A comparison of double Endobutton and triple Endobutton techniques for acute acromioclavicular joint dislocation

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Purpose of the study: The purpose of this study was to evaluate the results of patients treated with either double Endobutton device or triple Endobutton device for acute acromioclavicular joint dislocations.

Patients and methods: Eighty patients were randomized to operative stabilization either by double Endobutton device (group A, 40) or by triple Endobutton device (group B, 40). Preoperative variables included the patients’ age, sex, the affected side, cause of injury, Rockwood classification and time from injury to surgery. Peri-operative variables were incision length, blood loss, the operative time and the radiation time, length of hospitalization and hospital costs. Postoperative variables were complications, the Constant and VAS scores and the ability to return to previous work. The acromioclavicular (CC) distance of the affected shoulder was assessed on a standard radiograph and compared with the contralateral normal one.

Results: The average follow-up time of group A was 26.5 ± 7.3 months and group B was 24.2 ± 6.6 months. The overall complication rate was similar in both groups (26/40 vs. 24/40, P=0.644). There were no significant differences in the mean incision length, blood loss, the operative and radiation time, length of hospitalization, the Constant and VAS scores, and the ability to return to previous work between the two groups. However, the patients of group B had more hospital costs ($3802.5 ± 258.5 vs. $2433.6 ± 182.5 USD, P=0.000). The radiological assessment revealed no significant difference in the CC distance between the two groups (P=0.625).

Discussions: Triple Endobutton technique did not show significant clinical advantages over double Endobutton technique.

Level of evidence: Level II prospective randomized study.

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1. Introduction

There has been an understandable tendency toward anatomical coracoclavicular (CC) ligament reconstruction in the treatment of acute acromioclavicular (AC) joint dislocations [1–7]. The modern approach has been to reconstruct anatomic CC ligament with fixation or a loop at base of coracoid and a biological graft passing through clavicle either through a single drill hole or 2, to mimic the course of the conoid and trapezoid ligament [1,3–5,8,9]. The Endobutton device is one of them. Firstly described by Struhl et al. [1], anatomic ligament reconstruction using the Endobutton device has been proven to be an effective technique for the management of acute AC joint dislocations in both biomechanical and clinical studies [8,10–14]. However, using double Endobutton technique or triple Endobutton technique is still controversial [2,10,15–22]. Although the biomechanical strength of triple Endobutton device is superior to that of double Endobutton device [22], no study has confirmed its clinical advantages over double Endobutton device.

The purpose of this prospective comparative study was to evaluate the radiographic and clinical results of patients treated with either double Endobutton device or triple Endobutton device for acute AC joint dislocations. We hypothesized that triple Endobutton technique had lower rate of rupture, more durable time of coracoclavicular reduction and better radiological and functional outcomes compared with double Endobutton technique.

2. Materials and methods

2.1. Study population and study design

Eighty patients with Rockwood type III–V AC joint dislocation were treated with double Endobutton device (group A, 40) or with
triple Endobutton device (group B, 40) between September 2010 and September 2013 at our hospital. Approval for the study was given by the Ethics Committee and informed consent was obtained from all patients before operation. The inclusion criteria were:

- age 18–50 years;
- acute dislocations (<2 weeks after trauma);
- Rockwood type III patients with higher requirements for functional recovery such as manual laborers and athletes;
- Rockwood IV or V dislocations;
- no osteoporosis;
- all operations performed by the same group of surgeons;
- follow-up time of at least 12 months.

The following patients were excluded:

- open dislocations and old dislocations;
- previous shoulder complaints or surgery;
- combined with nerve or vascular injury;
- associated with vital organs damage;
- associated with fractures and/or dislocation of other parts of the ipsilateral limb.

At admission, type of treatment was randomized by computer allocation and assigned to patients prospectively through sequentially numbered opaque envelopes. There was no significant difference in the preoperative variables between the two groups (Table 1).

2.2. Surgical procedures and rehabilitation

The surgical procedure of double Endobutton technique was similar to that described by Struh et al. [1]. Operations were performed by the same group of surgeons (S.L.J., L.D. and C.H.). An incision was made above the edge of the clavicle and a second incision perpendicular to the clavicle towards the coracoid process (Fig. 1). The clavicle was manually reduced and this reduction was identified under C-arm visualization. A guide wire was drilled into the top of the clavicle approximately 3 cm medial to the AC joint. After confirming that the tip of the wire was 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. A second 2.5-mm drill hole was placed 1 cm lateral to the Endobutton drill hole. The appropriate size Endobutton closed loop (CL) was chosen, and five strands of #2 Ethibond suture were placed through the first and fourth holes of the Endobutton. The Endobutton and CL were inserted first through the clavicle and then the coracoid tunnel using a 3.2-mm smooth cylindrical plunger. The loop was pulled up, locking the Endobutton onto the underside of the coracoid. 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 then slid into the protruding loop. The suture tails exiting through the top of the clavicle were passed through the Endobutton holes. The sutures were tied on top of the Endobutton. Three strands (six tails) of Ethibond sutures were brought out of the coracoclavicular space and passed through the lateral drill holes (Fig. 2). The trapezius and deltoid were repaired and the wound was closed with sutures.

The surgical procedure of triple Endobutton technique was similar to that of double Endobutton technique. The only difference

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**Table 1**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Group A</th>
<th>Group B</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>32.2 ± 12.5</td>
<td>35.6 ± 11.0</td>
<td>0.200</td>
</tr>
<tr>
<td>Sex (male: female, n)</td>
<td>30: 10</td>
<td>25: 15</td>
<td>0.228</td>
</tr>
<tr>
<td>The affected side (left: right, n)</td>
<td>16: 24</td>
<td>14: 26</td>
<td>0.644</td>
</tr>
<tr>
<td>Cause of injury (road accident: fall, n)</td>
<td>28: 12</td>
<td>22: 18</td>
<td>0.166</td>
</tr>
<tr>
<td>Rockwood type (III: IV: V, n)</td>
<td>31: 7: 2</td>
<td>35: 4: 1</td>
<td>0.239</td>
</tr>
<tr>
<td>Injury to surgery time (days)</td>
<td>4.0 ± 3.0</td>
<td>4.5 ± 2.5</td>
<td>0.421</td>
</tr>
<tr>
<td>Follow-up time (months)</td>
<td>26.5 ± 7.3</td>
<td>24.2 ± 6.6</td>
<td>0.143</td>
</tr>
</tbody>
</table>
was that three strands (six tails) of Ethibond sutures were passed through the lateral clavicular hole and the holes of a third Endobutton then tied to reconstruct the trapezoid ligament (Fig. 3).

Postoperative protocol included shoulder immobilization in a sling for 4 weeks followed by progressive range of motion and strengthening exercises. Daily activities are resumed after 3 months and return to sports activities was allowed after 6 months.

2.3. Clinical and radiographic assessment

Clinical and radiological follow-up was at 2, 4, 8 and 12 weeks and then at 6 months and 12 months and finally at the last follow-up. Anteroposterior, axillary and Zanca radiographs views of both shoulders were obtained. Clinical data were collected on age, gender, the affected side, cause of injury, Rockwood classification and time from injury to surgery, complications, time from surgery to return to work and length of follow-up. Incision length, blood loss, the operative time and the radiation time, length of hospitalization and hospital costs were also recorded. The operative time was defined as the time from the skin incision to skin closure and the fluoroscopy time was obtained from the fluoroscopy logger. Heterotopic ossifications within the CC ligaments were also recorded. At the final follow-up, functional assessment was performed by an independent reviewer (WT) using the Constant score [19], and Visual Analogue Scale (VAS) score. The vertical distance between the superior border of the clavicle and the inferior border of the coracoid process (CC distance) was calculated on standard anteroposterior views of the AC joint preoperatively, and at the time of the last follow-up on both shoulders.

2.4. Statistical analysis

Statistical analysis was performed using SPSS software, version 11.0 (SPSS, Inc., Chicago, IL, USA). The patient demographics (sex, injured side, causes of injuries, Rockwood classification and postoperative complications) were compared using the Pearson’s Chi² test for nonparametric categorical variables. Independent sample t-test was used to compare the patients’ age, time from injury to operation, incision length, blood loss, operative time, radiation time, length of hospitalization, hospital costs, duration of follow-up, radiological results, Constant score and VAS score. The level of significance was set at $P < 0.05$.

3. Results

The average follow-up time of group A was $26.5 \pm 7.3$ months and group B was $24.2 \pm 6.6$ months. There were no significant differences in the mean incision length, blood loss, the operative and radiation time, length of hospitalization between the two groups (Table 2). However, the patients of group B had more hospital costs ($3802.5 \pm 258.5$ vs. $2433.6 \pm 182.5$ USD, $P = 0.000$) (Table 2).

The overall complication rate was similar in both groups ($26/40$ vs. $24/40$, $P = 0.644$) (Table 3). No intraoperative neurovascular injury, infection, osteolysis and AC joint osteoarthrosis occurred in both groups. In one patient of group A, the Endobutton under the coracoid slipped into the drill hole in the coracoid, resulting in a redislocation confirmed by radiographs of the involved AC joint on the second postoperative day. Revision was performed 2 days after primary surgery. In group B, coracoid fracture occurred in one patient. Slight loss of reduction ($<50\%$ of the width of the clavicle) was noted in 26 patients (14 in group A and 12 in group B). Obvious loss of reduction ($>50\%$ of the width of the clavicle) was observed in 11 patients (6 in group A and 5 in group B) (Figs. 4 and 5). No secondary surgical intervention was performed for the loss of reduction and also it had no impact on their functional outcomes. Heterotopic ossification was seen in 5 patients of group A and 6 patients of group B, but it did not cause loss of motion or other symptoms.

At the most recent follow-up, the mean Constant score was 93.5 points (range: 74–100) in group A and 93.1 points (range: 70–100) in group B. The VAS score averaged 0.2 points (range: 0–2) in group A and 0.2 points (range: 0–2) in group B. Twenty-nine patients in group A stated that they were very satisfied with the results of the surgery, 9 were satisfied, and 2 patient was partly satisfied. In group B, 31 patients stated that they were very satisfied with the results of the surgery, 8 were satisfied, and 1 patient was partly satisfied. All patients returned to their former work at a period of 6 months after surgeries. The clinical outcomes, when comparing Constant score ($P = 0.595$), VAS score ($P = 1.000$) and subjective results ($P = 1.000$), were no significant differences between the two groups (Table 4).

The mean final CC distance was $12.5$ mm (range: 11.4–22 mm) in group A in comparison with $12.1$ mm (range: 11.2–23 mm) in group B. The radiological assessment revealed no significant difference in the CC distance between the two groups ($P = 0.625$) (Table 4).

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Comparison of peri-operative variables between two groups.</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Group A</td>
</tr>
<tr>
<td>Incision length (cm)</td>
<td>7.2 ± 2.0</td>
</tr>
<tr>
<td>Blood loss (ml)</td>
<td>45.5 ± 8.0</td>
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<tr>
<td>Operative time (min)</td>
<td>48.0 ± 6.8</td>
</tr>
<tr>
<td>Radiation time (sec)</td>
<td>145 ± 4.2</td>
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<tr>
<td>Length of hospitalization (days)</td>
<td>5.8 ± 2.6</td>
</tr>
<tr>
<td>Hospital costs (USD)</td>
<td>2433.6 ± 182.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Comparison of postoperative complications between two groups.</th>
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</thead>
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<td></td>
<td>Group A</td>
</tr>
<tr>
<td>Coracoid fracture</td>
<td>0</td>
</tr>
<tr>
<td>Redislocation</td>
<td>1 (2.5%)</td>
</tr>
<tr>
<td>Loss of reduction</td>
<td>14 (35%)</td>
</tr>
<tr>
<td>Obvious</td>
<td>6 (15%)</td>
</tr>
<tr>
<td>Heterotopic ossification</td>
<td>5 (12.5%)</td>
</tr>
<tr>
<td>Total complications</td>
<td>26 (65%)</td>
</tr>
</tbody>
</table>
Fig. 4. a: a 55-year-old man with Rockwood type V right acromioclavicular joint dislocation; b: the second day after operation X-ray film showed a good reduction of acromioclavicular joint; c: three months after operation X-ray film showed a loss of reduction of the acromioclavicular joint.

Fig. 5. a: a 46-year-old women with Tossy type III left acromioclavicular joint dislocation; b: the second day after operation X-ray film showed a good reduction of acromioclavicular joint, but the Endobutton plate under the coracoid tilted to the inside; c: two months after operation X-ray film showed a loss of reduction of the acromioclavicular joint and the Endobutton plate under the coracoid tilted to the inside and upper.

Table 4
Functional and radiological results of both groups.

<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
<th>P</th>
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<tbody>
<tr>
<td>Constant</td>
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<tr>
<td>Preoperative</td>
<td>32.3 ± 6.5</td>
<td>33.0 ± 7.0</td>
<td>0.644</td>
</tr>
<tr>
<td>Postoperatively</td>
<td>93.5 ± 3.2</td>
<td>93.1 ± 3.5</td>
<td>0.595</td>
</tr>
<tr>
<td>VAS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>5.7 ± 1.2</td>
<td>5.8 ± 1.4</td>
<td>0.733</td>
</tr>
<tr>
<td>Postoperatively</td>
<td>0.2 ± 0.1</td>
<td>0.2 ± 0.2</td>
<td>1.000</td>
</tr>
<tr>
<td>CC distance (mm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>20.5 ± 3.6</td>
<td>20.8 ± 3.3</td>
<td>0.699</td>
</tr>
<tr>
<td>Postoperatively</td>
<td>12.5 ± 3.0</td>
<td>12.1 ± 4.2</td>
<td>0.625</td>
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<tr>
<td>Subjective results</td>
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<tr>
<td>Excellent</td>
<td>29</td>
<td>31</td>
<td>1.000</td>
</tr>
<tr>
<td>Good</td>
<td>9</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Fair</td>
<td>2</td>
<td>1</td>
<td></td>
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</table>

4. Discussion

This is the first clinical study to compare double Endobutton and triple Endobutton techniques for acute acromioclavicular joint dislocation. This series has the advantage of prospective randomized nature and use of validated outcome measures. We found no significant differences in the mean incision length, the operative and radiation time, blood loss, length of hospitalization between the two groups. It is because most surgical procedures of double and triple Endobutton technique were the same. However, due to the additional use of an Endobutton plate, the hospitalization cost of triple Endobutton group thus increased significantly.

Regardless of using double or triple Endobutton technique, loss of reduction was still the most common complication. We found that the loss of reduction rate in our study was higher than the rate reported in the previous literature [8,14,21,23,24]. However, previous literature did not report the cases of slight loss of reduction, only reported the cases of complete loss of reduction (obvious loss of reduction). The rate of obvious loss of reduction in our study was close to their rates of obvious loss of reduction [8,14,21,23,24]. The possible reasons for loss of reduction were as follows.

First, the clavicular and coracoid bone tunnel malposition might be the main contributing factor. Cook et al. [25] found a significant impact of the clavicular bone tunnel position on the failure rate after CC ligament reconstruction with two clavicular bone tunnels. Higher peak loads to failure for centre–centre and centre–medial drilling of the coracoid bone tunnel in cortical button reconstructions were also reported [15,26]. In surgery practice, we found that the accuracy of drilling coracoid tunnel was relatively poor. In the mini-open operation, surgeons experience played a very important role in determining the correct position of drilling coracoid hole. Additionally, failure of the reconstruction was also likely to occur due to misplacement of the Endobutton plates. The failure rate was higher if coracoid plate was not parallel to the subcoracoid or not perpendicular to clavicular plate [15]. In our institution, one case of redislocation performed surgical revision because the plate under the coracoid was not parallel to the subcoracoid and slipped into the coracoid hole. Besides, loss of tension of the device was associated with more this complication. Unreasonable choosing the length of the loop and clavicular osteolysis under the superior flip button
could lead to looseness of Endobutton. Finally, too early passive and active motion would induce the loss of reduction. Shoulder pain in most patients subsided significantly at 1 month after surgery, and the patient activity would correspondingly increase. At this time the ligament often had not achieved completely healing, and repeated stress stimulation might enhanced the risk of loss of reduction. Moreover, anatomic position of the conoid ligament might be more important than the anatomic position of the trapezoid ligament for maintenance of reduction. The conoid ligament was the most important structure resisting superior translation and the trapezoid ligament contributed only 15% of the total resistance to superior translation [25,26]. Even using an extra Endobutton plate to reconstruct the trapezoid ligament, it was not much use maintaining a reduction. As a result, triple Endobutton technique might not reduce the incidence of loss of reduction. From our past practice, we also believed that the main cause of loss of reduction was determined by surgical technique, rather than by the number of Endobutton plates. Cocaroid fracture and hardware migration also had been reported frequently [14,20,21]. However, only two patients in our group appeared these complications. Skilled surgical techniques were important for reducing these complications. Ossification also was a relatively common complication, but there was significant variation among the different studies ranging from 0% to 85% [12,18,21]. The specific reasons of its formation have not yet been learned.

The reported mean Constant scores of double Endobutton technique ranged from 61 to 100, the mean VAS scores ranged from 0 to 2 and the subjective result was 95–100% [8,12,15,18]. The reported mean Constant score of triple Endobutton technique ranged from 60 to 100, postoperative pain VAS scores ranged from 0 to 2.7 and the subjective result was 93.3–100% [10,11,17,22]. The functional scores of our study were all within the scope of the data reported in the previous literature [8,10–12,15,17,18,22]. The clinical outcome and the radiological assessment both revealed no significant difference between the two groups.

The limitations of the present study were that:

- this was a single center study, which enrolled only a small number of patients. To further convince these results, high quality randomized controlled trials with larger sample size were still needed;
- although patients were allocated randomly to either surgical group, it was impossible to perform blindness to both the surgeon and patients, which might influence the results;
- this study contained more type III dislocations and only a small number of type IV and V dislocations. Thus it was difficult to fully know whether these results and conclusions could be extrapolated to higher levels of dislocations;
- another limitation of the study was the short follow-up period.

5. Conclusion

Both triple Endobutton technique and double Endobutton technique were efficient methods with few complications for treating AC joint dislocations. Triple Endobutton technique did not show significant clinical advantages over double Endobutton technique. Our results provided surgeons some suggestions on how to choose different Endobutton techniques for acute acromioclavicular joint dislocation.

Disclosure of interest

The authors declare that they have no competing interest.

References