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Tips, Quips, and Pearls

Triplanar Correction for First Metatarsophalangeal Fusion

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ABSTRACT

Successful deformity correction utilizing first metatarsophalangeal (MTP) fusion for hallux valgus with concomitant degenerative changes of the first MTP joint is well documented. Currently, there is limited discussion in the literature focusing on triplanar correction of the first MTP arthrodesis. Presented is a novel approach for triplane correction and fusion of the first MTP joint utilizing a biplanar locked plating system.

A concern when choosing first metatarsophalangeal (MTP) arthrodesis is the ability to correct the hallux valgus deformity. Also of concern is the ability to correct the deformity in all 3 cardinal planes. It is understood that correcting the hallux in all 3 planes with first MTP arthrodesis can readily be accomplished. Less understood is the ability to equally correct the first metatarsal, specifically the first intermetatarsal angle (IMA), in all 3 cardinal planes with first MTP arthrodesis. This misconception is especially unknown with larger IMA deformities. Multiple authors have described and reported on IMA correction with first MTP arthrodesis in previous publications. Even with previous reports on IMA correction with first MTP arthrodesis, some continue to advocate that proximal osteotomies or other additional procedures are needed to correct large IMA following first MTP arthrodesis (1).

A systematic review was performed by Dayton et al in an attempt to examine the deformity correction obtained with first MTP arthrodesis (2). Fifteen studies were identified that reported on the correction of the hallux valgus angle and IMA following first MTP arthrodesis. Of these 15 studies, 8 studies showed an average IMA of 15 degrees preoperatively with an average IMA reduction of 3.7 degrees following the procedure. The other 7 studies reviewed had an average IMA preoperative of greater than 15 degrees. Following the first MTP arthrodesis of these patients, the mean IMA was reduced by 5.4 degrees. This review of the abovementioned 15 studies clearly illustrates a consistent reduction in IMA following first MTP arthrodesis with HV deformities without any additional procedures to gain this correction. The purpose of this paper is to illustrate a novel approach to triplane correction through first MTP arthrodesis which reproducibly corrects the hallux and first metatarsal deformities without the need for additional procedures.

Surgical Technique

The patient is placed supine, and general anesthesia or Monitored Anesthesia Care is administered. Hemostasis is obtained with either a thigh or mid-calf tourniquet. A 6 to 8 cm dorsomedial incision is made just medial to the extensor hallucis longus tendon centered over the first MTP joint. Full thickness subperiosteal dissection exposes the first MTP joint, while maintaining full thickness flaps medially and laterally to preserve blood supply to the soft tissues. The lateral and medial collateral ligaments are released exposing the head of the first metatarsal. All exuberant bony exostoses are removed as necessary from the first metatarsal head dorsally, medially and laterally and also at the proximal phalanx base with a saw or rongeur. The sesamoid complex is released with an elevator to allow relocation of the sesamoids under the first metatarsal head. This is done plantarly, medially, and laterally as needed.

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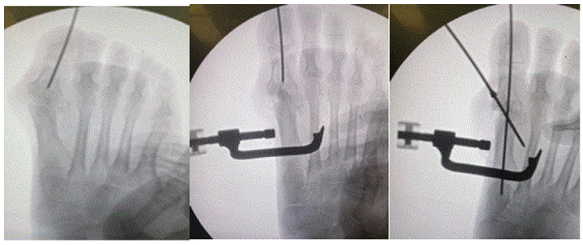

Fig. 1. Demonstrates temporary fixation wire retrograded out of hallux (*A*), the first MTP joint reduced in all planes (*B*), and the olive placed for compression and a second point of fixation (*C*).

Aggressive joint resection removes all the cartilage and subchondral bone from the first metatarsal head and proximal phalanx base. This can be done with a cup and cone reaming system, a rougeur or with a high speed burr. Final preparation for fusion involves fenestration with a 2.0 mm drill bit. Once the joint is prepared for fusion a 0.062 Kirschner-wire is advanced from the base of the hallux proximal phalanx out the end of the hallux (Fig. 1*A*) to be used to hold the corrected position of the hallux at the first MTP joint. The positioner from the Lapiplasty® 3-plane correction system (Treace Medical Concepts, Inc., Ponte Vedra, FL) is utilized to reduce the deformity in the frontal, sagittal, and transverse planes. The cup of the positioner is placed on the medial ridge of the first metatarsal at the proximal incision (Fig. 2). The opposing end of the positioner is placed on the lateral aspect of the second metatarsal through a small stab incision. The first ray deformity is then reduced in the transverse, frontal and sagittal planes by engaging the positioner. The endpoint for the reduction is elimination of the lateral round sign with reduction of the IMA and appropriate alignment of the sesamoid complex. After reduction, a 0.062 Kirschner-wire is provisionally placed retrograde out of the proximal phalanx (Fig. 1*B*). When the desired reduction of the first metatarsal is achieved, the hallux is held in appropriate position in all 3 planes. Functional position is confirmed by loading the foot on a rigid surface while the 0.062 Kirschner-wire is advanced into the first metatarsal to hold correction (Fig. 3). To prevent loss of rotational correction, a threaded olive wire is advanced, crossing the first MTP joint dorsomedially. This step also adds compression stability to the fusion site (Fig. 1*C*). Intraoperative fluoroscopy is utilized to confirm the position on both anteroposterior (AP) and lateral views. Biplanar plating is utilized to fixate the first MTP joint. The plates are placed as close to 90 degrees to each other as possible. The dorsal plate is placed just lateral to the midline spanning the first MTP joint. The plate is temporarily fixated with an olive drill pin placed through the preloaded drill guides which also provides the drill hole for screw insertion. The locking screws for the biplanar plating system are 12 mm and 14 mm in length for a locking uni-cortical purchase. This creates stability in all 3 planes of motion. The second plate is placed medial spanning the first MTP joint, as care is taken to contour the plantarmedial base of the proximal phalanx to ensure appropriate placement of the medial plate.

Fig. 2. Shows positioner placement for triplane correction at the first metatarsophalangeal (MTP) joint.

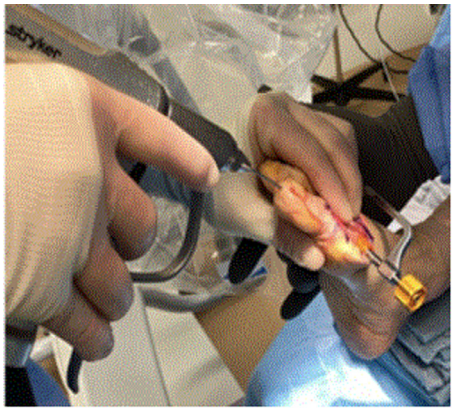

Fig. 3. The first metatarsophalangeal (MTP) joint is loaded and the hallux is supinated to hold reduction in all three planes as the K-wire is advanced.

Intraoperative fluoroscopy confirms final position and biplanar plate placement (Fig. 4). The final biplanar construct is demonstrated intraoperatively (Fig. 5) and on final radiographs (Fig. 6). Preoperative and postoperative radiographs are shown demonstrating triplanar correction with first MTP fusion (Fig. 7).

Discussion

Satisfactory outcomes after first MTP arthrodesis are related to achieving a successful union, as well as proper union position that ultimately affects foot function. Poor union positioning may subsequently lead to additional pathology and require further revision surgery (3). A review by Roukis on first MTP fusions noted an overall nonunion rate of 5.4%, a malunion rate of 6.1%, and an 8.5% rate of hardware removal (4). Although union rate was good, the malunion incidence and rates of hardware removal needed improvement. Hardware placement and proper union position are important to achieve bony union and maintain foot function.

While the literature varies on recommended position for first MTP fusion, 10 to 15 degrees of abduction and 10 to 25 degrees of dorsiflexion appear to be the consensus (3–6). A dorsiflexion angle higher than this results in a flexion contracture of the hallux interphalangeal (IP) joint and altered gait mechanics. In the authors' experience, excessive dorsiflexion of the hallux leads to severe pain plantarly at the first metatarsal head and sesamoids due to altered gait mechanics resulting in increased pressures with weightbearing and callous formation. Excessive dorsiflexion of the hallux may also lead to IP joint arthritis

Fig. 4. The biplanar 90-90 plating construct for first metatarsophalangeal (MTP) fusion.

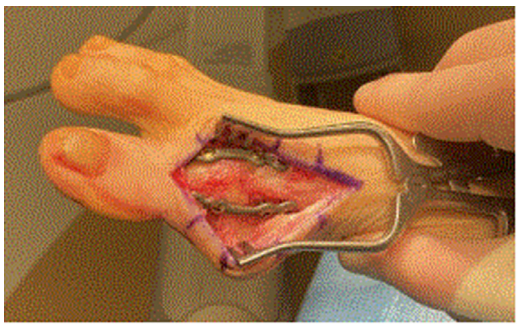

Fig. 5. The final biplanar plating construct is demonstrated.

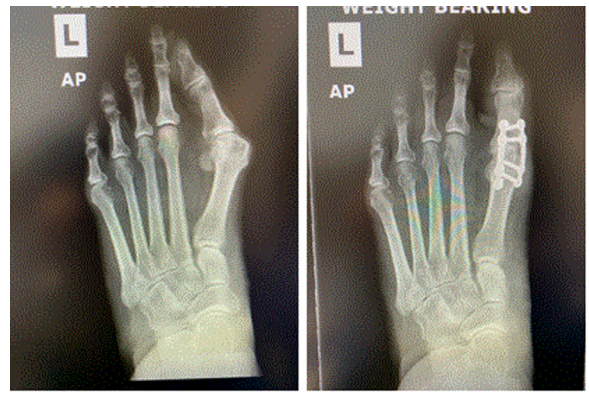

Fig. 7. Preoperative and postoperative anteroposterior (AP) radiographs showing the triplanar first MTP fusion.

and pain distally in the hallux from shoe wear. The authors feel the ideal position for first MTP fusion is by positioning the hallux slightly off the weightbearing surface (7).

The hallux dorsiflexion angle after first MTP fusion plays an important role in plantar pressures of the hallux and first metatarsal head during gait (8). A dorsiflexion angle greater than 15 degrees clinically and greater than 30 degrees radiographically resulted in increased plantar pressures at the first metatarsal head. Therefore, it is recommended that first MTP fusions achieve a dorsiflexion angle less than 30 degrees radiographically and 15 degrees clinically to prevent this complication. Alternatively, if the hallux is positioned too low then IP joint arthrosis may develop from dorsal jamming or transfer metatarsalgia may result from subsequent lateral weight transfer.

Most of the research on the ideal position of the hallux focuses on the sagittal and transverse planes. In the authors' experience, the frontal plane positioning is just as important if not more important than the sagittal and transverse planes. Failure to supinate the hallux results in several defects in position and function. First, a pronated hallux causes weightbearing on the medial hallux IP joint and leads to callus and pain. Second, the authors have consistently observed that a pronated hallux affects the first ray position pushing the IMA open higher. The authors have found a dramatic IMA reduction effect when the hallux is supinated as part of the triplanar first MTP fusion. Although the exact mechanism of the maintenance of reduction has not been confirmed experimentally, the observation of the IMA reduction which has been made by the authors is very consistent. Once the hallux position is locked into place with the fixation described, fusion prevents the first metatarsal from moving back into an adducted and pronated position. As with many fusion procedures locking the position of one joint affects the position and function of adjacent joints. With respect to the first ray, triplane movement of the first metatarsal corrects the hallux position due to the functional connection of the structures. In the case of MTP fusion, the same functional connection is exploited using the hallux to drive the correction more proximal. Although this may not be intuitive, you can see a real-time change in the IMA and sesamoid position with adduction and supination of the hallux. It is this functional association of the first ray structures that makes it possible for triplane MTP fusion to correct and maintain consistently normal IMA. This is accomplished by exploiting the normal mechanical connection between the segments through motion at the proximal first ray articulations; eg, the TMT and the navicular-cuneiform joints.

Fig. 6. Radiograph showing the final biplanar plating construct.

Choice of fixation also plays a key role in hallux positioning. Excessive hallux dorsiflexion may result from precontoured plates and natural shape of the hallux proximal phalanx (9). The hallux proximal phalanx has a conical configuration, allowing flat plates at the first MTP joint to provide 15 degrees of dorsiflexion naturally. A flat plate creates a functional dorsiflexion position after the dorsal prominences are removed, which is related to the natural configuration of the hallux proximal phalanx forming a 30-degree angle at the dorsal and plantar surfaces. A dorsiflexion angle over 15 degrees may result with increased bending of the plate, a potential problem with precontoured plates. A study by Marsland et al found that precontoured plates placed dorsally may lead to excessive dorsiflexion clinically relating to the dorsiflexion angle at the first MTP joint being considerably smaller than the IMA (10). Placement of the plate more proximally resulted in greater dorsiflexion angles regardless of plate type, although the greatest changes were seen with precontoured plates (11). These findings demonstrate the importance of hallux position and choice of fixation for achieving the ideal position for first MTP fusion.

With biplanar plating, the plates are applied 90 degrees to each other as described after achieving satisfactory positioning of the fusion site, which helps avoid many of the pitfalls of anatomic plates. In addition, biplanar plating provides excellent stability for healing (12–14). Previous studies have shown biplanar plating to be a stronger construct and better form of biologic fixation than certain anatomic plates to allow physiologic micromotion and promote healing (12–15). Biplanar fixation provides a stable construct and allows the surgeon more precision controlling motion in all 3 planes.

In conclusion, achieving triplanar correction is important during first MTP fusion. This technique and plating system allows full anatomic correction and natural bone healing.

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