Dorsal Locking Plate without Interfragmentary Screw Fixation for First Metatarsophalangeal Joint Arthrodesis: Case Series

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Statement of Purpose

The purpose of this study is to determine the efficacy and fusion rate of dorsal locking plate fixation alone without the use of any interfragmentary fixation for first metatarsophalangeal joint (MTPJ) arthrodesis.

Methodology & Hypothesis

A search was performed based on operative report Current Procedural Terminology (CPT) codes for all patients who underwent first MTPJ arthrodesis by one of three foot and ankle surgeons (LK, JF, JA) between July 2013 and November 2016. Of the 76 patients identified, 26 consecutive patients (26 feet) met our inclusion criteria of using dorsal locking plate fixation alone without interfragmentary screw, Kirschner wire (K-wire), or pin fixation. Revision arthrodesis and primary arthrodesis as a salvage procedure following failed bunionectomy or implant were included. A retrospective review of electronic medical records and radiographs was performed to record age, smoking status, pre-operative diagnosis, concomitant procedures, length of follow-up, clinical and radiographic fusion rates, complications, and revision surgeries. Clinical and radiographic fusion were evaluated and recorded by the attending surgeon and reviewed by the resident investigator. Clinical fusion was defined as no motion at the fusion site with minimal pain with the patient able to be full weight-bearing. Nonunion was defined as no sign of bone healing 6 months post-operatively with clinical symptoms. Complete radiographic fusion was defined as cortical and trabecular bridging across the fusion site on plain radiographs.

Our hypothesis was that the fusion rate of first MTPJ arthrodesis using a dorsal locking plate without any interfragmentary fixation would be comparable to the fusion rates of other techniques and fixation constructs reported in the literature.

Procedure

The patient was placed in supine position and administered either general anesthesia or conscious sedation with a regional block. A pneumatic tourniquet was applied, and the foot was prepped and draped. A dorsal or dorsomedial skin incision was made over the first MTPJ, and the joint was exposed by linear capsulotomy. Any large medial eminence, bony prominences, or osteophytes were resected (**Fig. 1**). The articular surfaces were then prepared either by planar resection with a sagittal saw or by a cannulated ball-and-socket reaming system to maintain the convexity of the metatarsal head (**Fig. 2A**) and concavity of the proximal phalanx (**Fig. 2B**). The subchondral bone was then fenestrated using a K-wire or small drill bit. The hallux was then appropriately positioned in neutral rotation, approximately 10-15^0 abduction (or parallel to the second digit), and approximately 15-20^0 dorsiflexion with the plantar aspect of the hallux resting on a simulated weightbearing surface (**Fig. 3**). A dorsal locking plate was then applied and secured to bone using a combination of locking and non-locking screws (**Fig. 4**). In most cases, a non-locking screw was inserted eccentrically in an oblong hole to provide compression across the arthrodesis site. No interfragmentary fixation was used. The wound was then closed in layers (**Fig. 5**). Concomitant procedures were performed as indicated.

Post-operatively, patients were placed in a posterior splint for one week. At that time, some patients were allowed partial protected weightbearing, but most patients were kept non-weightbearing for an additional 4-5 weeks and then progressed to full weightbearing. Serial radiographs were taken to evaluate progression of fusion.

FIGURE 1. Joint debridement.

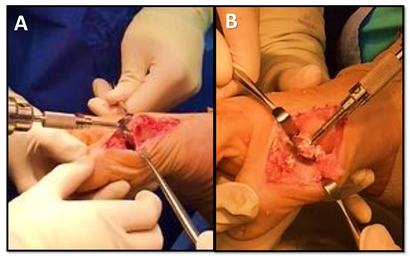

FIGURE 2. A) Convex reamer on metatarsal head. **B)** Concave reamer on proximal phalanx.

FIGURE 3. Positioning of hallux using a simulated weight-bearing surface.

FIGURE 4. Application of dorsal locking plate.

FIGURE 5. Wound closure.

Literature Review

Arthrodesis of the first MTPJ arthrodesis is commonly performed for treatment of hallux rigidus (HR), severe hallux abductovalgus (HAV), rheumatoid arthritis (RA), traumatic arthritis, and recurrent valgus and varus deformities following bunion correction [1-3]. Several surgical techniques and fixation options have been described in the literature. Joint preparation techniques include manual debridement with curettage and rongeur to maintain joint congruity, planar resection with osteotomes or sagittal saw for flat bone-to-bone contact, and cup-and-cone or ball-and-socket cannulated power reaming systems to create a concave/convex configuration for arthrodesis. Fixation options include K-wires, Steinmann pins, staples, single or crossed screws, and locking or non-locking plates with or without interfragmentary fixation [1-3].

Historically, fusion rates of first MTPJ arthrodesis have varied but have generally improved over time with advances in techniques and fixation options. In 1990, Coughlin [4] reviewed 22 case series including 1,451 first MTPJ fusions and found an average fusion rate of 90% (range: 77% to 100%). In 2011, Roukis [2] performed a systematic review of 37 studies published after 1980 involving 2,818 first MTPJ fusion procedures utilizing 6 different “modern” fixation methods (staples, screws, and/or plates). Studies were excluded if they primarily involved RA as an indication or used structural bone grafts for revision surgery. One study was level II evidence, 10 were level III, and 26 were level IV. Twelve of the 37 studies, however, were unpublished abstracts. He found an overall fusion rate of 94.6% and noted only 32.7% of the nonunions were symptomatic (1.8% total incidence).

More recently, in 2017, Korim et al [3] published a systemic review and meta-analysis of 26 studies (2 prospective cohort, 24 retrospective case series) involving 2,059 first MTPJ fusions. They excluded studies in which the preoperative diagnosis or fixation methods were not clear as well as studies primarily involving revision procedures. The overall union rate was 93.5% with only 17.6% of nonunions being symptomatic. They observed a significantly higher union rate in patients with a preoperative diagnosis of HR (98.8%) compared to HAV (94.4%), as well as in cases in which the joint was prepared using hand tools such as curettes and rongeurs (100%) compared to power saws or ball-and-socket reamers (92.7%). There was no difference in union rate between joint configuration (flat-on-flat vs ball-and-socket), joint fixation methods (crossed screws vs staples vs non-locked plate vs locked plate vs single screw vs other), and post-op weightbearing status (non-weightbearing vs weightbearing in orthosis).

Reviewing the literature specifically for clinical studies involving dorsal plate fixation alone without interfragmentary fixation reveals a relatively small proportion of cases in which this construct was used. In 1994, Coughlin et al [5] reviewed 58 fusions using a 6-hole non-locking plate with an interfragmentary K-wire (n=43) or without (n=15). He reported only one nonunion (98.3% fusion rate), however, it was not specified whether or not a K-wire was used in that case. Leaseburg et al [6] in 2009 reported a 100% fusion rate in 35 cases using a pre-contoured locking plate, which was supplemented by a lag screw (LS) in patients with poor bone quality, but the authors did not specify in how many cases this was used. A study by Hyer et al [7] in 2008 compared a 5-hole low-profile locking plate (n=31) and two crossing screws (n=14) and found fusion rates of 90.3% and 92.9%, respectively. Hyer et al [8] performed another retrospective study in 2012 comparing four fixation constructs (n, fusion rate): static plate (43, 93.35%), static plate with LS (14, 85.71%), locking plate (36, 91.67%), locking plate with LS (45, 95.56%).

There was no significant difference in patient age, time to weightbearing, time to fusion, or rate of fusion between the groups. Dening et al [9] also performed a retrospective study in 2012 comparing four constructs: single oblique LS (24, 71%), two crossed LS (21, 90%), pre-contoured nonlocking plate (13, 100%), and pre-contoured nonlocking plate with LS (14, 93%), and found a significant difference in union rates only between plate fixation alone and single screw fixation. In a 2014 retrospective study, Mayer et al [10] compared a nonlocking 1/3 tubular plate with LS (n=102, 92.2%) and a pre-contoured locking plate (n=26, 92.3%), most of which used only a locking plate without LS (n=18, 88.9%).

In the context of the current study, there are very few studies in the literature that exclusively look at first MTPJ fusions using a dorsal plate alone without interfragmentary fixation. In 1979, von Salis-Soglio et al [11] retrospectively reviewed 48 cases fixated with a 4-hole non-locking dynamic compression plate and reported a fusion rate of 95.8%. Hawkins et al [12] in 2005 presented their unpublished retrospective review of 32 fusions using a pre-contoured locking plate and had a fusion rate of 94%. Lastly, in 2009, Bennett et al [13] published a prospective case series involving 233 fusions using a pre-contoured nonlocking plate and reported a fusion rate of 98.7%. Two of the three nonunions were asymptomatic fibrous unions, and none required revisional surgery.

Results

Of the 26 patients (26 feet), 17 were female and 9 were male. The average age was 57 years (39 to 76). There were 21 right feet and 5 left feet. Seven patients were current smokers at the time of surgery, 2 were former smokers, and 17 had never smoked. Pre-operative diagnoses included HR (12 patients; **Fig. 6**), severe HAV (6, **Fig. 7**), idiopathic hallux varus (1), hallux varus following bunionectomy (3, **Fig. 8**), HR following bunionectomy (2), failure of silicone implant (1), malunion of MTPJ arthrodesis (1). Concomitant procedures were performed on 10 of 26 patients, which included hammertoe corrections (7), metatarsal osteotomies (4), and in revision cases, harvesting of bone graft (2).

Two different joint resection techniques and two types of dorsal locking plates were used. In 23 patients, concave and convex reamers were used for joint resection, and an anatomic pre-contoured plate was fixated with 3.0mm locking and non-locking screws. In the other 3 patients, planar resection was performed using a sagittal saw, and a 5-hole broad straight plate was fixated with 3.5mm locking and non-locking screws.

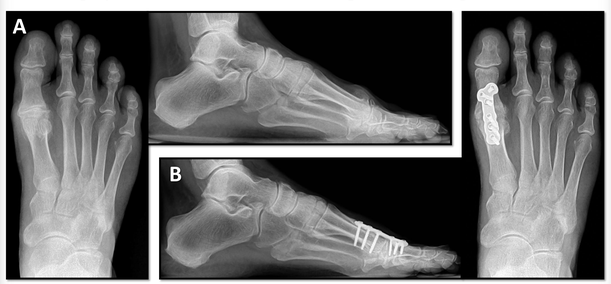

FIGURE 6. A) Pre-operative AP and Lateral radiographs of patient with HR. **B)** Post-operative AP and Lateral radiographs.

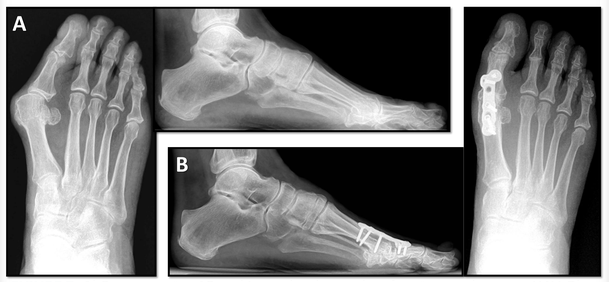

FIGURE 7. A) Pre-operative AP and Lateral radiographs of patient with severe HAV. **B)** Post-operative AP and Lateral radiographs.

Average length of follow-up was 12.42 months (4.93 to 35.1). Clinical fusion was achieved in 24 of 26 patients (92.31%). Complete radiographic fusion was achieved in 22 of 26 patients (84.6%). Other complications included broken hardware requiring removal and revision arthrodesis with crossing K-wires (1 patient), painful prominent hardware requiring removal (1), and wound dehiscence (1).

In both cases of clinical nonunion, the patients had never smoked, and the pre-contoured plate was used for fixation. In one of the cases of nonunion, the patient had a pre-op diagnosis of hallux varus following bunionectomy. At 3 months post-op, she was started on an external bone stimulator, and despite some improvement in clinical symptoms, no radiographic healing was observed at 6 months post-op. The patient elected not to have revisional surgery. In the other case of union, the patient had a pre-op diagnosis of HAV. She was noncompliant with post-op weightbearing restrictions and injured her operative foot at 3 weeks post-op, which caused the arthrodesis site to shift several millimeters. After several months of recurring noncompliance, the patient was lost to follow-up.

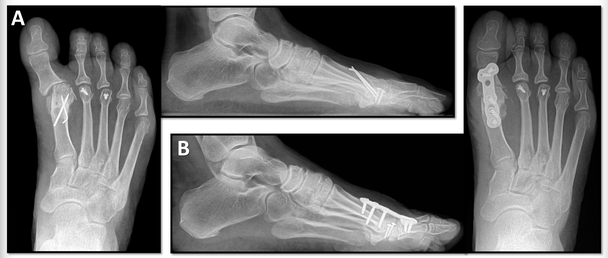

FIGURE 8. A) Pre-operative AP and Lateral radiographs of patient with hallux varus after bunionectomy. **B)** Post-operative AP and Lateral radiographs.

Analysis & Discussion

The present study evaluated 26 first MTPJ arthrodesis procedures utilizing a dorsal locking plate alone without interfragmentary fixation. Our fusion rate of 92.31% is similar to those of other case series also utilizing dorsal plate fixation alone [11-13]. Our fusion rate is also comparable to those of different fixation constructs described in the literature [1-10]. Korim et al [3] found overall fusion rates to be significantly lower in patients with HAV compared to HR. In our study, all 12 patients with a diagnosis of HR had successful fusion (100%), while one nonunion occurred in 6 patients with HAV (83.3%). Although most published reports [2,3] exclude revision arthrodesis and salvage arthrodesis after failed bunionectomy or implant, our study included 7 such procedures, with only 1 resulting in nonunion.

Limitations of our study include the following: retrospective design, lack of functional scores, limited number of patients and consequently lack of statistical analysis, use of two types of plate fixation, and multiple attending surgeons leading to variations in surgical technique and post-op weightbearing restrictions.

Overall, in light of the results of our study and similar case series, dorsal locking plate fixation alone without interfragmentary fixation for first MTPJ arthrodesis is a reliable procedure with high fusion rates comparable to other fixation constructs reported in the literature.

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