J Shoulder Elbow Surg (2016) 25, e7-e12

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Minimally invasive plate osteosynthesis for midshaft clavicular fractures using superior anatomic plating

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Background: The minimally invasive plate osteosynthesis procedure has been widely applied for long-bone fixations; however, this technique is not commonly used for clavicular midshaft fractures. In this study, we introduced this technique for midshaft clavicular fractures using superior anatomic locking plates and evaluated its clinical and radiographic outcomes.

Materials and methods: From June 2013 to July 2014, 15 patients with acute midshaft clavicular fractures were treated with the minimally invasive plate osteosynthesis technique using a 3.5-mm clavicular superior anatomic locking plate. Anteroposterior plain X-ray images of the clavicle were taken at 4-week intervals until union was observed. The last clinical follow-up assessments were performed postoperatively at a mean of 16.54 months (range, 10-23 months). In addition, for clinical evaluations, the Constant score and the Disability of the Arm, Shoulder and Hand score were assessed.

Results: The average operative time was 60.2 ± 20.1 minutes (range, 40-80 minutes), with blood loss of 25 ± 5 mL (range, 20-30 mL) during the operation. The mean union time for the patients was 10.1 ± 1.4 weeks (range, 8-12 weeks), and no delayed union or nonunion was observed. There were no major complications, including infections, plate breakages, or neurovascular injuries. No skin irritation was observed, and only 2 patients felt local incision numbness. All patients obtained satisfactory shoulder functions. The mean Constant score was 99 ± 1.8 (range, 95-100), and the mean Disability of the Arm, Shoulder and Hand score was 3.8 ± 2.9 (range, 0-10) at the last control visit.

Conclusion: The minimally invasive plate osteosynthesis procedure that was introduced in this study for midshaft clavicular fractures with superior anatomic locking plate is a reproducible procedure and an alternative to conventional operative methods.

Level of evidence: Level IV, Case Series, Treatment Study.

Keywords: Midshaft clavicular fracture; MIPO; anatomic locking plate

Most fractures of the clavicle occur in the middle third region due to its thin form and direct contact with the skin.[20,36] Midshaft clavicular fractures have traditionally been treated with a sling or figure-of-eight bandage, even when grossly displaced.[1,16] Owing to higher rates of nonunion, malunion, and shortening with conservative

This study was approved by the Sixth People's Hospital of Shanghai Jiao Tong University Office of Research Ethics.

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1058-2746/$ - see front matter © 2016 Journal of Shoulder and Elbow Surgery Board of Trustees.
http://dx.doi.org/10.1016/j.jse.2015.06.024

Figure 1 (**A**) Preoperative radiograph of the injured clavicle. (**B**) Photograph shows the clavicle superior anatomic locking plate. (**C**) Two incisions of the minimally invasive plate osteosynthesis technique for midshaft clavicular fractures.

treatment compared with surgical management reported in recent studies, open reduction and internal fixation (ORIF) is preferred by more and more surgeons.[10,23,27,30,36] However, there are various complications for traditional ORIF methods with plates, including infections, incisional numbness, nonunion, delayed union, and extensive scars. These may be related to extensive exposure of the fracture site and stripping of peripheral soft tissues.[2,8,9,28,34]

Intramedullary nailing may minimize soft tissue injuries during fracture reduction. However, problems, such as malunion or nonunion, migration or nail breakages, difficulty in controlling clavicular rotation, and low fixation quality of the nail, are still concerns.[6,14,16,19,29]

Minimally invasive plate osteosynthesis (MIPO) has widely been chosen as the treatment for shaft fractures of the long bones because it allows indirect fracture reduction and preservation of the blood supply to the fracture site.[11,25] However, indirect reduction of the clavicle is technically demanding due to the curved shape of the clavicle and the risk of iatrogenic neurovascular injury; thus, these MIPO procedures have not been frequently performed for midshaft clavicular fractures.

In this study, we report the radiologic and functional outcomes of our novel MIPO technique for midshaft clavicular fractures using a superior anatomic locking plate.

Materials and methods

From June 2013 to July 2014, 42 patients with midshaft clavicular fractures were admitted to our treatment group. All patients volunteered to participate and signed written informed consent forms. The primary indications for surgery were shortening greater than 20 mm, total fracture displacement, and any displacement with comminution. Patients between the ages of 18 and 65 with isolated midshaft clavicular fractures were included in the study. Exclusion criteria were pathologic fracture, open fracture, fracture with neurovascular injury, fracture of more than 2 weeks, and nonunion fracture. Finally, 15 patients (10 men and 5 women) with acute midshaft clavicular fractures were treated with the MIPO technique with 3.5-mm clavicular superior anatomic locking plates. Patients were a mean age of 48.3 years (range, 28-64 years). The left arm was affected in 11 patients the right arm in 4 patients. The fractures were classified using the Robinson classification system: 9 were type 2B1 and 6 were type 2B2.

The surgical procedure

After general or nerve-blocking anesthesia, each patient was placed on a radiolucent table in the beach chair position. A 2-cm lateral incision was first made along the superior border of the clavicle, and the dissection was extended between the trapezius and deltoid muscles to expose the superior surface of the clavicle. A blunt dissection was performed from the lateral to the medial side of the fracture with a periosteal elevator. The plate was inserted from the lateral access across the fracture area, to the medial clavicle. Another 2-cm incision was made along the superior border of the medial clavicle (Fig. 1).

A cortical screw was inserted into 1 of the 4 lateral holes to closely attach the locking plate to the lateral region of the fracture on the superior border of the clavicle. Then, a sleeve was placed into the locking hole beside the cortical screw. After this procedure, the sleeve could control the lateral region of the clavicle. The sleeve was retracted laterally and downward to reduce the fracture with the help of the trapezius and deltoid muscles' envelope. Meanwhile, the medial clavicular region was pushed by hand to close to lateral clavicular region for reduction. Another sleeve was placed into one of the median locking holes, and a 2-mm Kirschner wire was inserted through the sleeve into the median side of the clavicle for temporary fixation.

After the reduction procedure was finished, the reduction was confirmed with anteroposterior and 45° oblique radiographs (Fig. 2, *A-C*) If an obvious free fragment remained, as observed in the 45° oblique radiograph, a towel forceps was used to reduce the fracture. If the length of the clavicle was not equal to other side, then the above procedure was applied again (Fig. 2, *D-F*). After radiographic confirmation of reduction, 3 to 4 locking screws were inserted on each side of the fracture, and the cortical screw used to attach the plate was replaced with a locking screw. Finally, the incision was closed (Fig. 3, *A* and *B*).

Rehabilitation

After surgery, patients were instructed to protect their shoulder with a sling for approximately 2 weeks, and within this period, pendulum mobilization of the shoulder joint was encouraged. Daily activities were allowed 4 weeks postoperatively. Weight lifting with the injured arm was forbidden until a bony union was observed.

Regular follow-up occurred at 4, 8, and 12 weeks postoperatively. Anteroposterior plain X-ray images of the clavicle were taken at follow-up and were evaluated by 1 orthopedist and 1 radiologist blinded to the study. Union was defined as bony bridging between fracture fragments and confirmed by clinical manifestation, which consists of tenderness and shoulder joint function. Delayed union was defined as radiologically visible