Minimally invasive double endobutton of coracoclavicular ligament reconstruction for the treatment of acute complete acromioclavicular joint dislocation

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Background
Numerous procedures have been described for the operative management of acromioclavicular (AC) joint injuries. Some of these techniques have focused on anatomical restoration of the coracoclavicular ligaments to achieve optimal clinical outcomes. This report introduces a novel procedure for the reconstruction of complete AC joint dislocation by using double endobutton technique to separately reconstruct the conoid and the trapezoid portions of the coracoclavicular ligament.
The aim of this prospective study was to assess the functional and radiological efficacy of minimally invasive double endobutton of coracoclavicular ligament reconstruction in the treatment of acute complete AC joint dislocation.
Patients and methods
During the period from January 2014 to September 2015, 20 patients with Rockwood types IV and V AC joint dislocation were treated with minimal invasive double endobutton of coracoclavicular ligament reconstruction. The improvement in shoulder functions was assessed using a Constant score and visual analog scale system.
Results
The authors 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. Excellent reduction of the AC joint was maintained. The mean follow-up period was 20.6±5.4 months. The mean Constant scores improved from 25.2±6.6 preoperatively to 92.4 ±6.5 postoperatively, whereas the mean visual analog scale score decreased from 5.9±1.4 preoperatively to 1.2±0.9 postoperatively; significant differences were observed. The final follow-up revealed that excellent outcomes were achieved in 16 (80%) patients and good outcome in four (20%) patients.
Conclusion
Preliminary follow-up results for the patients indicated that the method is a safe, practical, and effective surgical approach for treatment of acute complete AC joint dislocation and significantly relieves pain, effectively improves the function of shoulder, and can be used as an alternative to arthroscopic and open methods for acute complete AC joint dislocations.

Keywords:
acromioclavicular joint dislocation, ligament reconstruction, minimal invasive double endobutton fixation

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Introduction

Traumatic separation of the acromioclavicular (AC) joint is common, particularly in active or athletic young adults, which accounts for approximately 9% of all shoulder injuries [1].

It ranks second only to glenohumeral joint dislocation. The biomechanics of the AC joint involve dynamic stability, static stability, and AC joint motion. Static stability is supplied by the AC, coracoacromial, and coracoclavicular ligaments, whereas dynamic stability is maintained by the trapezius and deltoid muscles [2]. According to the Rockwood classification [3], both static instability and dynamic instability occur in types IV–VI. Therefore, nonoperative treatments are recommended for Rockwood I and II separations; however, there is a discrepancy in the treatment of Rockwood type III [4]. Rockwood IV and above injuries require operative intervention for adequate reduction and stabilization [5].

A gold standard for the reconstruction of the coracoclavicular complex has yet to emerge for the treatment of

separation of the AC joint. Most of the current techniques not only fail to recreate the original anatomy but also do not use materials that are strong enough to maintain the reduction during the healing process. Many techniques are used to treat AC joint dislocations. Techniques using various forms of hardware fixation, such as the hook plate and Bosworth screw, have fallen out of favor because of problems of 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 less compliant than the native ligament, leading to the reported high failure rates [6].

More recently, the double endobutton technique has been described for the treatment of complete AC joint dislocations [7]. 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 two endobuttons (Acufex; Smith and Nephew, British multinational medical equipment manufacturing company headquartered in Watford, England) and five strands of #2 fiberwire suture. We present here the preliminary clinical and radiological results of this technique in patients with acute complete dislocation of the AC joint.

Patients and methods

During the period from January 2014 to September 2015, 20 patients with Rockwood types IV and V AC joint dislocation were treated with coracoclavicular ligament reconstruction combined with double endobutton, Including 15 men and five women, with an average age of 43.6±13.4 years. The study was approved by the institutional ethics committee in the Orthopedic Department of Orthopaedic Surgery, Tanta University, Egypt. The dominant shoulder was involved in 16 patients (80%). The causes were falling injury in 12 cases, road traffic accident injury in four cases, and sports injury in four cases, and all were closed injuries. According to the Rockwood classification, type IV dislocation was found in 11 cases, and type V dislocation was observed in nine cases.

The average time from injury to surgery was 7.3±3.6 days.

Diagnosis of AC joint dislocation relied on physical examination and radiographic inspection.

Clinical signs included swelling of the injured shoulder, tenderness of the AC joint, a positive piano-key sign, a bone rubbing feeling, and limitation of shrug activity.

Radiographic evaluations included anteroposterior radiography of the bilateral AC joint, Zanca view oblique radiography, and an additional stress radiography for the dislocation with unknown classification.

Surgical technique

All patients underwent general anesthesia. The patient lay in a beach-chair position with the head turned away from the injured shoulder. Two small incisions were made—one at the base of the coracoid tip and the other at the anterior edge of the distal clavicle ~4–5 cm medial to the AC joint.

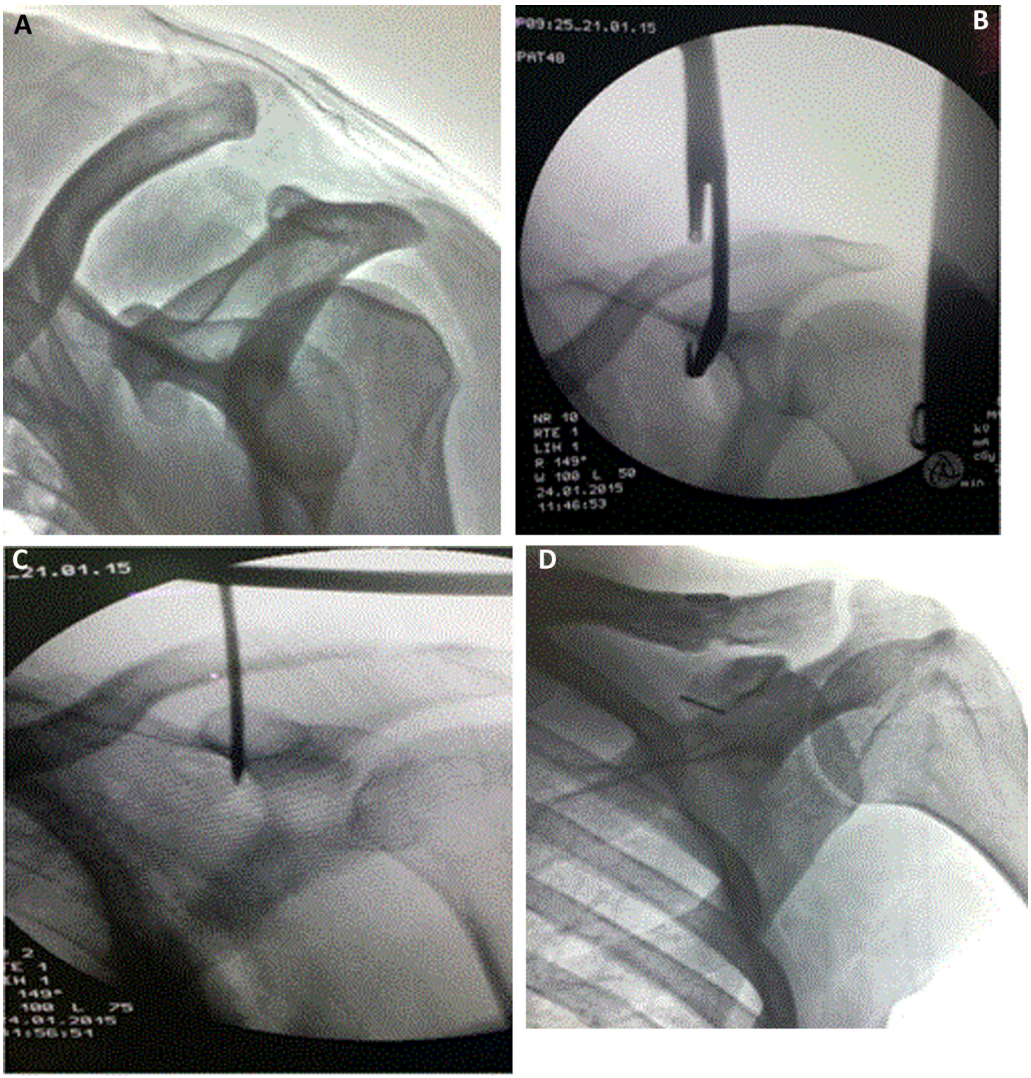
Medial and lateral skin flaps were developed, and the coracoid was identified and cleared off all the way to the base. The medial and lateral edges of the coracoid at the base were clearly identified. Reduction of the clavicle was performed and maintained by using the C-clamp with its target tip being under the coracoid base, and its upper pole centered on the superior surface of the clavicle approximately 3–4 cm medial to the AC joint and midway between the anterior and posterior borders of the clavicle. Reduction was then confirmed under fluoroscopic image intensifier. A drill tip guide wire was then drilled all the way through the clavicle and the base of the coracoid. The C-clamp was then removed leaving the guide wire in place. Then, reduction was maintained manually till 4.5-mm drill was being used to ream over the previously introduced guide wire all the way throughout the clavicle to the base of the coracoid, and the drill should be aimed slightly anteriorly (Fig. 1).

Now two tunnels were developed—one through the clavicle and the other through the coracoid. With a special suture retriever, we passed the suture strains from the coracoid hole to the clavicle hole in a retrograde manner leaving the first endobutton down the coracoid, and then we passed the suture strains again through the holes of another endobutton above the clavicle.

With maintaining the anatomical reduction of the AC joint manually, sutures were being tied and tightened securely.

To resemble the trapezoid portion of the CC ligaments to increase the A/P stability, another 2.5-mm drill hole

Figure 1



(a) Preoperative image of acromioclavicular dislocation grade V. (b) Intraoperative image of the C-clamp maintaining the reduction. (c) Intraoperative image of the guide wire after removal of the C-clamp. (d) Intraoperative image showing two end-buttons one above the clavicle and the other below the coracoid with satisfactory radiological reduction.

Figure 2

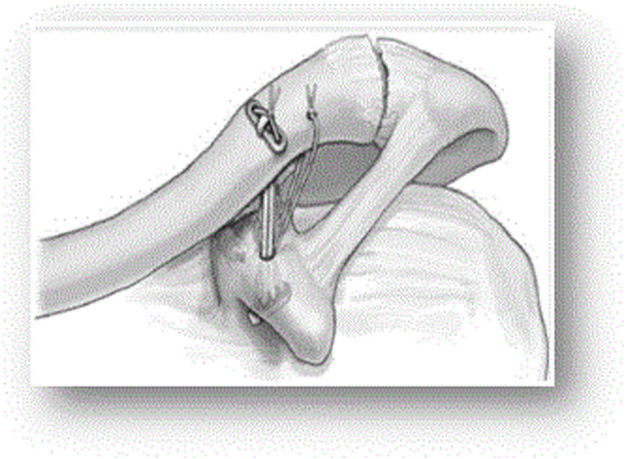


Diagram showing double endobuttons technique for reconstruction of the conoid and trapezoid component of coracoclavicular ligaments.

was placed 1 cm lateral to the Endobutton drill hole, and then the looped strains of fiberwire under the coracoid were pulled out through this hole and tied together (Fig. 2).

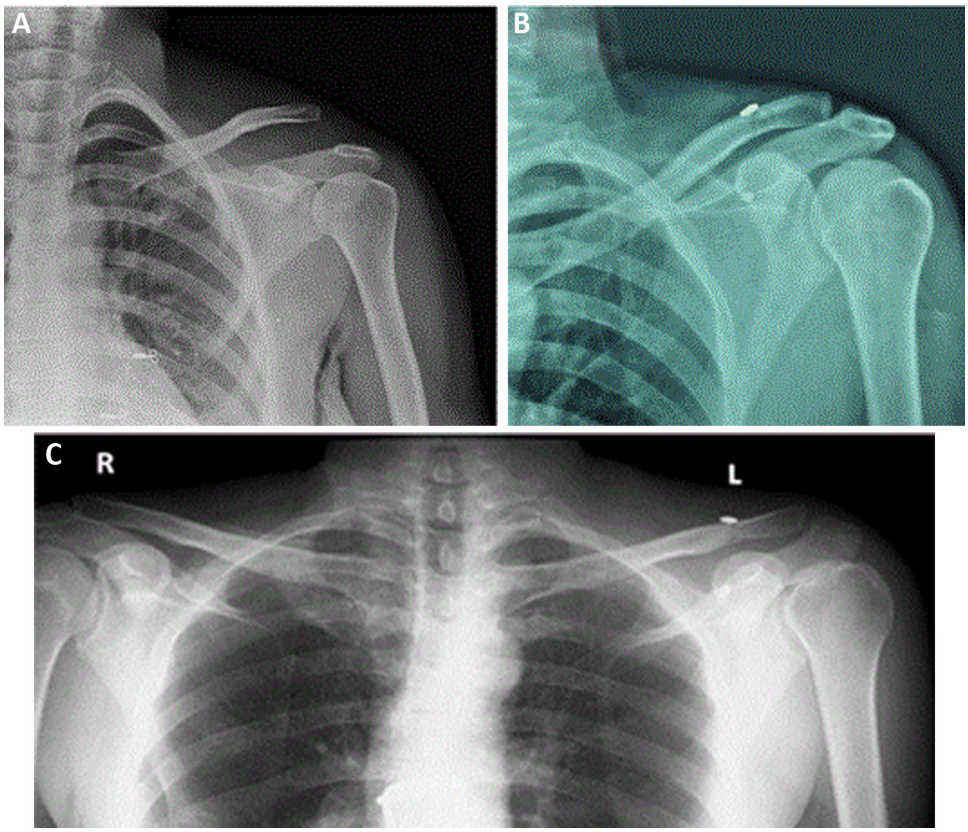
Final reduction was then confirmed under image (Fig. 3b).

Postoperative management

Postoperatively, the patient shoulder was immobilized in a broad arm sling, giving instructions for gentle range of passive shoulder motion as pendulum exercise.

Four weeks later, progressive active exercises of the shoulder were allowed, and daily activities resumed 3 months after surgery, whereas contact sporting activities were permitted after 6 months of surgery.

Figure 3



(a) Preoperative radiography of acromioclavicular dislocation grade V. (b) Immediate postoperative anteroposterior view with good reduction. (c) Comparative anteroposterior view of both shoulders with sufficient reduction after 6 months.

Statistical analysis

All statistical analyses were performed using the paired *t*-test before and after surgery, with a *P* value less than 0.001 considered statistically significant.

The differences in the Constant and visual analog scale scores were tested for statistical significance.

Results

All 20 patients were followed up. The mean follow-up period was 20.6±5.4 months. The final follow-up revealed that excellent outcomes were achieved in 16 (80%) patients and good outcome in four (20%) patients.

The mean Constant scores improved from 25.2±6.6 preoperatively to 92.4±6.5 postoperatively, whereas the mean visual analog scale score decreased from 5.9±1.4 preoperatively to 1.2±0.9; postoperatively; significant differences were observed ($P<0.001$).

During the follow-up period, no complications of infections, or endobutton translation, or coracoid fracture were observed.

Discussion

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° and rotates on its long axis by 45°. With adduction and extension, it displaces up to 35° anteriorly and posteriorly [8]. Any form of rigid fixation is therefore non-anatomical and will inevitably impair the range of motion of the AC joint.

Native coracoacromial ligaments can withstand tensile forces of up to 500 Newtons [9]. The metallic buttons can withstand forces in excess of 1150 Newtons [10]. Thus, the strength and stiffness of the device (CL and 5 strands of #2 Fiberwire suture) are much stronger than that of the native ligament complex [11]. 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 [12]. 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. Extrasuture material that passes through the Endobutton holes can be used to recreate the course of the trapezoid component of the coracoclavicular ligament, thereby adding stability in the anteroposterior plane. In addition, the required drill holes are relatively small (4 mm), allowing the implant to be used as a stand-alone device. Accurate placement of the device is also of paramount importance. The coracoid process should be drilled at its center on the coronal plane and close to the neck where the coracoid gives off the scapula. This area has greater resistance compared with the anterior part of the coracoid, which is important in order to avoid erosion and cephalad migration of the button. In addition, the clavicle tunnel should be drilled halfway between the anterior and posterior border of the clavicle [13–16].

Although there is no long-term study evaluating the effectiveness of this technique, WeiH-F *et al.* 2011 [17] based on second-look arthroscopy findings of biologic reaction around the TightRope device after 6 weeks and 3 months hypothesized that long-term stability may be achieved by scarring the ligament stumps with soft tissue complexes [18].

Minimally invasive approach has better cosmetic results and less-invasive maneuver, which preserves soft tissue, allowing early rehabilitation.

Beris *et al.* [16] conducted a retrospective evaluation of data of eight patients with type III and four patients with type IV AC joint dislocations who were treated with double-button fixation using the miniopen method and the TightRope system. Defoort *et al.* [19] performed open surgical treatment method with double-button fixation. Conversely, Murena *et al.* [20] used arthroscopic CC double-button fixation for type III and IV acute AC joint dislocations. Both authors reported excellent clinical and satisfactory functional and cosmetic results.

This technique does not require arthroscopic experience, and anatomic fixation is achieved.

Furthermore, compared with the open double-button technique, the incision is of a size sufficient for the button to pass over the clavicle, and there is no requirement for a second operation to remove screws, K-wires, or hook plates implanted for fixation. The satisfactory cosmetic results are a significant advantage of this technique. However, it has several disadvantages such as the increased need for use of a C-arm compared with open and arthroscopic methods.

Additionally, when the button system is passed under the coracoid process percutaneously, it may become trapped in the tunnel; if this occurs, the operation must be changed to open method.

The limitations of this study were the lack of arthroscopic double-button fixation groups for comparison, the number of patients included in this study was low, and long-term results were not reported.

Conclusion

In our study, we used a miniopen approach that can effectively restore the AC joint and CC ligament complex anatomy. The endobutton CL material has been shown to have both strength and stiffness in excess of the native anatomy, ensuring a stable reduction. The procedure is simple, has low morbidity, and can be easily adapted to an arthroscopic technique. The percutaneous double-button fixation method is rapid, straightforward, and cost-effective. Moreover, strong results are obtained via this method in terms of low complication rates and high functional recovery rates.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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