

Coracoclavicular Ligament Suture Augmentation with Anatomical Locking Plate Fixation for Distal Clavicle Fracture

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Background: For Neer type IIB fracture of distal clavicle with coracoclavicular ligament injury, various surgical treatments have been used in literatures. However, there was no consensus on the optimal treatment. The aim of this study is to report the clinical and radiological results of open reduction and internal fixation of unstable distal clavicle fracture and suture augmentation of disrupted coracoclavicular ligament.

Methods: A prospective study was performed in 23 patients with Neer type IIB distal clavicle fracture in Seoul Medical Center, Eulji Hospital, and National Medical Center. Firstly, suture anchors are inserted in the base of coracoid process and preliminary reduction was achieved by tie-off of three suture limbs around the clavicle. Then, the final fixation was completed with anatomical locking plate. Bony union and the distance between coracoclavicular ligaments were evaluated. Clinical results and complications including stiffness and secondary procedures were evaluated.

Results: Bony union was achieved in all cases except one (22 of 23). At mean 14.9 months, no significant difference in the mean coracoclavicular distance was observed compared to uninjured shoulder (8.2 ± 7.9 mm versus 7.3 ± 3.4 mm, $p=0.14$). Pain visual analogue scale, American Shoulder and Elbow Surgeons score, Constant score, and Disabilities of the Arm, Shoulder and Hand score were 0.5, 83.4, 78.5, and 6.2, respectively. Revision surgery was performed in one case of nonunion. Four patients who complained of skin irritation underwent implant removal.

Conclusions: In cases of an unstable distal clavicle fracture with coracoclavicular ligament disruption, satisfactory clinical results were obtained by locking plate fixation and coracoclavicular ligament suture augmentation concurrently.

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Key Words: Shoulder fractures; Clavicle; Plate; Coracoclavicular joint

Introduction

Clavicle fractures account for 2.6% of all fractures and this means an annual incidence rate of 64 per 100,000 populations.^{1,2} In particular, distal clavicle fracture represents approximately 10 to 15% of all clavicle fractures.³ Of these, especially, Neer type IIB clavicle fracture is inherently unstable because coracoclavicular (CC) ligament injury is accompanied, and high nonunion or malunion rate of more than 20% after nonoperative

treatment has been reported.^{1,4} Therefore, surgical treatment is generally considered for Neer type IIB clavicle fracture.^{3,5}

Various surgical procedures for the treatment of this have been reported and in recent years. Treatment options include transacromial K-wires,⁶ temporary CC screw fixation,⁷ tension band suturing,⁸ and arthroscopic stabilization.⁹ The procedure using a hook-plate¹⁰⁻¹² or an anatomical locking plate has been increasingly used.¹³ However, each of these techniques come with specific benefits and disadvantages or complication such as

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non-union, implant failure,¹⁴⁾ pin migration,⁶⁾ bony defects and subacromial impingement.¹⁰⁾ A consensus has not been achieved yet on the issue of optimal surgical technique for Neer type IIB clavicle fracture.

Small distal fragment often precludes adequate screws purchase, which is the case in old-aged patients with osteoporosis.¹⁵⁾ Furthermore, superior displacement of medial fragment by muscle action is aggravated by disrupted CC ligament.¹⁶⁾ We postulated that a small distal fragment can be fixed with a locking plate and superiorly displacing force by disrupted CC ligament can be successfully neutralized with use of suture augmentation. Accordingly, the purpose of this study is to report the clinical and radiological results of open reduction and internal fixation of unstable distal clavicle fracture and suture augmentation of disrupted CC ligament.

Methods

Patient Collection

From March 2011 to December 2012, a prospective study was performed in the patients, who need surgical treatment, with an unstable distal clavicle fracture by using in three different hospitals. For the radiographic evaluation, an antero-posterior radiograph and a lordotic view of the clavicle were taken. The inclusion criteria was acute type IIB distal clavicle fractures according to the Neer classification and we excluded the patients

who had damage on the ipsilateral upper extremity, a history of fracture or surgery in the ipsilateral shoulder joint, other medical problem or poor general condition that are inevitable to delay surgery for clavicle injuries. During the study period, 23 patients who meet the criteria were analyzed (19 men, 4 women; mean age 48 ± 25).

This Study was approved by the Institutional Review Board of Seoul Medical Center (Seoul MC IRB study number assigned: 2012-028).

Surgical Technique

All patients received CC ligament suture augmentation and internal fixation of fracture with a locking plate. The surgery was performed by three different surgeons. However, anesthetic and surgical techniques, and post-surgical rehabilitation were equally provided to all patients. The patient was placed in beach chair position for the surgery under general anesthesia. The standard sabre-cut or transverse incision was made on the site of a distal clavicle fracture and the fracture site was exposed. After the fracture site was confirmed, the dorsal surface of coracoid process base was exposed in order to perform CC ligament suture augmentation. We used 2 methods for CC ligament fixation. Firstly, the temporary reduction on the fracture site was achieved by manual reduction and the sling procedure was performed using #2 Ethibond (Ethicon, Somerville, NJ, USA) looped around the coracoid process and tied over a clavicle. Another method was

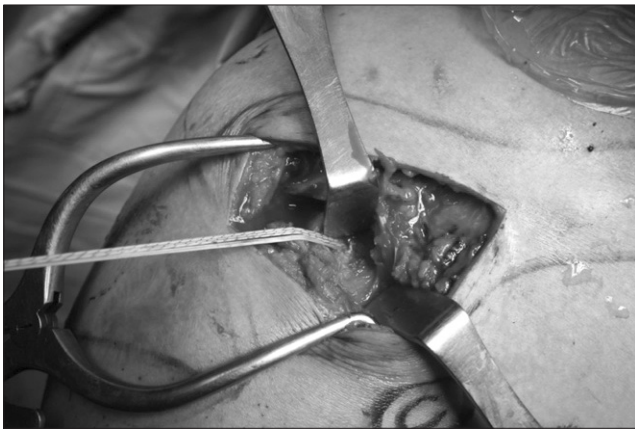


Fig. 1. Photograph taken after insertion of triple loaded suture anchor into the basal part of coracoid process.

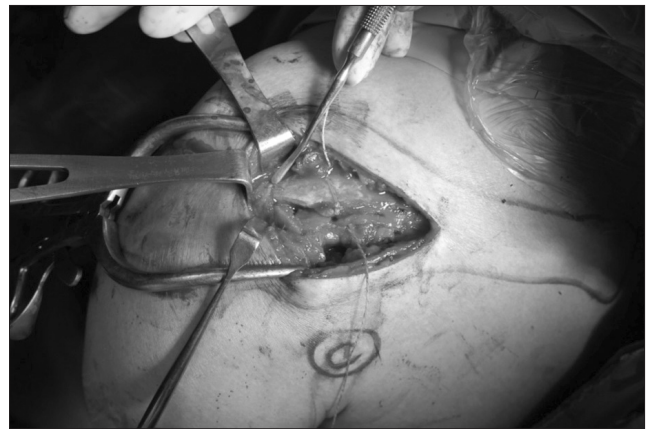


Fig. 2. Sutures was looped around a clavicle and tied off in maintaining the reduction of a medial fragment of the clavicle.

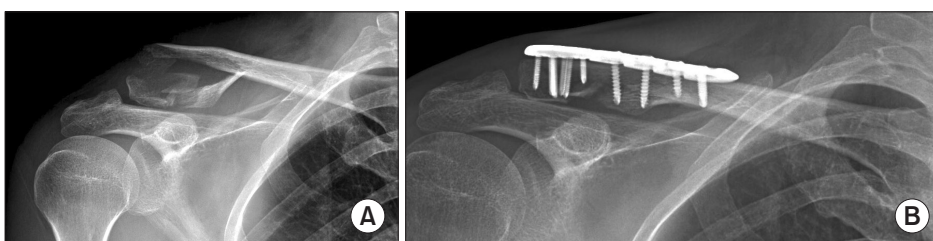


Fig. 3. (A) Preoperative radiograph of unstable distal clavicle fracture. (B) Radiograph showing final application of anatomical locking plate and suture augmentation.

that of using suture anchor. The 4.5-mm bio-absorbable screws (CrossFT suture anchor; ConMed Linvatec, Largo, FL, USA) loaded with three strands of suture was inserted into the basal part of coracoid process (Fig. 1). Sutures was looped around a clavicle and tied off in maintaining the reduction of a bone fragment (Fig. 2). The small distal fragment was fixed using 3.5-mm locking compression Clavicle Shaft Plate (Synthes, Paoli, PA, USA) and locking screw which were designed to fit for the anatomical shape of the distal clavicle (Fig. 3) after the final confirmation of anatomical reduction of fracture.

Rehabilitation

After the surgery, the surgery site was protected by wearing a sling for approximately 3 weeks. Range of motion (ROM) exercise of finger and wrist was permitted right after the surgery. Scapular stabilizing exercise and elbow flexion/extension exercise were allowed to perform intermittently. Three weeks after the surgery, sling was taken off and the patients started performing passive ROM exercise. As recovering passive ROM, active ROM exercise and strengthening exercise were performed gradually.

Evaluation

At final follow-up, the bony union was evaluated and the CC distance in both injured and uninjured shoulder was measured by radiographic examinations. For the radiographic evaluation, an antero-posterior radiograph and a lordotic view of the clavicle were taken. For analyzing the period of bony union, we defined the bony union as the period when there was no pain at the fracture site and callus formation was observed on three sides among 4 sides of cortical bone.⁴⁾ The CC distance was defined as measuring the shortest distance between the

peak of coracoid and the lower boundary of clavicles.¹³⁾ Clinical results were evaluated by visual analogue scale score for pain (PVAS), American Shoulder and Elbow Surgeons (ASES) score,¹⁷⁾ Constant score,¹⁸⁾ Disabilities of the Arm, Shoulder and Hand (DASH) score,¹⁹⁾ and ROM of the shoulder joint. Moreover, we assessed the presence of complications during the surgery or the postoperative period. We additionally investigated whether any secondary surgery, including implant removal, was performed or not due to any reason. In order to confirm the clinical results of patients who did not visit the hospital after the union was achieved, we called them at least one year after the surgery and questioned about PVAS, ASES score and any other discomfort. In this process, we recommended the patients, who complained of discomfort, to see a doctor for re-examination. It was impossible to evaluate ROM objectively because the patients mostly did not visit the hospital 3 months after the surgery. However, we intended to figure out it even indirectly using the notion of patient defined stiffness and performed the telephone survey. The patient defined stiffness is a clinically more reliable method and its criteria are not a threshold system on physical examinations by the inspector but the discomfort that the patient feels during ROM exercise.²⁰⁾ Patients were questioned whether they had the discomfort during ROM exercise after their surgery and we regarded that the patients have postoperative stiffness if they complained of it.

Statistical analysis was performed using PASW Statistics ver. 18.0 (IBM Co., Armonk, NY, USA) and *p*-values below 0.05 were considered significant.

Results

As a result of radiographic evaluation, the bony union was

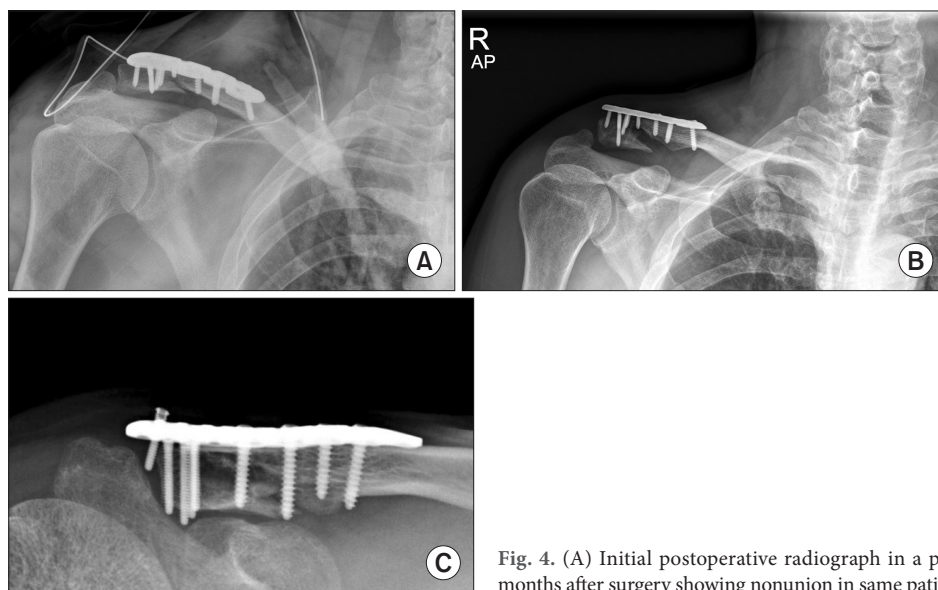


Fig. 4. (A) Initial postoperative radiograph in a patient showed nonunion. (B) Radiograph at 3 months after surgery showing nonunion in same patient. (C) Another case with screw loosening.

Table 1. Comparisons of Coracoclavicular Distance between Injured and Uninjured

Variable	Mean ± standard deviation
Injured (mm)	8.2 ± 7.9
Uninjured (mm)	7.3 ± 3.4

p-value: 0.14.

achieved in all cases except for 1 case (95.7% of union rate). At final follow-up (mean 14.9 months; range 12 to 23 months after the surgery), there was no significant difference in the mean CC distance ($p=0.14$). It was 8.2 ± 7.9 mm on the affected side and 7.3 ± 3.4 mm on the unaffected side. The preoperative mean distance between the fractured clavicle and the coracoid process was 15.1 ± 7.7 mm on the affected side. Except for 1 patient with nonunion, all patients achieved the bony union at the mean 2.8 months after the surgery. At 14.9 months follow-up, we obtained good clinical results as follows: the results of ROM were 168 degree of forward elevation, 74 degree of external rotation and T7 of internal rotation. In addition, PVAS, ASES, constant score and DASH score were 0.5, 83.4, 78.5, and 6.2, respectively. Complications after the surgery were nonunion in 1 patient (Fig. 4B), screw loosening in 1 patient (Fig. 4C). In one patient, nonunion developed at 3 months postoperatively, and underwent re-surgery using bone graft and a locking plate and could succeed to acquire the bony union finally. Implant removal was carried out in 4 patients who complained of skin irritation due to the plates. There were no other major complications such as infection. Also, all patients did not complain of stiffness during follow-up period. Results are summarized in Table 1 and 2.

Discussion

This study proved that the successful results can be achieved by performing conoid ligament suture augmentation with locking plate fixation for unstable distal clavicle fracture (Neer type IIB) with conoid ligament disruption. Surgical treatment has been recommended for an unstable distal clavicle fracture and many studies have introduced several surgical methods.¹⁵ Recently, open reduction and internal fixation using a hook plate has been more widely used for Neer type IIB fracture of distal clavicle because it is easier and faster than other surgical methods with excellent results.¹⁰ On the other hand, this method may induce the complications such as subacromial impingement, rotator cuff damage, acromion fracture, and hook cut-out.³ There are some patients who suffer from severe shoulder pain after hook plate fixation. Because a forward elevation is limited over a period of time, the patients sometimes complain of postoperative stiffness.³ In order to prevent these complications, removal should be performed as soon as possible after the bony union

Table 2. Clinical Results

Variable	Mean ± standard deviation
Pain VAS	0.5 ± 1.6
Constant score	78.5 ± 27.5
DASH score	6.2 ± 22.1
Range of motion	
Forward elevation (°)	167.5 ± 47.5
External rotation (°)	73.5 ± 33.5
Internal rotation*	T 7 ± 7

VAS: visual analogue scale, DASH: Disabilities of the Arm, Shoulder and Hand.

*Internal rotation was measured according to the place on the back that could be reached by the thumb.

is achieved.¹⁵ Even though the results of this surgery are favorable, this is the insurmountable disadvantage to have the surgery twice (implant removal) comparing with other treatment that usually solve the problems by undergoing the surgery only once.

In this study, we achieved the successful results from open reduction and internal fixation using anatomical locking plate and conoid ligament suture augmentation for Neer type IIB fracture of distal clavicle. In this surgical procedure, primary stability of fracture reduction is obtained by performing conoid ligament suture augmentation first and it helps the plate insertion easier. Conoid augmentation sutures may neutralize superior displacing force and facilitate healing in the early postoperative period. In addition, secondary operations such as implant removal are not necessary unless there is complication, such as skin irritation by plate. There is also no risk of the complications such as erosion or cut-through of acromion as like those of the surgery using hook plate. The surgical procedure using a hook plate is the method to lead the bony union by achieving the indirect reduction of fracture site and neutralizing the superior displacing force. However, the procedure of this study is the way to induce fracture healing by anatomic reduction and fixation of fracture.

Similar methods have been reported recently. Modern locking T-plate and suture anchors or looped sutures for CC augmentation provided over 94% union rates with few complications.^{13,16,21} Furthermore, a recent biomechanical study demonstrated that CC fixation adjunct to locking plate improved stability of type IIB fractures in cadaveric specimens.²² Nevertheless, there was a case of nonunion in our case series (Fig. 4B). The initial reduction was not acquired successfully in this case (Fig. 4A). While the gap was remained significantly in the lower margin of fracture, the upper margin was contacted well. The plate fixation and CC augmentation suture were done in this situation and the nonunion was occurred. This represents how important the achievement of initial reduction is. However, in this case, we consider that the reduction of lower margin was

also difficult to achieve even though the indirect reduction was attempted with a hook plate. A locking screw was pulled out in another case. In our opinion, motion of acromioclavicular joint existed during ROM exercise and this could affect to screw pull-out. Furthermore, in this case, screw position that inserted in the acromioclavicular joint could affect to pull-out, too. However, the fracture healing was completed successfully. On the other hand, the patients included in this study did not complain of postoperative stiffness because they could perform ROM exercise relatively early after the surgery. This early ROM is also considered as another advantage of our surgical treatment comparing to the surgery with a hook plate that can causes stiffness significantly due to the motion limitation before implant removal.

This study has limitation of the small sample size and the short follow-up period. Even though we collected the data prospectively, the long term follow-up for ROM and clinical score was difficult because the patient rarely visited the hospital after the bony union was achieved and the discomfort was disappeared. Also, there is another limitation that this is not a comparative study with the surgery using a hook plate or other surgeries. Those patients involved in this study might be heterogeneous because three surgeons were involved and they had some minor differences in their surgical procedures and rehabilitation. However, the results from three surgeons in three different hospitals could provide an external validity of our technique in this study.

Conclusion

In cases of an unstable distal clavicle fracture (Neer type IIB) with CC ligament disruption, the satisfactory bony union and clinical results were obtained by the surgical approach to conduct locking plate fixation and CC ligament suture augmentation concurrently.

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