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SPECIAL FOCUS

Correction of Hallux Valgus Deformity Using the Mini TightRope Device

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ABSTRACT

The correction of the first intermetatarsal angle (IMA) has by and large relied on a distal or proximal osteotomy of the first metatarsal. In addition to being potentially technically challenging, these osteotomies are also prone to the complications of shortening, dorsiflexion angulation, delayed union, and nonunion. The use of fiberwire-attached metallic buttons to close and maintain the IMA provides an innovative alternative to the technical challenges and potential complications associated with traditional metatarsal osteotomies. This article describes the surgical technique for the correction of the IMA component of hallux valgus deformity.
Keywords: intermetatarsal angle (IMA), hallux valgus (HV), fiberwire, Mini TightRope

HISTORICAL PERSPECTIVE

Currently, the backbone of operative procedures for the correction of the first intermetatarsal angle (IMA) associated with hallux valgus deformity relies on the use of either a distal or a proximal first metatarsal osteotomy. These correctional osteotomies are used in conjunction with lateral capsular release, resection of the medial eminence, and medial capsular plication. The location of the osteotomy of the first metatarsal, distal versus proximal, is predicated on the degree and location of the deformity.[1]

Distal osteotomies have been advocated for the correction of hallux valgus deformity associated with mild IMA deformity of 15 degrees or less.[2] Among numerous available distal osteotomies include the chevron osteotomy, the Austin bunionectomy, and the Mitchell osteotomy.[3–6] Potential complications include malunion, shortening, and avascular necrosis.[6]

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Proximal osteotomies have been recommended for the correction of IMA greater than 15 degrees.[1] Available osteotomies include the proximal chevron, proximal crescentic, Ludloff, scarf, proximal closing wedge, and Mau osteotomy.[7,8] The potential complications associated with proximal osteotomies include shortening of the first metatarsal, loss of fixation, delayed union, nonunion, and malunion (ie, elevation of the first ray).[9–11]

The osteotomy-sparing technique using fiberwire-attached buttons (Mini TightRope) was developed as a technical advancement over the available osteotomy techniques and to decrease or eliminate the complications associated with first metatarsal osteotomies.

INDICATIONS AND CONTRAINDICATIONS

The Mini TightRope is indicated for the correction of symptomatic hallux valgus deformities with a congruent joint with an IMA less than 15 degrees and an incongruent joint of essentially any magnitude including those with an IMA greater than 15 degrees.

The use of the Mini TightRope is contraindicated in the presence of arthrosis or dorsoplantar hypermobility of the first metatarsal cuneiform (M-C) joint, a proximal first metatarsal facet abutting the base of the second metatarsal, arthrosis of the first metatarsophalangeal (MTP) joint, lateral angulation of the distal metatarsal articular angle, large congruent deformities, diabetes mellitus, rheumatoid arthritis, gout, and neuromuscular disease. The presence of an interphalangeus deformity will necessitate the additional utilization of an Akin procedure. To date, I have no experience combining the use of the Mini TightRope with a proximal metatarsal osteotomy. However, I and others have used the Mini TightRope along with a Lapidus procedure with good results.

PREOPERATIVE PLANNING

As with all patients with hallux valgus deformities, it is important to obtain a complete history of the patient's complaints. It is important to determine the degree and location of the pain. A minimally painful bunion may

not require surgical intervention. Even in the presence of pain, there should be an attempt at conservative measures before surgery of any nature. It is important to determine if the pain is isolated to the medial eminence or if it also includes the sesamoids, interphalangeal joint, or the M-C joint.

The history should question the patient regarding the presence of rheumatoid arthritis, diabetes, gout, systemic inflammatory arthropathies, or neuromuscular disease. The presence of one or more of these processes will be at least a relative contraindication to using the Mini TightRope.

Always consider the presence of associated conditions such as hammertoes, clawtoes, intractable plantar keratoses, neuromas, and corns.

The physical examination should include observation, foot position, range of motion, motor function, gait, the presence or absence of hypermobility of the first M-C joint, vascular assessment, and neurologic assessment.

The weight-bearing radiographs should be analyzed for the determination of the HVA, the IMA, the interphalangeal angle, the distal metatarsal articular angle, the presence or absence of arthrosis of the first MTP joint, the presence or absence of arthritis of the first M-C joint, the size of the medial eminence, and the presence of a facet or os intermetatarseum at the lateral base of the first metatarsal. Reducibility of the M-C joint can be assessed preoperatively by obtaining an anterior-posterior weight-bearing film with the forefoot wrapped with coband, an ace, or bunion-type tapped dressing.

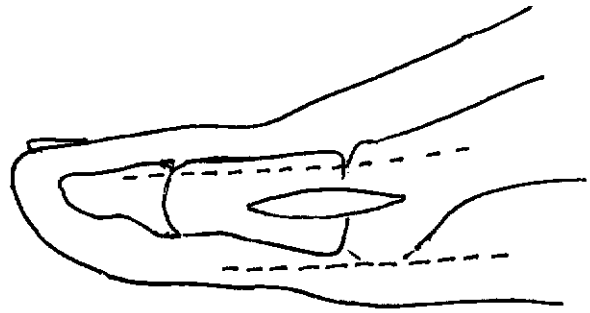


FIGURE 2. Medial approach to the first MTP joint.

■ TECHNIQUE

The technique of the Mini TightRope uses a 2 incision approach (Figs. 1 and 2). The initial dorsal incision is F1 F2 made in the interspace between the distal aspect of the first and second metatarsals. This allows for the release of the adductor tendon from its attachment to the base of the first proximal phalanx and to the lateral aspect of the fibular sesamoid (Fig. 3). This is followed by transection of the deep intermetatarsal ligament with a #11 or #15 blade. A freer elevator is placed beneath the ligament to protect the underlying neurovascular structures. The lateral capsule of the first MTP joint is released by a series of perforations of the lateral capsule followed by a varus stress to the joint. F3

Attention is now directed toward the release of the intermetatarsal ligament between the second and third metatarsal heads through the same dorsal incision

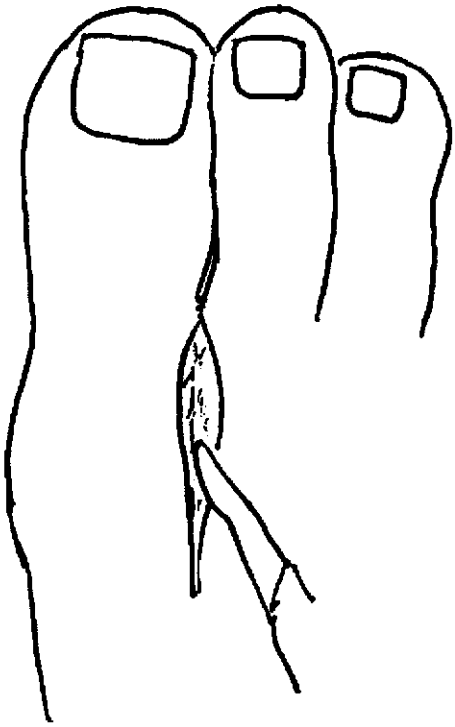


FIGURE 1. Dorsal incision between the first and second metatarsals.

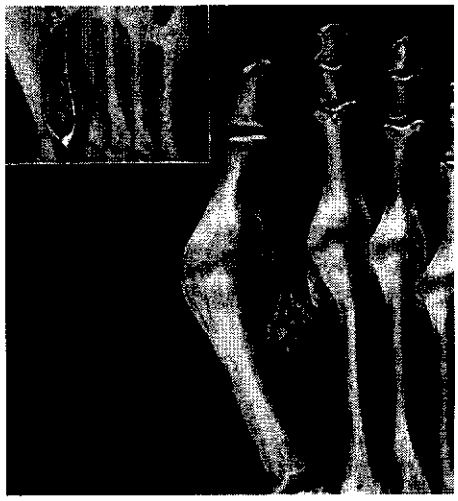


FIGURE 3. Release of the adductor and intermetatarsal ligament.

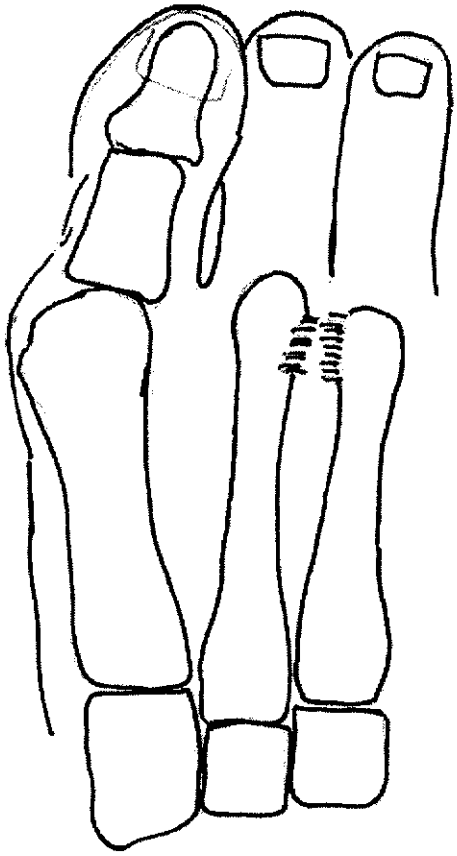


FIGURE 4. Release of the second intermetatarsal ligament.

F4 (Fig. 4). A Weitlander retractor or Senn retractor is usually sufficient to allow for exposure of the second interspace. A laminar spreader is placed between the second and third metatarsals to place tension on the intermetatarsal ligament. Again protecting the interdigital nerve with a freer elevator beneath the ligament, a #11 or #15 blade is used to cut the ligament in a longitudinal direction.

The reducibility of the IMA is now assessed by manually applying medial and lateral compression across the forefoot (Fig. 5). The preoperative assessment has F5 excluded the presence of arthritis of the first MTP joint or the first MC joint. The preoperative physical has also excluded hypermobility of the first MC joint. If the IMA can be manually reduced, one can proceed with the planned use of the syndesmotic suture-attached buttons (Mini TightRope) for reduction of the IMA. To date, I have not had to abandon the use of the Mini TightRope intraoperatively due to irreducibility of the IMA: (1) when there is no lateral facet of the proximal first metatarsal abutting the second metatarsal and (2) when there is no arthritis, hypermobility, or excessive medial angulation of the first MC joint.

Before addressing the medial eminence and the medial capsule, 3 separate sutures of 2-0 Vicryl sutures are placed in the first interspace. Using a #6 or #7 Mayo needle, 3 separate sutures are passed in order to incorporate the lateral capsule of the first MTP joint, the previously released adductor tendon, and the medial capsule of the second MTP joint (Fig. 6). The sutures are indi- F6 vidually tagged for tying later in the procedure.

Attention is now turned to the medial aspect of the first MTP joint via a longitudinal incision oriented between the dorsal and plantar digital nerves. Dorsal and plantar flaps are created avoiding injury to the respective digital cutaneous nerves. The capsule is entered through

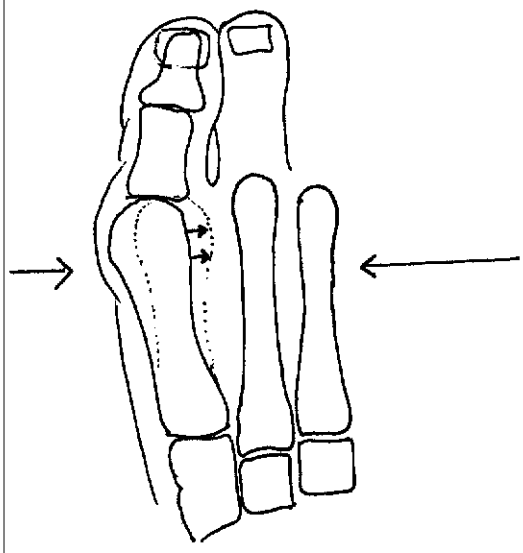


FIGURE 5. Lateral translation of the first metatarsal.

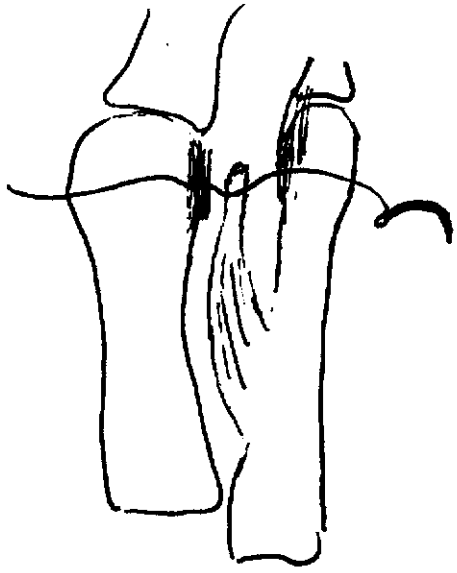


FIGURE 6. Suture incorporating the adductor tendon and the capsules of the first and second metatarsals.

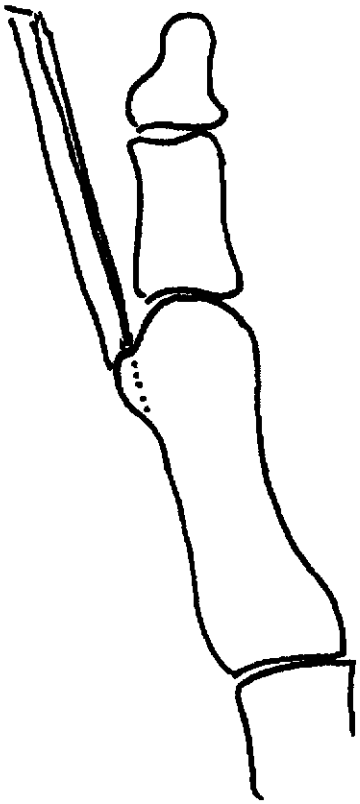


FIGURE 7. Removal of the medial eminence.

an inverted v-incision, and the medial eminence is removed with an osteotome. The eminence should be removed just medial to sulcus to prevent overexcision of the medial eminence (Fig. 7). F7

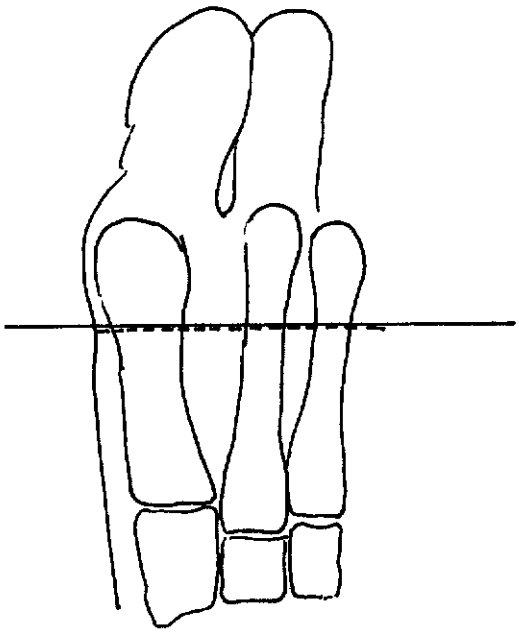


FIGURE 8. Orientation for guide pin placement.

With a fluroscan aligned to take an anterior-posterior view of the foot the guide wire is placed over the foot in order that the pin will exit medially just behind the confluence of the first metatarsal shaft (shelf area) and the proximal flare of the medial eminence (Fig. 8). Laterally, the pin should be aligned well proximal of the neck of the second metatarsal. A skin scribe is used to mark this path on the dorsal aspect of the foot. Using this skin-marked template, the guide wire is inserted transversely from the lateral aspect of the second metatarsal. Exposure to the lateral shaft is facilitated with the use of Homan or baby Chandler retractors. The guide pin must engage the midshaft portion of the second metatarsal (Figs. 9A, B*). To engage the first metatarsal, the guide pin is generally aimed slightly plantarward. After the guide pin passes through the lateral cortex of the second metatarsal, the retractors are shifted to the first F8 F9 AQ2

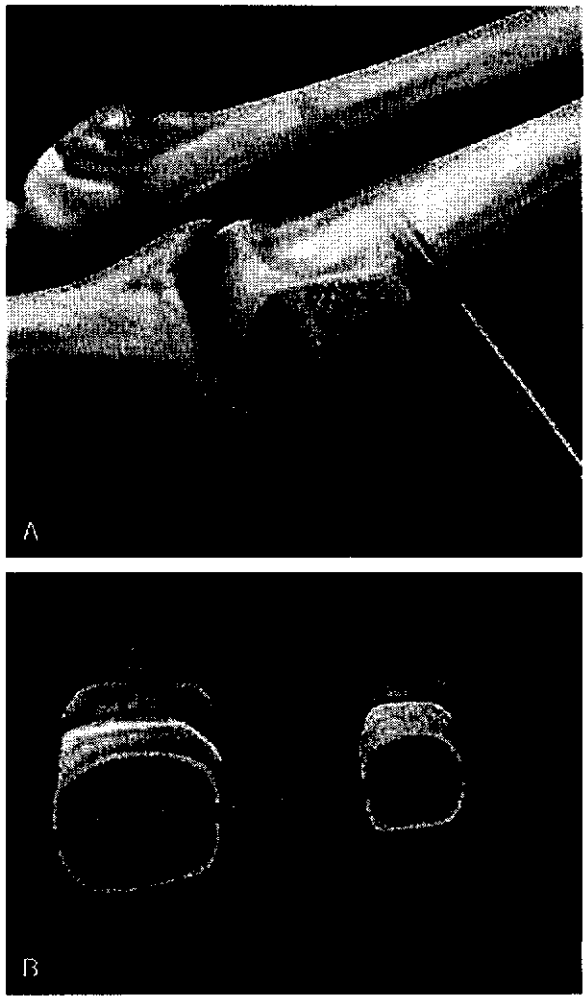


FIGURE 9. A, Guide pin crossing the first and second metatarsals. B, Guide pin bisecting the first and second metatarsals.

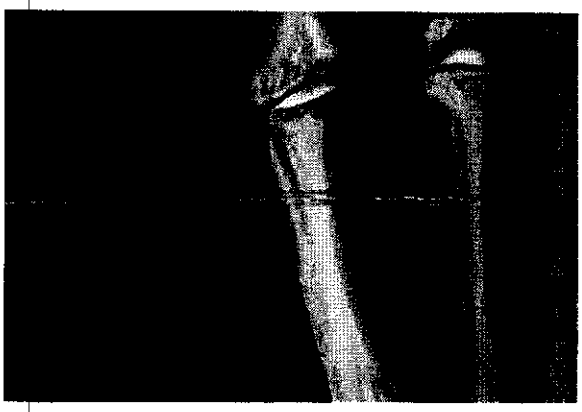


FIGURE 10. Drilling over the guide wire with the 2.7-mm drill.

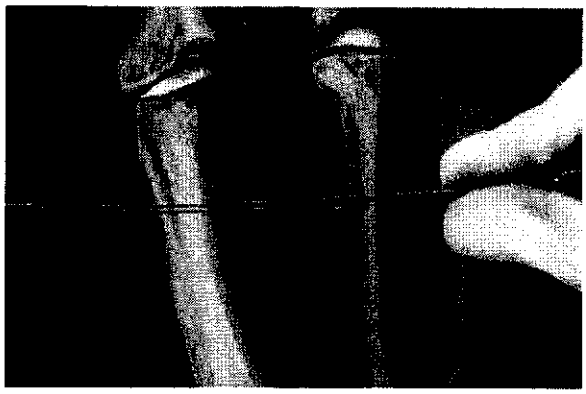


FIGURE 12. Passage of the oblong button through the drill hole.

metatarsal to visualize the passage of the guide wire across the interspace to the medial cortex of the first metatarsal. Because the first metatarsal is significantly larger than that of the second metatarsal, it is fairly easy to engage the first metatarsal without further dorsal or plantar adjustments of the guide wire. The guide wire is then advanced out the medial aspect of the first metatarsal.

The bone tunnel for passage of the buttons is drilled over the guide wire using the 2.7-mm cannulated drill bit aiming from a medial to lateral direction from the first F10 to the second metatarsals (Fig. 10). The needle guide system is used to thread the farside oblong button through both drill holes in a lateral to medial direction F11 (Fig. 11). This will place the oblong button on the F12 medial aspect of the first metatarsal (Fig. 12). After passage of the oblong button through the drill hole, it is flipped 90 degrees to engage the medial cortex (Fig. 13). The pulling suture attached to the oblong button is then cut (Fig. 14). The lateral, round button is F13 F14 tightened against the lateral cortex of the second metatarsal by pulling on the 2 fiberwire sutures exiting the laterally placed round button. To prevent shear on the sutures, the pull should be with the 2 sutures in line with one another rather than pulling them apart (Fig. 15). The surgeon has the option of maintaining F15 the reduction of the IM angle during the drill process or achieving the reduction again after passage of the buttons. The reduction is checked with the fluroscan or C-arm. The buttons should be well seated on the cortex of the metatarsals. Five knots are then made with the fiberwire to secure the reduction. The fiberwire is cut

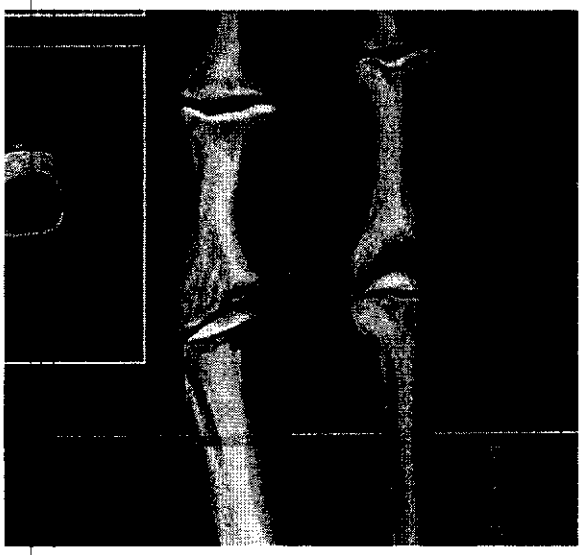


FIGURE 11. Passage of the needle lateral to medial.

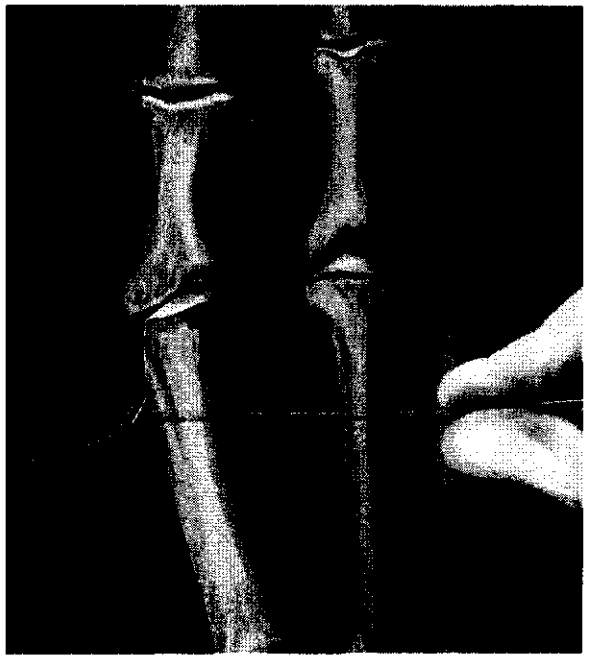


FIGURE 13. Flipping the oblong button to engage the first metatarsal.

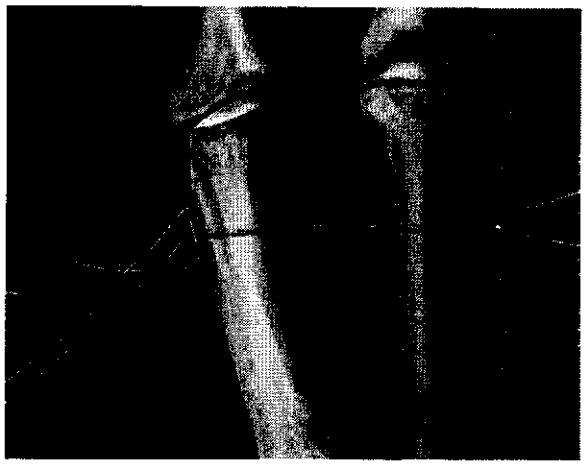


FIGURE 14. Release of the pulling suture for the oblong button.

with a small tail so that the knot will be of sufficient length so that it may be folded plantarward to reduce any subcutaneous prominence.

The previously placed 2-0 Vicryl sutures are now tied between the first and second metatarsals. The medial capsular structures are plicated in the standard fashion to facilitate the correction and maintenance of the hallux valgus angulation. The intermetatarsal and medial first MTP incisions are closed in a routine manner. After the final films, the patient's foot is placed in

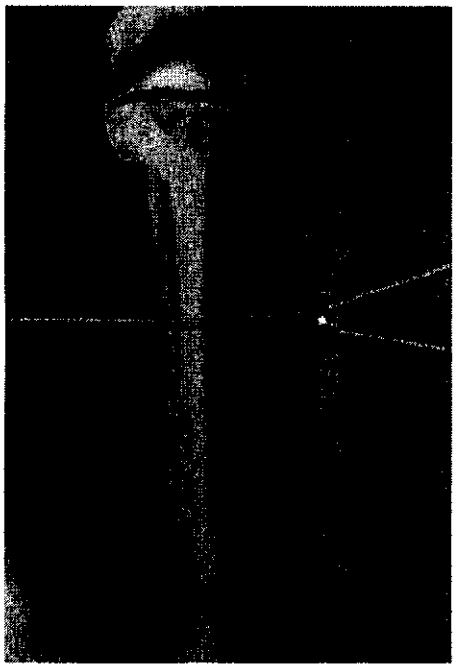
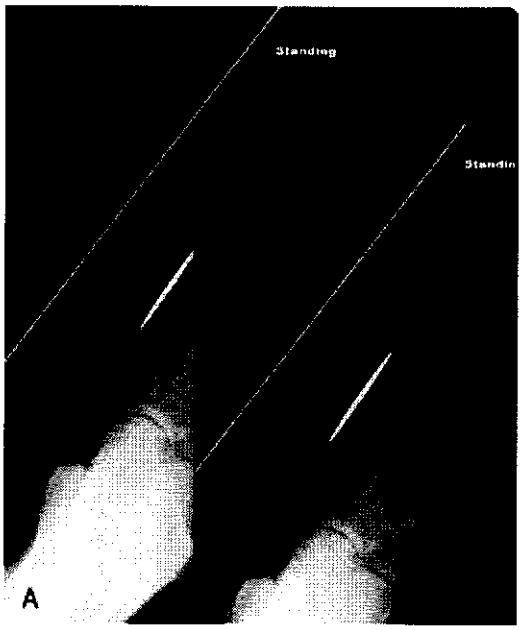


FIGURE 15. Tightening of the buttons across the metatarsals.



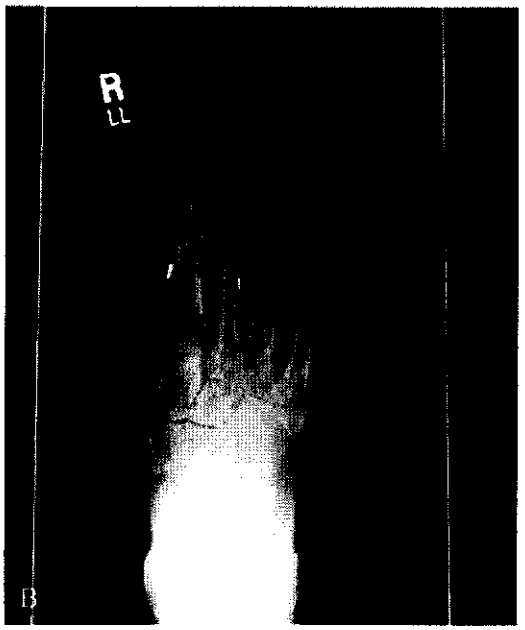


FIGURE 16. A, Anterior-posterior (AP) view of the uncorrected deformity. B, AP view of the corrected deformity.

a compression dressing with the use of an optional spacer (gauze or felt) between the first and second toe (Figs. 16A, B). F16

■ COMPLICATIONS

This technique was developed to eliminate the most formidable complications associated with currently osteotomy-based bunion procedures. Correction by the osteotomy sparing Mini TightRope technique a priori

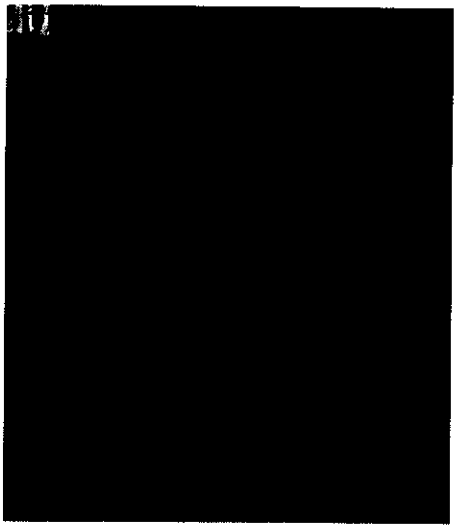


FIGURE 17. AP view of a second metatarsal fracture.

prevents the osteotomy-associated complications of shortening, delayed union, malunion, transfer metatarsalgia, and avascular necrosis. However, some relatively minor complications specific to the Mini TightRope have been encountered to date.

In the initial technique not described in this discussion, the round button was placed over the medial aspect of the first metatarsal. This necessitated placement of the fiberwire knot medially as well. Consequently, some patients became mildly symptomatic due to the prominence of the medial knot. On one occasion, the knot was excised without loss of correction. This complication has been eliminated by placing the knot over the lateral aspect of the second metatarsal.

Fracture of the second metatarsal has been encoun-
F17 tered on isolated occasions (Fig. 17). Almost universally, the fracture has been treated with prolongation of the use of a postoperative wooden shoe, boot, clog shoe, or stiff-sole shoe. In addition, patients have been either asymptomatic or only minimally symptomatic secondary to the fracture. The factors associated with the development of an acute fracture include the following: (a) placement of the drill hole in the second metatarsal at or too close to the neck of the metatarsal, (b) failure to centrally place the drill hole midway between the dorsal and plantar aspects of the second metatarsal, and (c) the placement of an axial Kirschner wire through the second toe and into the second metatarsal ending near the site of the placement of the fiberwire and button construct. These risks can be reduced or eliminated by placement of the drill hole proximal to the second metatarsal neck, accurate placement of the drill hole midway between the dorsal and plantar cortices of the second metatarsal, and avoiding placing Kirschner wire near the level of Fiberwire and the button in the second metatarsal.

There has been the rare occurrence of late (6–16 weeks), usually asymptomatic second metatarsal fractures distal to the button. This has occurred when the restraining force of the second intermetatarsal ligament has not been released. It is now my practice to release this ligament, which neutralizes the static restraint of this ligament on the distal second metatarsal.

An estimation of the total percentage of patients in our early series with second metatarsal fractures is approximately 10%. These have all healed with the use of a postoperative shoe without the necessity of additional surgical intervention. To date, our patients have not experienced transfer lesions to the third metatarsal.

I am aware of a report of the widening of the IMA within a few weeks of the procedure without evidence of fracture or subsidence of the buttons. It was subsequently determined that only 3 knots were placed in the fiberwire rather than the recommended five knots with a residual tail. Therefore, this was presumed to be a technical failure related to an insufficient number of throws in the fiberwire knot. Otherwise, to date, I am not aware of an episode of actual breakage of the fiberwire after placement of the buttons.

The use of the Mini TighRope has no bearing on the potential complications of excessive resection of the medial eminence and possible hallux varus deformity. Nor does it play a role on the possible stretching of the medial capsular repair and the subsequent increase hallux valgus angulation at the first MTP joint. I have had 2 patients who have required an Akin procedure and/or medial capsular revision due to stretching of the medial capsule.

■ POSTOPERATIVE MANAGEMENT

Postoperatively, the patient is placed in standard soft compression dressing that also allows for the maintenance of the corrected hallux valgus angulation and any associated rotatory corrections as well. The patient is immediately allowed to bear weight on the heel as tolerated in a postoperative stiff-soled shoe or walker boot. The patient is maintained in the postoperative shoe or boot for a period of 4 to 8 weeks. A bunion dressing is maintained and changed weekly during this period of time. The patient is next transitioned to a wide, thick soled street shoe by 6 to 8 weeks.

■ RESULTS

With the availability of this technique since January 2007, the first clinical follow-up studies should become available in 2008. However, this technique has been far

less technically challenging than many of the traditional available osteotomies. Postoperative pain and recovery have been reduced secondary to the lack of an osteotomy of the first metatarsal.

■ POSSIBLE CONCERNS, FUTURE OF THE TECHNIQUE

A possible concern raised by colleagues is about the long-term affects of this procedure on the first M-C joint with the correction of the IMA. Thus far, at a maximum of 2-year follow-up using this osteotomy sparing technique, we have had no radiographic or symptomatic evidence of arthritis at the first M-C joint. More likely, the joint is placed in a more anatomic position with reduction of the M-C joint. Obviously, there is room for further bench work and clinical investigations of this question. However, even in a worst-case scenario of the late development of symptomatic arthritis, this technique has still avoided the profound complications of shortening, dorsiflexion, malunion, nonunion, transfer metatarsalgia, and avascular necrosis. In the event of the development of arthritis of the first M-C joint, one is still left with the fallback of a Lapidus procedure.

It is our presumption that in the long term, the realignment of the M-C joint is similar to that of the Lisfranc joints and the ankle syndesmosis. Fixation for Lisfranc dislocations can be removed after a period of time with maintenance of reduction secondary to the remodeling of the soft tissues. This mechanism of soft tissue remodeling also occurs in patients with ankle syndesmotic injuries treated with the insertion of a syndesmotic device such as a screw or TightRope.

The risks of second metatarsal fracture will be further reduced by progress in using this concept with the use of smaller diameter drills and K-wires in order to place the buttons across the metatarsals.

All currently available osteotomy techniques have some potential risk of intraoperative and postoperative complications. Some of these complications can be devastating and consequently can result in painful structural problems with poor potential for correction. With this as the backdrop, the Mini TightRope technique was developed to avoid the inherent complications of a first metatarsal osteotomy. The potential complications of the Mini TightRope—second metatarsal fracture, knot/fiberwire failure, or subsidence of the buttons—do not lead to shortening of the first metatarsal, dorsiflexion of the first metatarsal, nonunion, or varus and valgus angulation of the first metatarsal articular surface. Therefore, the complications of the Mini TightRope do not burn any bridges in terms of the list of potential remedies for revision.

As with the initial development of the techniques of arthroscopic surgery and total joint arthroplasty, there will be more research and certainly more modifications in the future. The gist of this technique is that it attempts to address the correction of what is essentially an acquired soft tissue angular deformity with an osteotomy sparing procedure of the first metatarsal and thereby avoiding the potential complications associated with an osteotomy. As young surgeons, we were all taught to use soft tissue procedures for flexible, soft tissue deformities while reserving bony procedures for fixed, bony deformities. In the case of the reducible IMA, the Mini TightRope procedure is an attempt to return to this principle.

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