included anteroposterior, axillary and Zanca views of both shoulders. The grade of AC dislocation was determined based on these radiographs. The degree of displacement of the AC joint was measured and compared with that of the contralateral shoulder on the pre- and postoperative radiographs.

Surgical techniques

The procedure was performed under general anaesthesia in the beach chair position. An “L” skin incision was made spanning the AC joint to proximal to the coracoid process. The trapezius-deltoid fascia was opened transversely. The deltoid was dissected from the anterosuperior clavicle subperiosteally exposing the AC joint, distal one third of the clavicle and the base of the coracoid process.

The clavicle was manually reduced by direct pressure and this reduction was then maintained with a 2.0-mm Kirschner wire. The Zanca and axillary views were taken to identify the reduction of the AC joint and no anteroposterior displacement of the clavicle. A guide wire was drilled into the superior surface of the clavicle approximately 3 cm medial to the AC joint. After confirming that the tip of the guide wire was well centred between the medial and lateral edges of the coracoid, drilling was continued to the base of the coracoid. A 4.0-mm drill was then used to ream over the guide wire. Another drill hole was made 2 cm from the distal end of the clavicle [23]. The position of the medial drill was slightly posterior of the superior surface of the clavicle. And the position of the lateral drill was slightly anterior. A depth gauge was used to determine the channel length from the medial drill hole to the base of the coracoid process. An endobutton with appropriate size CL was chosen and five strands of #2 Ethibond suture were placed through the first and fourth holes of the endobutton.

Using a 3.2-mm smooth cylindrical plunger, the endobutton and CL along with its associated sutures, were pushed into the top of the clavicle through the medial drill hole and then pushed further into the coracoid drill hole until it passed through the underside of the coracoid. The loop was pulled up, locking the endobutton onto the underside of the coracoid. Three of the five strands (six tails) of Ethibond sutures were pulled out of the interval between the coracoid and clavicle. This left two strands (four tails) going from the coracoid endobutton exiting the top of the clavicle. When tension was placed on the loop, the very tip of the CL was seen protruding from the top of the clavicular hole. A free endobutton was held with a suture holder and then slid into the protruding loop. The suture tails exiting through the top of the clavicle were passed through the endobutton holes (preferably the second and third holes; Fig. 1). The sutures were tied on top of the endobutton [23]. The suture tails were brought out of the coracoclavicular space and passed through the lateral drill holes. Then, the suture tails were passed through the holes of the free endobutton and tied. This process completed the reconstruction of the coronoid and trapezoid portions of the coracoclavicular ligament (Fig. 1). The Kirschner wires used for temporary fixation of the AC joint were pulled out. The trapezius and deltoid were repaired and the wound was closed with sutures.

Fig. 1 Coracoclavicular ligament reconstruction with triple endobutton technique

Postoperative care and functional exercise

Postoperatively, a sling was applied for three weeks and patients were given instructions for gentle range of passive shoulder motion. Light duties, passive and active assisted range of motion exercises were allowed from four to 12 weeks and full duties resumed after three months. Contact sports were discouraged for six months. Clinical and radiological follow-up was at two, four, eight and 12 weeks and then at six months. Patients were evaluated at the follow-up based on visual analog scores (VAS) and Constant scores. Anteroposterior, axillary and Zanca radiographs views of both shoulders were obtained. The paired *t* test was used to measure statistical differences and *p*-values ≤ 0.05 were considered statistically significant.

Results

In one patient, the endobutton under the coracoid slipped into the drill hole in the coracoid, which resulted in a loss of the anatomical reduction that had been confirmed on radiographs of the involved AC joint on the third postoperative day. Two days later, a second operation was performed to correct the displacement of the endobutton and reduce the AC joint.

At the most recent follow up, the mean follow-up period was 12 months (range, 8–14 months). There were no infections or other type of short-term complications in the series. Anatomical reduction of the AC joint was maintained with no loosening or breakage of the CL and Ethibond sutures and no displacement of endobuttons (Fig. 2). The

Fig. 2 **a** Preoperative anteroposterior view radiograph of a type IV acromioclavicular dislocation (right shoulder). **b** Postoperative anteroposterior view radiograph shows anatomical reduction of the right acromioclavicular joint using triple endobutton technique

mean VAS scores of all patients was 0.2 (range, 0–2) at the final follow-up evaluation. Preoperatively, the score was 5.5 (range, 4–7). There was a statistically significant difference between the preoperative and postoperative pain VAS scores ($t=13.7$, $P<0.0001$). The mean Constant scores were 29.3 (range, 14–39) preoperatively and 91.3 (range, 74–100) at the time of postoperative evaluation. At most recent follow-up, excellent results were obtained in 11 patients (73%) and good in two patients (13%) based on Constant scores. There were also statistically significant differences between the pre- and post-op Constant scores ($t=35.5$, $P<0.0001$).

Two patients (13%) had shoulder pain with limitation of internal rotation and abduction. One of them had slight discomfort with activities of daily living. The other one complained of mild pain during shoulder loading. They also had Constant scores under 80. However, they were symptomatically better than preoperative status. The detailed data of the patients are shown in Table 1.

Discussion

AC joint injuries are one of the most common problems in the athletic population [7]. They account for 3% of all shoulder injuries and 40% of sports-related shoulder injuries [1]. Since Cooper's first description of surgical fixation of AC dislocation in 1861 [5], many techniques, often in combination, have been described to treat AC separations. In many cases, however, optimal clinical outcomes are difficult to achieve.

Surgical treatments using various types of hardware have shown much higher success rates in recent studies [4]. However, many of these techniques have been associated with significant implant-related complications, such as hardware failure, early loosening and intraarticular injury [3, 13]. The use of hook plates for repair of AC dislocations was, until recently, very popular. The main advantages of this technique are that the AC joint is reduced indirectly, the reduction is maintained in all planes and healing is promoted with formation of scar tissue allowing early mobilisation [10]. On the other hand, the technique's disadvantage is evident—it requires a second operation to remove the implant. Furthermore, this technique was usually associated with some complications, such as shoulder pain, subacromial impingement, loosening and unhooking of the plate, limited postoperative range of motion (especially abduction of the shoulder) and fractures distal to the plate [12, 18].

The AC joint is not a rigid joint. Techniques using various forms of hardware fixation have failed to achieve optimal results for exactly this reason. With full overhead elevation, the clavicle rises by up to 35 degrees and rotates

Table 1 Detailed data of the patients

Patient	Age (y)	Cause of injury	Grade of injury (Rockwood)	Days from injury to surgery	Follow-up (months)	Preoperative VAS score	Postoperative VAS score	Preoperative Constant score	Postoperative Constant score	Subjective results	Complications
1	50	Traffic accident	V	3	14	5	0	28	95	Excellent	None
2	33	Traffic accident	III	4	10	7	0	14	82	Good	None
3	39	Traffic accident	V	3	14	7	0	28	95	Excellent	None
4	40	Soccer	III	5	14	7	0	32	100	Excellent	None
5	25	Traffic accident	IV	4	14	4	0	33	100	Excellent	None
6	58	Traffic accident	V	14	12.5	6	0	31	93	Excellent	None
7	33	Traffic accident	IV	4	12.5	6	0	27	93	Excellent	None
8	31	Traffic accident	IV	8	13	7	0	26	89	Good	None
9	29	Traffic accident	V	5	12.5	6	0	33	95	Excellent	None
10	46	Bike accident	V	14	11.5	7	0	25	92	Excellent	None
11	27	Bike accident	IV	5	11.5	5	0	30	93	Excellent	None
12	60	Traffic accident	IV	6	9	4	2	28	74	Fair	Shoulder pain
13	37	Fall	V	6	10	4	0	38	96	Excellent	None
14	66	Fall	IV	12	12	5	0	39	95	Excellent	None
15	30	Fall	V	4	8	5	1	28	78	Good	Shoulder pain

on its long axis by 45 degrees. With adduction and extension, it displaces up to 35 degrees anteriorly and posteriorly [16]. Any form of rigid fixation is therefore non-anatomical and will inevitably impair the range of motion of the AC joint.

The Weaver-Dunn procedure for coracoacromial ligament transfer, first described in 1972, avoids the use of metallic implants and continues to be a popular procedure. However, biomechanical evaluation has demonstrated that acromio-coracoid ligament strength is approximately 75% of normal coracoclavicular ligaments [17], which probably accounts for the high failure rate of this particular technique.

The triple endobutton technique provides reconstruction of the coracoclavicular ligament and biomechanical fixation of the AC joint, thus allowing for normal clavicular rotation. Anatomical studies have shown that the coronoid 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 [19, 20]. Experimental studies have revealed that the two components of the coracoclavicular ligaments have different functions according to the direction and magnitude of the forces applied [6, 14]. The trapezoid ligament provides the major support against compressive loads applied along the axis of clavicle and acts as a secondary restraint to superior translation. The coronoid ligament contributes to both superior and anterior stability [8, 15]. The ideal surgical treatment for complete AC dislocation would separately restore each ligament supporting the AC joint to achieve functionally optimal outcomes. In our study, the location of the drill holes on the top of the clavicle and the orientation of the reconstructed ligaments are selected to correspond to the anatomical attachments of the coronoid and trapezoid ligaments so as to achieve the anatomical reconstruction of coracoclavicular ligament.

Native coracoacromial ligaments can withstand tensile forces of up to 500 Newtons [11]. The metallic buttons can withstand forces in excess of 1,150 Newtons [9]. Thus, the strength and stiffness of the device (CL and 5 strands of #2 Ethibond suture) are much greater than that of the native ligament complex [23]. The deforming forces of the weight of the arm are distributed along the surfaces of the two metal endobutton plates and not the suture material itself, which passes through the holes of the endobutton. This design prevents the sutures from “slicing” through the clavicle when extreme forces are applied [23]. The low profile of the implant minimizes the chance of soft tissue reaction and eliminates the need for a second operation for removal of the implant.

This study evaluated the preliminary results of a triple endobutton fixation technique to treat acute complete AC joint dislocations. In all 15 patients, reduction of the AC joint was achieved as confirmed by radiographs at a mean

follow-up time of 12 months. All patients also continued to report substantial symptom relief and functional improvement. We will continue to follow-up this cohort of patients to define the long-term outcomes of this technique. In addition, future avenues of investigations will include biomechanical testing in a cadaveric model to directly compare this technique with the modified Weaver-Dunn technique. These future studies will allow us to better understand the indication and applications of this approach in patients with acute AC joint dislocations.

Conclusion

Coracoclavicular ligament reconstruction using a triple endobutton technique in acute complete AC joint dislocation may be a reliable technique for restoring stability to the AC joint.

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

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