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Mini-open Treatment Using Plate of Clavicle Mid-shaft Fractures

Yong-Geun Park*, Hyunseong Kang*, Shinil Kim, Jong-Hwan Bae, Sungwook Choi✉

Department of Orthopedic Surgery, Jeju National University School of Medicine, Jeju, Korea

Background: Increased frequency of comminuted clavicle mid-shaft fractures and importance of functional satisfaction through early joint exercise has resulted in higher emphasis on surgical treatments. This study aimed to evaluate the clinical radiological results of treatment of clavicle mid-shaft fractures by open reduction and internal fixation using a plate with a small incision.
Methods: The subjects of this study were 80 clavicle mid-shaft fracture cases treated with internal fixation using a plate from October 2010 to July 2014. Clavicle mid-shaft fractures were internally fixated using anatomical plates or locking compression plates. Achievement of bone union, union period, and clavicle length shortening were evaluated radiologically, and clinical assessment was done by using Constant and University of California at Los Angeles (UCLA) scores.
Results: All 80 cases were confirmed to have achieved bone union through radiographs with an average union period of 10.9 weeks (range: 7–18 weeks). The average clavicle length of shortening in the affected side was 1.8 mm (range: 0–17 mm). The average UCLA score and Constant score were 33.6 (range: 25–35) and 92.5 (range: 65–100), respectively. Regarding complications, four cases reported skin irritation by metal plates, and one case reported a screw insertion site fracture due to minor trauma history.
Conclusions: We were able to induce successful bone union and obtain clinically satisfactory results in displaced mid-shaft fractures of the clavicle without major complications such as nonunion through treatment of internal fixation using a plate.
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Key Words: Clavicle mid shaft fracture; Open reduction and internal fixation; Anatomical plate; Locking compression plate

Introduction

Clavicle fractures are common and represent 2.6% of all fractures in adults and 44% of those in the shoulder girdle.[1] Mid-shaft fractures account for approximately 69% to 82% of all clavicle fractures[2] which generally respond well to conservative treatment. However, cosmetic defects or discomfort due to bony prominence of fractured fragments, angular deformity, and shortening have not been considered. Severely comminuted and displaced fractures can increase nonunion rates to over 20% and incidence of malunion with shortening. Functional disability can also occur.[3,4]

Therefore, although nonoperative treatment is a viable option to treat displaced mid-shaft fractures, operative treatment should be considered in patients with multiple risk factors for nonunion, especially significant fracture displacement or clavicle shortening with early range of motion (ROM) exercise.[5]

Treatment options for acute mid-shaft clavicle fractures include open reduction and internal fixation with plates as well as closed or open reduction and internal fixation with intramedullary (IM) pins, wires, or a nail.[6-8] Advantages of plate fixation are anatomical reduction, which enables immediate stabilization. Although high success rates of plate fixation have been achieved, reported complications of plate fixation include implant failure, implant prominence, nonunion as a result of extended periosteal stripping, and soft tissue damage.[9] Recently, an anatomic precontoured clavicular plate was designed to reduce the contact surface of the plate and bone as well as to preserve vascularity of

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*These authors contributed equally to this article as co-first authors.

✉**Correspondence to:** Sungwook Choi
Department of Orthopedic Surgery, Jeju National University Hospital, 15 Aran 13-gil, Jeju 63241, Korea
Tel: +82-64-754-8116, **Fax:** +82-64-717-1656, **E-mail:** swchoi1115@gmail.com
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the fracture site by using locking screws to lower the risk of metal failure.[10,11]

This study aimed to evaluate the clinical radiological results of clavicle mid-shaft fracture treatment by open reduction and internal fixation using a plate with a small incision.

Methods

We retrospectively reviewed clavicle mid-shaft fracture cases treated with internal fixation using a plate from October 2010 to July 2014 and with a follow-up of at least 12 months. This study was approved by the Institutional Review Board at the beginning.

There were 80 total patients (65 men and 15 women) with a median age of 38.2 years (range: 18–82 years), and the average follow-up period was 15.2 months. Right side fractures were present in 41 patients while 39 patients had left side fractures. Twenty-eight patients (35.0%) were injured by traffic accidents, 17 patients (21.3%) by slipping, 11 patients (13.8%) by falling from height, four patients (5.0%) by direct trauma, and 20 (25.0%) patients by sports activity. The interval between injury and operation was determined based on whether or not the fracture site was an open wound, comorbidity injury, and general condition of the patients, and average interval was 6.2 days (range: 0–25 days). Based on the Edinburgh classification[12] system, four cases (5.0%) were 2A1 type, 17 cases (21.3%) were 2A2 type, 44 cases (55.0%) were 2B1 type, and 15 cases (18.8%) were 2B2 type (Table 1).

Under general anesthesia, the patient was placed in the beach-chair position. The arms and shoulders were draped freely to allow for necessary manipulation to achieve reduction. The skin was incised minimally over the clavicle fracture site along the Langer lines at about 2 to 3 cm. Incision through the platysma muscle was done carefully to avoid the underlying supra-clavicular nerve. Dissection was made in the plane deep in the trapezius muscle to minimally strip the periosteum around the fracture site.

Table 1. Pre-operative Radiologic Evaluation

Parameter	Value
Edinburg classification	
2A1	4
2A2	17
2B1	44
2B2	15
Displacement (mm)	1.8 ± 3.6 (0–17)
Free fragments	1.1 ± 0.9 (0–5)

Values are presented as number only or mean ± standard deviation (range).

Maintaining provisional stability was performed to obtain control over the proximal and distal fragments using reduction clamps. If significant comminution was encountered, then careful initial re-approximation of the smaller fragments was performed with one or two 2.4 mm inter-fragmentary screws (Synthes, Paoli, PA, USA), if possible.

Maintenance of anatomical reduction was checked, and a pilot hole was drilled before screw fixation without creating a thread by cortical tap or near cortex widening. Inter-fragmentary screws were used to compress the fracture fragments together (small fragment to main fragment) and to comminute the fracture into a simple fracture and achieve complete reduction. The anatomical clavicle plate (Acumed, Hillsboro, OR, USA) or Locking compression superior anterior clavicle plate (LCP; Synthes) was positioned on the anterosuperior surface of the clavicle, and either locking screws or cortical screws were placed to achieve fixation. Subsequently, the trapezius and platysma were repaired and soft tissue enveloped over the plate.

Postoperatively, an arm sling with abduction pillow was applied, and the patients were encouraged to start ROM exercises of the joint. Continuous passive motion was begun 2 weeks after the surgery, and active exercise was started 4 weeks after the surgery.

Plain radiographs and 3-dimensional reconstructed computed tomography scan images were obtained to establish the amount of clavicle shortening, the fracture pattern, and preoperative planning. Radiologic examinations were performed every month in the outpatient department. Radiological bone union was defined as bridging of the callus or disappearance of the narrow fracture line on follow-up radiographs (Fig. 1). Clavicular shortening after bone union, complications, and functional outcome assessment were examined at final follow-up.

Clavicle length was defined as the distance between the lateral-most point of the clavicle in the acromioclavicular joint and the medial-most point of the clavicle in the sternoclavicular joint,[13] and differences in length between affected and unaffected limbs were evaluated. Clavicle shortening of more than 2 cm was considered a malunion.

Shoulder function was quantified using Constant and University of California at Los Angeles (UCLA) scores.

Results

Preoperatively, the mean gap between the major fragments were 12.7 mm (range: 0–31 mm) as determined by radiologic evaluation, and the mean number of comminuted fragments was 1.1 (range: 0–5) (Table 1).

The patient underwent open reduction and internal fixation with an anatomical clavicle plate in 31 cases and LCP in 49 cases. For fixation of comminuted fragments, one cortical screw was used in 20 cases, two cortical screws in 22 cases, three corti-

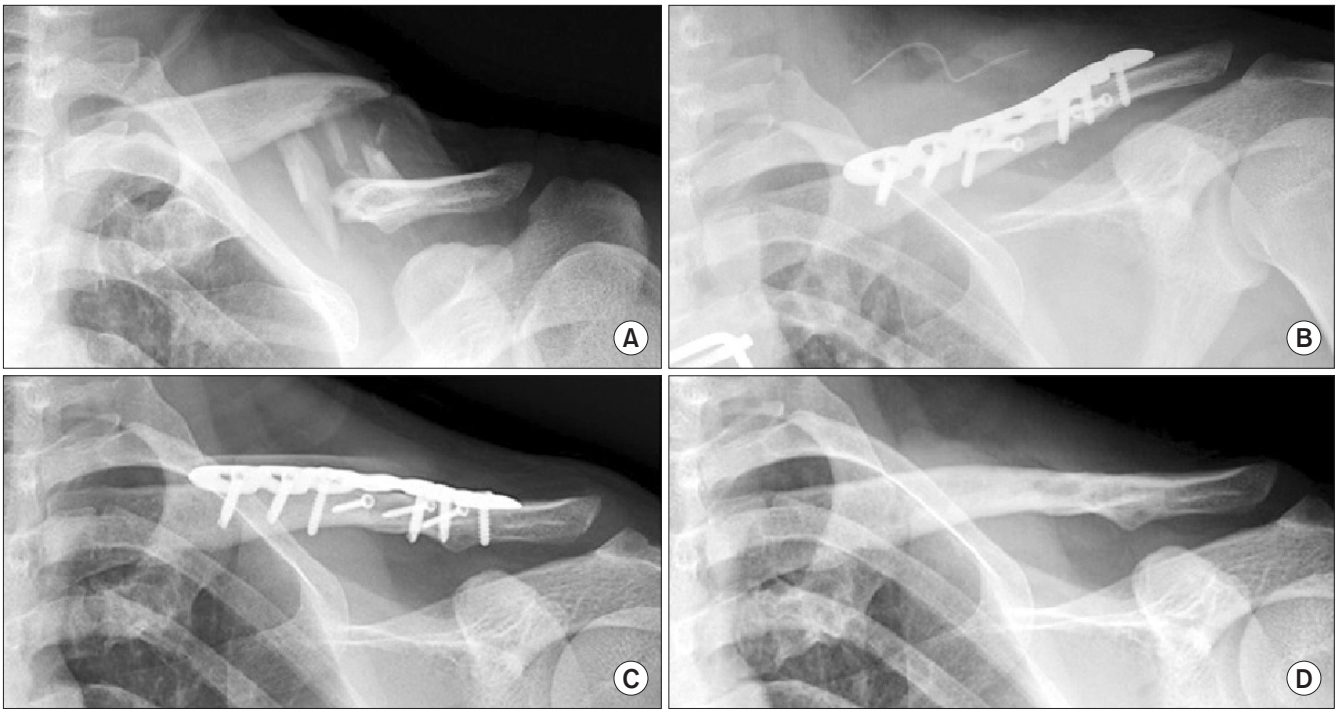

Fig. 1. (A) Preoperative radiograph. (B) Immediate postoperative radiograph. (C) Radiographs showing bone union. (D) Final radiograph after metal removal.

Table 2. Fixation Modality

Variable	Number
Plate	
Anatomical plate	31
Locking compression plate	49
Lag screw	
0	35
1	20
2	22
3	2
4	1

Table 3. Postoperative Result

Variable	Value
Bone union (wk)	10.9 ± 2.9 (7–18)
Clavicle shortening (mm)	1.8 ± 3.6 (0–17)
University of California at Los Angeles score	33.6 ± 2.0 (25–35)
Constant score	92.5 ± 8.7 (65–100)

Values are presented as mean ± standard deviation (range).

cal screws in two cases, and four cortical screws in one case (Table 2).

Radiographic examination showed union in all cases, and the mean time to union was 10.9 weeks (range: 7–18 weeks). The mean decrease in clavicular length after fracture union was 1.8 mm (range: 0–17 mm).

The mean postoperative UCLA score was 33.6 (range: 25–35), and mean Constant score was 92.5 (range: 65–100) (Table 3).

Skin irritation occurred in four patients postoperatively and healed with plate removal after bone union in all cases. One patient had a fracture at the screw removal site after plate removal operation due to minor trauma at the removal site at 8 days postoperatively.

There were no complications such as metal failure, limitation of shoulder joint mobility, nonunion, malunion, and infection.

Discussion

Traditionally displaced mid-shaft clavicular fractures have been successfully treated nonoperatively and have a high union rate with few complications. Treatment of mid-shaft clavicular fractures by means of a figure-of-eight bandage has the benefit of being simple and easy to apply, but it has often been criticized for imposing on patients unnecessary inconvenience, discomfort, unsatisfactory anatomical reduction, and complications such as axillary pressure sores, compression of the neurovascular bundle, and deformity from angulation or shortening.[14]

Among 1,145 patients with a clavicle mid-shaft fracture, Zlowodzki et al.,[3] reported the rate of nonunion of displaced mid-shaft clavicular fractures to be 15.1% after nonoperative care compared with 2.2% after plate fixation.

In a recent prospective randomized trial, functional outcomes and patient satisfaction following plate fixation of displaced mid-shaft clavicular fractures were superior to those following nonoperative treatment of such fractures.[15] Pearson et al.[16] examined the cost effectiveness of primary fixation of displaced mid-shaft clavicle fractures using the quality-adjusted life-years method. They concluded that the cost effectiveness of fixation was dependent on the durability of the functional improvement compared with nonoperative treatment.

Complications of operative treatment include injury to the subclavian artery or vein, brachial plexus palsy, infection, postoperative wound complications, and metal failure. Recently, operative treatments have shown good outcomes, and the large number of cases documenting consistently satisfactory outcomes after plate fixation lends support to use of this technique as the treatment of choice.

Clavicular plating remains the gold standard of operative treatment. Other types of internal fixation that have been used include IM devices, Kirschner wire, rush nails, and Kuntscher nails.[17,18]

IM fixation can be accomplished with smaller incisions, less dissection, and soft tissue stripping, and it may permit callus formation due to relative stability and protection of the supraclavicular nerves. Otherwise, complications related to IM fixation include hardware prominence, implant migration, implant breakage, vulnerable to rotational force, and deformity after early ROM, which leads to difficulty removing the nail.[19] IM fixation has the potential for simple fractures but may be unsuitable for comminuted fractures due to the risk of shortening and nonunion after additional k-wire fixation or bone graft.[20-22]

Clavicular plating may be used rather than IM nails for comminuted fractures to increase rigid stabilization.[10] For plate fixation, different types of plates are available: (pre-contoured) dynamic compression plates, tubular plates, reconstruction plates, anatomical plates, or locking plates.[18] Reconstruction plates have an advantage as they conform to the contour of the clavicle, whereas anatomical plates allow contouring of plates to fit the patient's anatomy. Anatomic pre-contoured locking plates are widely used for the following advantages: strong fixation due to locking between the screw and plate as well as blood supply preservation due to minimal contact between the plate and cortical bone.[23-26]

Minimally invasive percutaneous plate osteosynthesis technique along with application of a locking plate has been recently introduced, offering an ideal combination in terms of bone fixation and soft-tissue sparing since periosteal stripping can be minimized to promote rapid union.[6,27]

In this study, fractures were treated with an anatomical plate or locking plate, and union was achieved in all cases. We prefer open reduction and internal fixation over minimally invasive techniques since they allow for ease of access to the fracture site and precise reduction of complex fractures. There was no complication of nonunion, there was a low rate of soft tissue problems.

A satisfactory result in terms of limitation of motion after stable fixation with a metal plate was attained comparable with that of the unaffected limb, including functional score and ROM in the shoulder joint at the final follow-up.

The middle third of the clavicle is the thinnest part and is located directly under the skin with less soft tissue. Some patients complain of skin irritation at the plate fixation site, but it can be resolved with plate removal after union in all cases.

Variable types of plates have been developed to overcome the weak point of plate fixation and maintain bone healing even in comminuted fractures without complications such as nonunion.

Limitations of this study include the lack of a comparison group and its retrospective nature. Further study is needed using a large number of samples to compare clinical and radiological outcomes with variable treatment options.

Conclusion

We were able to induce successful bone union and obtain clinically satisfactory results in displaced mid-shaft fractures of the clavicle without major complications such as nonunion through mini-open treatment of internal fixation using a plate.

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