Outcome of Acute Acromioclavicular Dislocation Surgery by Modified Weaver-Dunn Technique

Abstract
Background: Weaver-Dunn technique is one of the common methods for treatment of acute acromioclavicular joint (ACJ) dislocation. Several modifications of this technique have been already described. Because of shortcomings of the previous modifications and due to the importance of keeping coracoacromial ligament (CAL) intact, we report the preliminary results of a new modification to this technique.

Methods: Fifteen patients with acute ACJ were enrolled in the current study. In the modified surgical technique, the medial half of CAL was dissected from the bone and passed through a hole made in the clavicle bone and tied on itself. Preoperative CC distance, constant score and UCLA were compared with those of the last visit. Pain intensity was measured using visual analogue scale (VAS). The patients were followed for 4.2±2.6 years.

Results: Preoperatively, CC distance of the injured side was significantly greater than the non-injured side (19.5±1.6 mm vs. 7.1±0.5 mm; p<0.001). At the last visit, CC distance of the operated side was insignificantly greater than the healthy side (8.2±0.9 mm vs 7.1±0.5 mm; p=0.318). Mean constant score was 93.3±13.2 and 95.1±10.8 in operated and healthy shoulders, respectively (p=0.118). UCLA averaged 32.6±3.3 and pain intensity 1.4±0.8.

Conclusion: Treatment of acute ACJ dislocations using the proposed modified Weaver-Dunn technique is associated with favorable outcomes, while it preserves joint stability and function.

Keywords: acromioclavicular joint, dislocation, coracoacromial ligament, Weaver-Dunn technique

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Introduction

Acute acromioclavicular joint (ACJ) injuries are common problem that involves more than 12% of shoulder injuries\textsuperscript{(1,2)}. ACJ injuries can range from a simple sprain with very mild to severe dislocation and facial rupture, rupture of the coracoacromial ligament (CC) or ACJ, and consequent severe shoulder dysfunction\textsuperscript{(3)}. In recent years, various causes have led to significant increase in the prevalence of these injuries. The most common mechanism of ACJ injury is falling on the shoulder with the arm in adduction\textsuperscript{(4)}.

The purpose of ACJ dislocation treatment is returning the patient’s activity level to pre-injury level with a strong, painless, and mobile shoulder joint; joint reduction and restoration or CC ligament restoration is part of the treatment\textsuperscript{(4,5)}. In type I and II injuries, non-surgical treatments and in type IV-VI injuries, surgical treatment is used. This is while the appropriate treatment for type III injuries is controversial\textsuperscript{(6)}. In a study in 2013, Beitzel and colleagues stated that more than 150 different surgical techniques have been introduced for treatment of ACJ injuries\textsuperscript{(7)}. Despite all studies addressing ACJ injuries treatment, the ideal treatment approach is still controversial\textsuperscript{(4)}.

One of the commonly-used techniques with favorable outcomes is the one introduced by Weaver and Dunn in 1972, which includes removal of distal clavicle and coracoacromial ligament displacement\textsuperscript{(8)}. 
One of the commonly-used techniques with favorable outcomes is the one introduced by Weaver and Dunn in 1972, which includes removal of distal clavicle and coracoacromial ligament displacement\(^{(8)}\). Since the introduction of Weaver-Dunn technique, several modifications have been suggested to this technique, each with its own advantages and disadvantages that usually involve using coracoclavicular stabilizer\(^{(1,9,10)}\). Although these methods are associated with favorable results, various studies have shown very low efficacy of Weaver-Dunn technique compared to healthy CCL, with various problems such as laxity, especially in the sagittal plane\(^{(11-16)}\). In the present study, we will introduce a new modification to this technique, in which part of these ligaments remain intact, and we assume that this method will improve joint stability and patients’ function. In addition, we examined the short term treatment results of patients with ACJ dislocation by this method.

**Methods**

In this case series, all type III and V patients in senior surgery service (FL) with acute ACJ dislocation during 2007 to 2013 at Akhtar Hospital treated with this technique were investigated, if they had the eligibility criteria of the study and signed the written informed consent. In this study, simple and non-random sampling method was used and according to the new surgical method, the sample size was considered at 15 patients. It is noteworthy that none of the patients suffered from coinciding damages, such as humerus fracture. Initially, patients with ACJ injuries following trauma were explained about the study objectives and implementation. Those who were willing to participate in the study were asked to sign a written informed consent form. Patients underwent physical examination and their demographic information such as age, sex, and mechanism of injury were recorded. Then radiographic evaluations were done. To do this, using weight, stress was induced to ACJ for a stress-induced radiograph in bilateral anteroposterior view. In these images, the distance between the tip of coracoid to the lower surface of clavicle bone was measured (CC distant). Then the patients underwent surgery.

**The modified Weaver-Dunn surgical technique**

First, a C-shape cut was created (transverse, skin, or rotation toward the coracoid). This cut began a bit outside acromioclavicular joint and extended to the lateral one-third of clavicle bone. Then, the cut was continued in a curve shape up to coracoid (Robert approach). A small part of the anterior deltoid was separated from the clavicle and the ruptured coracoclavicular ligament and healthy coracoacromial ligament is exposed. Of course, in ACJ type 5, CAL may also be torn. Then half of the medial CAL segment of the acromion was removed, while care must be taken not to damage the coracoid adhesion. The separated ligament was made cylindrical by Krakow method with fiber suture thread No. 2 (2 mm fiber suture). Subsequently, a 3.2 mm drill head was used to create a hole on superior clavicle towards inferior, lateral to CAL attachment site, and then enlarged with a 4.5 mm drill head. Threads were passed from the created hole from inferior to superior. Clavicle and CAL were mounted and fixed with two 2 mm K-wire pins. The fiber thread was pulled so that the ligament entered the hole and was knotted on it. Then, deltoid and ACJ joint capsule were restored. The skin and the underlying skin are sewn. The limb was placed pendant for 4 weeks. Then pendulum and circulatory movements began on the pendant, after 6 weeks pins were pulled out at outpatient clinic, and physiotherapy was started.

After surgery, standard rehabilitation was performed for the patients. Patients referred to the hospital three months later for final evaluations. At this stage, the constant and
UCLA questionnaires were completed for all patients to evaluate the functional treatment outcome. Patients were asked to express their pain intensity and satisfaction with the results of the treatment using visual analogue scale (VAS). In addition, stress-induced radiography was performed to measure CC distant. It is noteworthy that CC distant was calculated proportional to the healthy side to give a more realistic view towards ACJ position. Also in the final visit, the joint was evaluated in reduction position in radiography. Finally, the data were analyzed statistically. Quantitative data were presented as mean ± SD and qualitative data were presented by numbers and percentages. To compare the data before and after treatment, paired t-test or Wilcoxon tests were used. McNemar test was used to compare qualitative data before and after treatment. All analyses were performed using SPSS ver.16 statistical software. In this study, p<0.05 was considered as the significant level.
In this study, a total of 15 patients with acute ACJ dislocation were investigated. The mean age of the patients was 34.6±10.2 years and all patients were male. Of these, the injury was grade III in 2, and grade V in the rest. It should be noted that two patients who suffered from grade III injury were professional athletes. Patients were followed for on average of 4.2±2.6 years.

The results of CC distant measurement are presented in table 1. Based on this table, CC distance before surgery was significantly higher than the healthy side. In postoperative assessments, the distance was less in the injured side than the healthy side, but the difference between the two sides was not significant. In fact, some overcorrection took place during surgery. In final evaluation, it was observed that CC distance increased slightly, but the difference between the two sides was not significant. Thus, in the final visit, acceptable modifications were made in all patients.

In the final visit, the mean constant score was 93.3±13.2 on the operated side and 95.1±10.8 in the healthy side, but the difference between two sides was not significant (p=0.118). Also, the mean UCLA score was 32.6±3.3 and the mean pain based on VAS was 1.4±0.8 and none of the patients needed analgesic. Fortunately, there was no cases of complications in this study.

### Table 1. Comparison of the results of CC distance before surgery, immediately after surgery and at final visit

<table>
<thead>
<tr>
<th>Measure</th>
<th>Healthy side (mm)</th>
<th>Injured side (mm)</th>
<th>P-value</th>
<th>Ratio of CC distance of the injured side to the healthy side (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before surgery</td>
<td>7.1±0.5</td>
<td>19.5±1.6</td>
<td>&lt;0.00</td>
<td>274.6±48.1</td>
</tr>
<tr>
<td>Immediately after surgery</td>
<td>6.9±0.8</td>
<td>97.1±19.3</td>
<td>0.53</td>
<td></td>
</tr>
<tr>
<td>Final visit</td>
<td>8.2±0.9</td>
<td>115.4±21.2</td>
<td>0.318</td>
<td></td>
</tr>
</tbody>
</table>

The most significant finding of the present study was that treatment of acute ACJ dislocation with the technique presented in this study can be associated with favorable and satisfactory short term results.

So far, various techniques have been introduced to treat acute ACJ dislocation, which makes it difficult to compare the results and to select the preferred method. The desirable method for treating ACJ dislocation should have five features: complete and anatomic joint reduction, restoration or reconstruction of coracoclavicular ligament, protecting the reconstructed ligament during the healing process, repairing the injuries of deltoid or trapezial fascia and removing the distal end of clavicle in cases with evidence of acute ACJ.\(^{5,17}\)

Typically, there are four methods for treating ACJ dislocation, each with its own advantages and disadvantages, and multiple modifications. One of the most commonly used techniques, presented by Weaver and Dunn, is a non-anatomical method, in which the distal end of the clavicle is cut and extracted, and the...
The coracoacromial ligament is transmitted to the end of clavicle to play the role of coracoclavicular ligament\(^\text{(18)}\).

Several biomechanical and clinical studies have shown that reconstitution of coracoclavicular ligament is more effective than ligamentous imbrication, non-anatomical repair or reconstruction, such as the Weavar-Dunn technique, and these methods do not result in favorable long-term results\(^\text{(18-21)}\). The CCL reconstruction using CAL (Weaver-Dunn’s procedure) seem insufficient for ACJ fixation, and the joint may have laxity at all planes \(^\text{(11,12)}\). It has been shown that CAL is biomechanically (strength and stiffness) much weaker than CCL\(^\text{(13,14)}\). In biomechanical studies, Mozzaka et al., Motamedi et al., and Costic et al. have shown that the CAL transmitted in the Weaver-Dunn technique only restores 25-30% of the biomechanical strength and 10% of the stiffness of the healthy CC ligament, and failure occurs mainly at CAL connecting sutures to clavicle\(^\text{(14-16)}\).

On the other hand, placing clavicle in a non-anatomical condition and sacrificing CA ligation can cause various problems\(^\text{(4)}\). Extraction of distal clavicle and coracoid-based transfer of CA ligament may move clavicle to anterior\(^\text{(22)}\). In a study by Deshmukh and colleagues in 2004, it was observed that ACJ laxity was significantly higher in sagittal plate, after restoration by Weaver-Dunn technique, than healthy ACJ, and this could explain the high loss of “reduction” in these patients\(^\text{(11)}\). In another study in 2009, Tauber and colleagues argued that the anatomical characteristics of CAL lead the distal end of the clavicle move to anterior and inferior after the transfer\(^\text{(13)}\).

Many researchers have proposed different modifications to Weaver-Dunn technique, which use several methods for CAL augmentation on clavicle. In the modified Weaver-Dunn technique, usually the distal clavicle’s excision and CAL transfer with augmentation of the ligament transferred is performed by circlage wire, screw, fascialata autograft, or synthetic grafts such as Gore-TEX, Dacron, carbon fiber and polyester\(^\text{(1, 9, 10, 22-30)}\). Although modified Weaver-Dunn technique had favorable results\(^\text{(23, 24, 31, 32)}\), it should be noted that newer techniques are not complication-free, and cases of loss of “reduction” have been reported and in some studies\(^\text{(33-35)}\).

Nevertheless, several studies have compared Weaver-Dunn’s modifications with other methods, which had interesting results. Hegazy et al. recently compared the modified Weaver-Dunn technique and the anatomical reconstruction of ACJ using the tendinous toxic autograft and stated that after about 28 months, significantly higher Oxford Shoulder Score and Nottingham Clavicle Score in the autograft group\(^\text{(1)}\). Michlitsch and colleagues also reported similar results in 2010 and stated that reconstructing ACJ with free tissue graft provides higher stability compared with the modified Weaver-Dunn technique, comparable to healthy ACJ \(^\text{(10)}\). Also, Beitzel et al. and Kumar et al. showed that reconstruction with synthetic ligaments compared to the modified Weaver-Dunn procedure are associated with better clinical and biocompatible properties\(^\text{(31,32)}\).

The idea of choosing this surgical procedure for treatment of ACJ had two clear reasons. The first reason is that the initial ligament repair in injuries to other joints (knees, wrists) is often unsuccessful and reconstitution of ligament is recommended. Secondly, with regard to the issues presented, we decided to introduce a new modification to Weaver-Dunn procedure to improve the treatment outcomes of this method and to resolve its problems and limitations. The most important part of the present technique was that there is no need to completely dissect the coracoacromial ligament, which does not completely eliminate the function of this ligaments and, as noted above, the function of these ligament plays an important role in proper functioning of the shoulder joint. In the present study, CC distant significantly increased (274.6%) before surgery, which decreased significantly in the
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The findings of this study showed that treatment of patients with acute dislocation of acromioclavicular with modified Weaver-Dunn technique, with incomplete dissection of coracoacromial ligament, can be associated with favorable clinical, radiological and functional outcomes. With this method, the joint stability is maintained and its function is restored.

Conclusion

The findings of this study showed that treatment of patients with acute dislocation of acromioclavicular with modified Weaver-Dunn technique, with incomplete dissection of coracoacromial ligament, can be associated with favorable clinical, radiological and functional outcomes. With this method, the joint stability is maintained and its function is restored.
References