First Metatarsal-Cuneiform Arthrodesis for the Treatment of First Ray Pathology: A Technical Guide

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The first tarsometatarsal arthrodesis is a powerful procedure often utilized in the correction of first ray pathology. It is primarily used to correct moderate to severe hallux abducto valgus deformity. The authors present this review as a summation of the classic and recent literature while offering a detailed illustrated technique guide for the first tarsometatarsal arthrodesis. (The Journal of Foot & Ankle Surgery 48(5):593–601, 2009)

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The first tarsometatarsal arthrodesis (TMA) is a powerful procedure often utilized in the correction of first ray pathology. Although primarily used to correct moderate to severe hallux abducto valgus (HAV) deformity, it may be used in a variety of first ray and medial column pathology, including juvenile HAV, revisional HAV surgery, hallux limitus, hallux rigidus, met primus varus, met primus elevatus, arthrosis of the first metatarsal-cuneiform joint (TMJ), and medial column instability. Since its inception in the early 1900s, there have been many modifications used to enhance outcomes and minimize complications. Many of these advances are related to the advent of modern internal and external fixation. Although the incidences of complications are relatively low, the most common complication after infection is nonunion.

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Classic Literature Review

Although originally introduced by Albrecht in 1911 (1) and further described by Truslow in 1925 (2) and Kleinberg in 1932 (3), the first TMA did not gain acceptance until popularized by Paul W. Lapidus in 1934 (4). Lapidus believed that an “atavistic” foot type and “arrest of ontogenic development” led to an excessively adducted first metatarsal at the first TMJ and subsequent hallux valgus (Figure 1). Lapidus originally recommended patients who were “young and robust,” with “fixed” deformity at the first TMJ as surgical candidates (5). Additionally, a first intermetatarsal angle of 15° or higher was regarded as the radiographic threshold for performing the first TMA.

The procedure Lapidus first described included arthrodesis of the first TMJ, arthrodesis of the first and second metatarsal bases, and medial capsulorrhaphy of first metatarsophalangeal joint (MTPJ). Fusion sites were prepared with drill holes and fixation was accomplished with cat gut suture (5). After 25 years, Lapidus reported his experience and described the first TMA useful in “properly selected cases,” reserving the procedure for significant hypermobility and deformity (5).

Over the last 75 years, there has been much controversy and debate on the use of the first TMA procedure and its indication for correction of HAV, with particular focus on the...
role of the hypermobile first ray. Yet, despite the lack of consensus on its indications and use, the first TMA still remains one of the most common procedures utilized for correction of first ray pathology. Considering the number of years that have elapsed since the first report in the literature, it is surprising to find that the number of prospective outcome studies reported is quite low. Although there have been multiple retrospective studies (6–15), prospective studies are less plentiful. Coetzee et al in 2003 (16) prospectively evaluated 26 patients who underwent a first TMA for failed HAV surgery. Their procedure included arthrodesis of the first TMJ and arthrodesis of the first and second metatarsal bases utilizing screw fixation. They reported a significant reduction in the postoperative VAS (visual analog scale) (6.2 to 1.4) and an improved American Orthopaedic Foot and Ankle Society (AOFAS) score (47.6 to 87.9). No “dissatisfied” patients were reported. Faber et al in 2004 (17) performed a prospective randomized trial in 101 feet, comparing the Lapidus procedure with the Hohman procedure. Similar to previous findings, the AOFAS score increased from 52 preoperatively to 87 postoperatively, with no difference between procedures or subgroups. The only differences found were radiographic in that the Lapidus procedure demonstrated greater plantarflexion of the first metatarsal, whereas the Hohman procedure showed greater shortening of the first metatarsal. Finally, in 2004 Coetzee and Wickum (18) reported prospectively on 105 feet in 91 patients that were followed up for an average of 3.7 years. Similar to previous findings, the AOFAS score increased from 52 preoperatively to 87 postoperatively. There were significant reductions in both the intermetatarsal and hallux abductus angles. They also reported their complications, stating there were 7 (6.7%) nonunions that required revision. In summation, although well-defined indications for use of the Lapidus procedure are unclear, the literature supports the use of the Lapidus procedure for correction of first ray deformities with and without hypermobility.

Technique Guide

Anesthesia may be achieved with either a general inhalation anesthetic or monitored anesthesia care. Local anesthesia is recommended in either case, as decreased exposure to
systemic agents is preferred. The agent used for local blockade is under the discretion of the surgeon. Positioning of the patient is in the supine position, with the heel at the end of the operative table. The operative foot should be placed in a rectus position. An ipsilateral bump placed under the buttock may be necessary to achieve desired positioning. There have been multiple incisional approaches described in the literature. These include 3, 2, and 1 incisional approaches. The 3-incisional approach includes an incision over the first TMJ, the medial first MTPJ, and the first inter-space. The 2-incisional approach includes the first TMJ incision, and the first MTPJ incision. Finally, the single-incision approach extends from the mid portion of the medial cuneiform to the mid portion of the hallux proximal phalanx. This is the preferred approach of the authors (Figure 2). The incision courses along the dorsomedial foot, just medial to the extensor hallucis longus tendon. Sharp dissection is carried through the epidermis and dermis, with blunt dissection with scissor or hemostatic forceps being used for subcutaneous tissues. The dissection of the first MTPJ is undertaken for release of joint contracture and resection of the prominent medial eminence if necessary. Blunt reflection of deep fascial tissues along the medial aspect of the first MTPJ is performed with attention directed to neurovascular structures of the medial foot. In contrast to distal osteotomies, there is less dissection about the medial eminence secondary to the absence of an osteotomy in the distal metatarsal. Next, attention is directed to the first metatarsal interspace in which blunt dissection allows for a lateral capsule release if desired. The decision to perform a lateral release and which structures should be released is under the discretion of the surgeon. The authors perform a sequential release of the adductor tendon, metatarsal sesamoidal ligament, and sesamoidal phalangeal ligament as necessitated by the deformity. A periosteal-capsular incision is made along the dorsomedial first MTPJ in the interval between the extensor hallucis longus and extensor hallucis capsularis (Figure 3). The extent of the incision should allow for exposure to the medial eminence. The authors use an “L” type capsulotomy for exposure of the eminence, which is subsequently resected with power instrumentation with careful attention to maintain the sagittal groove. Once the contrac-

FIGURE 3 Anatomic relationship of extensor hallucis longus (black line), extensor hallucis capsularis (blue line), and placement of periosteal/capsular incision (red line).

FIGURE 4 Subcutaneous dissection with the course of the medial dorsal cutaneous nerve (red arrow) traveling from lateral to medial within the incision.
mobilized, it is manually reduced while an abductory force is placed upon the first metatarsal to assess realignment. Once satisfactory, dissection of the first TMJ is undertaken, and special attention must be paid to the course of the medial dorsal cutaneous nerve, which often crosses from lateral to medial within the incision (Figure 4). A periosteal-capsular incision is made dorsally from the midpoint of the medial cuneiform traveling distally to approximately 1 to 1.5 cm distal to the first TMJ (Figure 5A). Perisoteal dissection is continued plantarly (Figure 5B). Other authors have purported a vertical capsulotomy at the first TMJ to decrease the amount of periosteal reflection, thereby reducing the chance of bone healing complications. The authors have not found their periosteal dissection to be problematic as long as careful layer dissection and closure are used. When dissecting the lateral aspect of the first TMJ, attention must be given to the course of the dorsalis pedis artery laterally and the perforating artery plantarly just distal to the conjunction of the first and second metatarsals. Once the first TMJ is released, a Weinraub retractor is placed to further open the arthrodesis site and joint resection may be undertaken. The authors utilize osteotomes (Figure 6), although it is recognized that curettage or use of power instrumentation may produce similar results. The base of the first metatarsal is resected, removing just cartilage. The plane of the cut is perpendicular to the long axis of the first metatarsal. The resection is from a medial to lateral direction, with caution taken when approaching the lateral aspect of the metatarsal to avoid the aforementioned neurovascular structures as well as the second metatarsal base. If wedge resection is desired, then the osteotomy may be directed to allow for plantar and laterally based wedges off the metatarsal to create
greater abduction and plantarflexion of the first metatarsal. Once the metatarsal cartilaginous base has been resected, the medial cuneiform cartilage may now be resected. The cuneiform cartilage is also resected from medial to lateral.

The orientation of the bone cut is perpendicular to the long axis of the cuneiform. Because of the commonly present obliquity of the articular surface, the osteotomy often creates a laterally based wedge resection. Particular attention must be paid to the lateral and plantar aspects of the fusion site because these often retain cartilaginous remnants. Often, the insertion of peroneus longus is encountered at the plantar lateral aspect of the first metatarsal base and the flare of the metatarsal is firmly adhered. A rongeur may be used to remove the adhered bone (Figure 7). If the lateral flare of the metatarsal is prominent, then it may be resected within the sagittal plane to narrow the metatarsal to allow for translation. Once appropriate joint resection (with or without wedging) is complete, then preparation of the arthrodesis site is undertaken. This may be performed with subchondral drilling using 0.035- to 0.045-inch Kirschner wire (K-wire) (Figure 8) or a ~1.5-mm drill bit. “Fish scaling” was performed with an osteotome or microfracture technique. The authors prefer the microfracture technique with the use of a small awl or pick and mallet. The goal of arthrodesis site preparation is to achieve a healthy bleeding substrate. This can be identified by the presence of pinpoint bleeding at the osteotomy site, also known as the “paprika sign.” The metatarsal may be transposed laterally and plantarly as needed. If wedge resection is used, transposition may not be necessary. Next,
temporary fixation with a 0.062-inch K-wire is used at the arthrodesis site (Figure 9), and the position is evaluated radiographically. If necessary, a K-wire may be placed between the first and second metatarsals to ensure intermetatarsal space reduction (Figure 10). Special attention must be paid to intermetatarsal reduction, hallux position, sesamoid position, and the metatarsal parabola to ensure avoidance of transfer metatarsalgia, recurrence, hallux varus, and other postoperative complications. Positioning of the arthrodesis site is of paramount importance and, in the authors’ opinions, intraoperative fluoroscopy is a necessity (Figure 11). Clinically, the foot should be balanced, with even weight distributed between the medial and lateral columns while loading the forefoot.

Once satisfactory positioning is achieved, the arthrodesis is stabilized with internal fixation. Many fixation techniques may be utilized including K-wires, screws (both cannulated and solid core), plating systems (locking and nonlocking), external fixation (monorail), or a combination. The authors prefer the use of a locked plating system (typically a 3.5-mm “H-plate” configuration) combined with an interfragmentary compression screw (typically 3.5-4.0mm). The compression screw is placed first and is directed from plantar medial to dorsolateral (Figure 12). The screw will engage the plantar first metatarsal cortex and the endosteal cortical bone at the dorsolateral aspect of the medial cuneiform. Positioning of this screw enables resistance of ground reaction forces. The plate is then placed in a dorsomedial position. Temporary fixation of the plate with K-wire or olive wires is recommended to hold the desired position (Figure 13). Drilling and measurement are performed in the typical fashion. If further stabilization is desired, then one can lengthen the plate screws to enable penetration of the intermediate cuneiform.

Completion of the arthrodesis of the first TMJ is followed by first MTPJ capsulorrhaphy and closure to maintain a rectus position of the hallux. The authors perform a dorsally based rhomboid wedge resection from the medial capsule. The capsule is closed with 2-0 gauge absorbable suture. Deep
capsular closure is on a bias from proximal dorsal to distal plantar to ensure reduction. The remaining periosteal and capsular layers are closed with a similar technique, in an over-and-over interrupted fashion. Subcutaneous tissues are closed with an absorbable 4-0 gauge suture, in a continuous running fashion. Finally, skin closure is achieved with a 5-0 gauge absorbable suture in a continuous running fashion. A dry, sterile dressing is applied, including an ACE\textsuperscript{TM} bandage (Becton, Dickinson and Company, Franklin Lakes, NJ) for compression. A nonweightbearing short leg cast is applied for a period of 8 weeks. Cast changes occur at 1, 4, and 8 weeks. Serial radiographs are performed immediately postoperatively and at 4 and 8 weeks. Typically, transition to a weightbearing cast occurs at the 8-week interval.

Discussion

The first TMA, popularly known as the Lapidus procedure, remains a mainstay for the treatment of first ray pathology, with the majority of its use seen in the correction of moderate to severe HAV deformity with or without hypermobility. Although the precise indications for its use are under constant debate, the majority of the literature (primarily retrospective, with few prospective studies) has been favorable with respect to the outcome of the procedure. These outcomes include both radiographic and clinical outcomes.

Pearls

1. When resecting the joint, using a mini-Hohman retractor or malleable retractor within the first interspace will protect the neurovascular structures and second metatarsal base.
2. Because of the inherent risk of nonunion, joint preparation must be performed correctly. Although there are data to support the onset of osteonecrosis with use of excessive drilling (19), patient-based comparisons of
Joint preparation techniques in foot surgery do not exist. In theory, the use of microfracture or “fish scaling” should decrease the probability of thermal osteonecrosis.

3. Removal of the subchondral bone plate is also debatable. Most authors advise leaving the subchondral bone plate intact (with subchondral bone plate perforation) to maintain the length and stability of the bone (8–11, 20). In contrast, subchondral bone has been described as “corticalized” bone (21). Therefore, some authors believe that removing the subchondral bone plate will aid in consolidation of the arthrodesis site (18). If shortening occurs, then bone grafting can be utilized. Use of the resected medial eminence has been described as a suitable bone graft (18). It is the authors’ opinions that, at the very minimum, significant perforation of the subchondral bone plate must be performed, if not complete removal.

4. Further wedge resection, if necessary, should be taken off of the first metatarsal base. The first metatarsal is the mobile segment and is easier to manipulate. Often, once the joint surfaces have been resected, the first metatarsal can be swiveled or transposed to reduce the first intermetatarsal angle, thus reducing the need for wedge resection.

5. Occasionally, it is necessary to resect the lateral flare of the first metatarsal base to increase the ability to swivel or translocate the first metatarsal. Sharp dissection of the plantar soft tissue attachments may be necessary.

6. Use of a smooth lamina spreader or Weinraub retractor will aid in visualization of the arthrodesis site.

7. The advent of step-off plating (Wright Medical DARCO LPS locking plate; Wright Medical Technology, Inc., Arlington, TN) allows the surgeon to swivel or transpose the first metatarsal without further bone resection or plate bending.

8. If plating is used, then one must consider a compression screw to enhance apposition at the fusion site. Locking plate and screw systems provide nice stability, but often do not afford the compression obtained with a compression screw. The authors recommend 3.5-mm or larger screws.

9. Stabilization of the medial column can be enhanced with elongated screws within the plate and/or the compression screw. Using longer screws that traverse the

FIGURE 15 Preoperative (A) and immediate postoperative (B) radiographs showing reduction of deformity.
intercuneiform or intermetatarsal joints will add stability (Figure 14).

10. Temporary fixation with K-wires or guide pins in multiple planes can aid in the maintenance of correction during permanent fixation. Use of a K-wire from the first to second metatarsal allows for consistent reduction and maintenance of correction of the first intermetatarsal angle while plate and screw fixation are applied.

In conclusion, the first TMA is a powerful procedure that may be utilized in various first ray pathologies (Figure 15). Complications include nonunion, delayed union, metatarsalgia, and sesamoiditis. These complications are under control of the surgeon and may be avoided with proper surgical techniques such as arthrodesis site preparation, use of temporary fixation, and intraoperative fluoroscopy. Further prospective studies are needed to further evaluate the success of the procedure.

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