Surgical Results of Zones I and II Fifth Metatarsal Base Fractures Using Hook Plates

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The purpose of this study was to evaluate the results of surgical treatment of fifth metatarsal base fractures using a mini-hook plate. Seventeen patients with Lawrence classification zones I (n=6) and II (n=11) fifth metatarsal base fractures with an initial fracture displacement more than 2 mm and a small (less than 2 mm) comminuted avulsion fragment were included in the study. Patients treated using a mini-hook plate fixation method were prospectively evaluated. A mini-hook tubular plate was designed so that the last hole functioned as a hook for the application of compression force, grasping of comminuted fragments, and rotational stabilization in metatarsal base fractures. Clinically, the American Orthopaedic Foot and Ankle Society (AOFAS) midfoot scale questionnaire was administered preoperatively and 1 year postoperatively. Union was determined by 3-dimensional computed tomography as clinically nontender callus formation. Time to union and return to sports were calculated. Mean AOFAS midfoot scale scores were 48±8 points (range, 35-60 points) preoperatively and 91±7 points (range, 85-100 points) 1 year postoperatively. Mean time to complete union, as determined by computed tomography, was 54±11 days (range, 38-74 days). All patients reported returning to prior activities of daily living at a mean of 74±10 days (range, 63-98 days). One patient reported hardware irritation secondary to inadequate plate bending and screw curving.

Mini-hook plate fixation is an effective alternative surgical method for zones I and II displaced fifth metatarsal base fractures or comminuted small fragment fractures.
Fifth metatarsal base fractures, the most common forefoot fractures, raise significant concerns. Guidelines for the treatment of this fracture are controversial. Fifth metatarsal base fractures are classified into 3 zones. Zone I fractures are avulsion fractures affecting the tuberosity, zone II fractures are located at the proximal metaphyseal–diaphyseal junction, and zone III fractures include diaphyseal and stress fractures (Figure 1). Most patients with nondisplaced fractures in zones I and II are treated conservatively.

However, fifth metatarsal base fractures can be significantly displaced and comminuted and result in significant disruption of the cuboid–fifth metatarsal joint. These fractures may require open reduction and internal fixation. Many techniques have been reported for the fixation of fifth metatarsal base fractures, including tension band wiring, the use of low-profile plates, and cross-pinning with K-wires; cannulated, titanium, or headless screws; and XS nails (Smith & Nephew Orthopaedics AG, Baar, Switzerland). This article reports the surgical results of mini-hook plate (Locking Compression Plate; Synthes, Oberdorf, Switzerland) fixation of displaced or comminuted fifth metatarsal base fractures in zones I and II. The goal of this study was to determine the time required for union by computed tomography and to determine the time required for return to activities of daily living.

MATERIALS AND METHODS

After institutional review board approval, 17 patients with fifth metatarsal base fractures treated surgically using mini-hook plate fixation between 2008 and 2010 were prospectively analyzed. Of the 17 patients, 11 had a zone II fracture with 2 mm displacement and 6 had a small (less than 2 mm) zone I avulsion fracture fragment treated using a mini-hook plate and screws. The proximal end of the plate could be firmly anchored in small, marginal fragments. The plate was redesigned by one of the authors (J.H.C.) so that the last hole functioned as a hook for the application of compression force, grasping of comminuted fragments, and rotational stabilization in metatarsal base fractures (Figure 2).

Mean patient age was 46±16 years (range, 19-77 years). Mean time from injury to definitive fixation was 5 days (range, 1-9 days). Mean follow-up was 17±10 months (range, 12-28 months). Inclusion criteria were the presence of a zone I or II fifth metatarsal base fracture with less than 2 mm of displacement or a comminuted fracture of less than 2 mm. Nondisplaced fractures in zones I and II, zone III stress fractures, and other combined foot and ankle fractures were excluded.

Clinically, the American Orthopaedic Foot and Ankle Society (AOFAS) midfoot scale questionnaire was administered preoperatively and 1 year postoperatively

SURGICAL TECHNIQUE

The patient was placed in the supine position with elevation of the hip on the affected side. The affected extremity was placed in neutral rotation. The procedure was performed under spinal anesthesia with C-arm fluoroscopic guidance and tourniquet application. A 3.5-cm skin incision was made just lateral to the fifth metatarsal. After soft tissue dissection, the fracture fragment was exposed. The proximal hook was placed into the tuberosity proximal and lateral to the dorsal fifth metatarsal surface. Reduction of the main fracture fragment was performed using a K-wire and adequate plate bending to the shape of the fifth metatarsal. A compression screw was applied, the small fracture fragment was hooked, and the displacement gap was reduced by compression with an eccentric screw. To obtain a tension-banding effect, the first screw was fixed loosely and the distal and proximal screws were fixed tightly. The proximal hole was accurately bent to the shape of the styloid process of the metatarsal base. Through direct incision and observation, the lateral band of the plantar fascia injury could be avoided. Adequate visualization was imperative to achieve good reduction.

Fixation was then performed using the mini-hook plate and 3 cortical screws. The plate was applied dorsolaterally or obliquely, depending on the location of the primary fracture disruption. Compression screw fixation was then performed. Bony union of all fractures was confirmed with computed tomography.
Postoperatively, a nonweight-bearing short leg splint was applied in a neutral position and kept in place for 3 weeks. Patients were followed at 3-week intervals until radiologic union was achieved. Bony continuity and the disappearance of the fracture line or gap was monitored with computed tomography. Postoperative rehabilitation involved 3 weeks of wearing the nonweight-bearing short leg splint. Three weeks of weight-bearing with short leg boots was then allowed.

RESULTS

Patients who had an initial zone II fracture displacement of more than 2 mm and a small (less than 2 mm), comminuted zone I avulsion fragment experienced complete union after mini-hook plate fixation (Figure 3). No patient in this series had bilateral injuries. The mechanisms of injury were a fall from a height in 8 patients, step-to-step inversion injury in 5 patients, and sports injury in 4 patients. Mean AOFAS midfoot scale score was 48±8 points (range, 35-60 points) preoperatively and 91±7 points (range, 85-100 points) 1 year postoperatively. Mean time to bony union was 54±11 days (range, 38-74 days). All patients reported a return to prior activities of daily living at a mean of 74±10 days (range, 63-98 days) (Table).

The single complication was hardware irritation in 1 patient due to inadequate bending and screw curving by pressure. The plate and screw were removed, and a short-leg cast was applied for 3 weeks.

DISCUSSION

Zuelzer11 introduced hook plates in 1951. Several authors have recommended the use of the hook plate to treat ankle fractures.11,12 Until now, conservative treatment was the standard for zone I fractures because they are hypovascular lesions, but surgical treatment is needed for displaced, intra-articular fractures and nonunions and malunions. In 2003, Carpenter and Garrett13 recommended the use of a hook plate in zone II fractures as an alternative treatment method for fifth metatarsal base fractures, but the hook plate available at that time was thick and straight. The current authors modified the mini-hook plate thickness to have a low profile and contoured the plate according to the shape of the fifth metatarsal base. Anatomically, the base of the fifth metatarsal shaft is curved, and the metatarsal base has a variable U-shape with an inadequate blood supply, which often causes failure or delay of union. The plate is thin and has a one-quarter tubular shape, and the proximal hook is hollow, enabling the surgeon to avoid injury to the lateral band of the plantar fascia.

Most metatarsal base fracture patterns are transverse to slightly oblique due to inversion and traction force mechanisms. Zones I and II displaced and comminuted fracture fragments lie near the tuberosity at the insertion of the injury to the lateral band of the plantar fascia. The proximal end of the plate can be firmly anchored into small, marginal fragments. The mini-hook plate in the current study was redesigned so that the last hole functioned as a hook for the application of compression force, grasping of comminuted fragments, and rotational stabilization in metatarsal base fractures. Conservative treatment is the standard for a nondisplaced metatar-
sal base fracture and has been reported to achieve successful union in 56% to 100% of cases, with a recovery period exceeding 6 months; malunion or delayed union prolongs the recovery period.\textsuperscript{14-16} Operative fixation shortens the recovery time and decreases the rates of nonunion, delayed union, and refracture.\textsuperscript{7} Surgical treatment is required for the internal fixation of small comminuted fracture fragments and displacements of more than 2 mm in zones I and II fifth metatarsal base fractures.\textsuperscript{1,4} The optimal surgical procedure for the treatment of these fractures is accurate anatomical reduction, which results in more rapid recovery and better function. Intramedullary screw fixation is the most widely accepted treatment option. However, a review of the literature showed that technical problems may occur in 45% of patients with a Jones fracture treated operatively, including medial or lateral cortex penetration, metatarsal fracture, screw failure in the medullary canal, or pain over the screw head.\textsuperscript{5,15,17-19}

The treatment of displaced or small comminuted fractures is technically difficult and may fail because of unreliable purchase and inadequate reduction by screws. The mini-hook plate provides compression to the fracture site and obtains a positive tension-banding effect. In the current study, the mini-hook plate fixation method decreased time to union and return to activities of daily living. Hardware irritation may occur due to screw fixation and to inadequate bending of the plate hook because the plate is a nonanatomical design. Hardware prominence may occur due to inadequate plate bending. Intraoperatively, attention should be given to the direction of proximal screw fixation and plane bending, which critically affects fixation stability. Mahajan et al\textsuperscript{7} reported that mean healing time of displaced fifth metatarsal base fractures after bicortical fixation was 7 weeks. Mean union time and complication rates in the current study were comparable with those following bicortical screw fixation. However, screw fixation may not overcome the resistant tension from ligamentous and muscle insertions.\textsuperscript{4} The mini-hook plate reinforces screw fixation and permits increased compression across the comminuted fragment by providing a barrier and improved rotational stability. Computed tomography was used in the current study to confirm bony union, which allows a rapid return to activities of daily living.

Limitations of the current study were a small patient sample and lack of a comparison group. Despite these limitations, fixation using the mini-hook plate achieved favorable results in displaced and comminuted fifth metatarsal fractures.

**CONCLUSION**

Surgical treatment of displaced and comminuted fifth metatarsal fractures allows an earlier return to weight bearing with a more rapid and predictable union rate. The authors recommend the mini-hook plate fixation method as a good alternative to rigid stabilization in the treatment of these fractures.

**REFERENCES**


