# FUNCTIONAL POSITION JOINT SECTIONING: Pre-Load Method for Lapidus Arthrodesis

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## INTRODUCTION

The Lapidus arthrodesis is the gold standard procedure for correcting the hypermobile hallux valgus deformity. The merits of fusing the first tarsal-metatarsal joint (TMTJ1) are contrasted by its inadequacies, namely, first ray shortening, second metatarsophalangeal joint over-load, and delayed or nonunion. Compounding these shortcomings, the Lapidus arthrodesis is a technically demanding procedure associated with increased anesthesia time, higher fixation costs, and prolonged non-weightbearing. The purpose of this article is to introduce a TMTJ1 fusion method that minimizes these polarizing deterrents (aside from endorsing early weightbearing) to performing the Lapidus arthrodesis. The development of this approach was spawned by personal suffering and discontent with classic first tarsal metatarsal joint "sectioning" techniques: namely wedging and curetting. Note: Throughout this article, the word "section" refers to the act of cutting articular surfaces, whereas "resect" refers to the act of excising sectioned articular surfaces.

Uniting reliable techniques of first metatarsophalangeal joint (MTPJ1) fusion and navicular-cuneiform joint (NCJ) fusion, this TMTJ1 fusion method involves pre-loading (i.e., anatomically aligning and functionally loading) TMTJ1 surfaces during both sectioning and fixation stages. The technique of sectioning MTPJ1 while held in a corrected position and of fixating NCJ while activating the windlass mechanism are combined, modified, and incorporated here (Figure 1). Pre-loading the TMTJ1 consists of 3 sequential actions: reduce the IMA1 (first inter-metatarsal angle), reduce the MTPJ1, and engage the windlass mechanism.

Common to other Lapidus arthrodesis techniques, this method reliably corrects both first ray hypermobility and hallux valgus. The distinguishing characteristic of the pre-loading technique is that the corrected position is achieved prior to joint sectioning. The sectioned surfaces become the fusion surfaces. Inherently, this approach minimizes first ray shortening and anesthesia time by virtually eliminating the process of post-resection modification.

Hallux valgus correction is achieved differently through wedging and curettage methods. Although wedge resection is an easy corrective approach, wedging the TMTJ1 removes a significant amount of bone to achieve correction. Overt first ray shortening is an inherent feature of wedge resection, which is magnified when post-resection adjustments are necessary.

While curettage may be the current state of the art for Lapidus arthrodesis, this minimalist joint resection approach is typically a time-consuming process associated with increased anesthesia time. Theoretically, curettage should result in less first ray shortening. Paradoxically, undesirable first ray shortening is common with the curettage technique. Since the arthrodesis site is curetted where it lies (i.e., in a noncorrected and nonopposed position) additional bone removal (and operative time) are predictably required to achieve favorable positioning.

Beneficial features inherent to the TMTJ1 pre-loading sectioning technique and fixation guide described below include enhanced anatomic alignment, bone apposition, and inter-fragmentary compression of the fusion site, along with decreased first ray shortening, anesthesia time, fixation cost, and post-resection adjustments.

## BRIEF PRIMER TO THIS TMTJ1 ARTHRODESIS TECHNIQUE GUIDE

This guide is divided into 3 procedural stages for fusing the TMTJ1: sectioning of joint surfaces; resecting and priming of fusion surfaces; and internal fixation. The key initial step to accurately align the TMTJ1 surfaces for sectioning is to ensure reducibility of both the MTPJ1 and the IMA1. Prior to sectioning, reducibility at both sites can be accomplished by performing a MTPJ1 soft tissue release, and by removing the TMTJ1 peri-articular osseous barriers (Figure 2).

The sectioning stage begins with sequentially reducing the IMA1, MTPJ1, and activating the windlass mechanism through hallux dorsiflexion. Maintaining this corrected position during both sectioning and fixation stages, simultaneously derotates first ray deformities, and anatomically aligns, stabilizes, and apposes the TMTJ1 surfaces (Table 1). While anatomically pre-loaded in this manner, joint sectioning is performed in parallel 2 mm bone cuts (without wedging) of the TMTJ1 surfaces.

Once sectioned, the TMTJ1 surfaces are resected and fusion surfaces are primed using fenestration techniques. While not compulsory, the use of a Hintermann distractor is recommended as this instrument consistently expedites this

Figure 1A, B. Preoperative and postoperative radiographs of a MTPJ1 fusion. This tri-planar MTPJ1 deformity was manually de-rotated and held in a corrected position throughout sectioning of fusion surfaces. Note the corrective retrograde buckling effect upon IMA1 requires a reducible and nonrigid IMA.

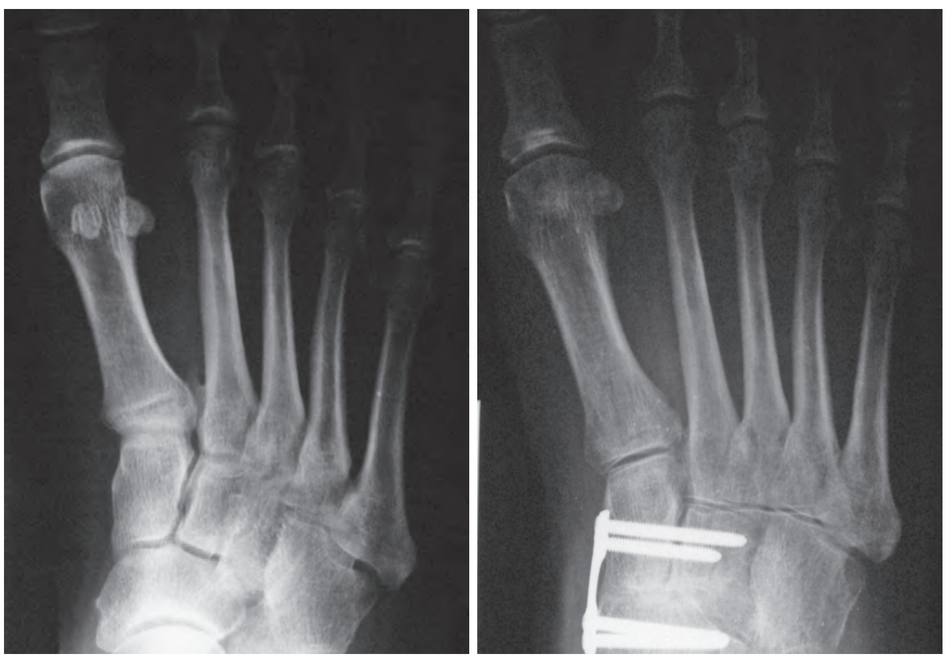

Figure 1C, D. Preoperative and postoperative NCJ fusion. Engaging the plantar fascia's windlass mechanism through hallux dorsiflexion apposes the NCJ surfaces during fixation placement. In this case this method of loading was performed during both sectioning and fixation.

second stage and reduces anesthesia time. The Hintermann accepts 2.0 mm pins that are resistant to bending (unlike 1.6 mm pins), and allows wide and stable TMTJ1 distraction to facilitate removal of bone fragments and priming of fusion surfaces. Placing pins at the sites that are conducive to temporary fixation is ideal. Detailed use of this instrument will be described.

The fixation stage is initiated by pre-loading the TMTJ1 surfaces and placing temporary fixation. An intra-operative radiograph is taken, and typically fusion surfaces are aligned in the pre-loaded position. Infrequently, a residual MTPJ1/IMA1 deformity is present. Presumably this occurs due to incomplete reduction during sectioning. When necessary, nominal reciprocal planing is performed while pre-loaded.

Figure 2. Proximal M1-M2 impingement. Ensure manual reducibility of both MTPJ1 and IMA1 prior to joint sectioning. To create IMA1 reducibility, resect TMTJ1 peri-articular osteophytes and impingements.

Two to three points of fixation are utilized to maintain correction throughout the fixation process. Crossed 4.0 fully-threaded Synthes screws are used for fixation in this guide and are placed bi-cortically in a fashion conducive to true inter-fragmentary compression. A third screw may be placed if desired. Specific details of achieving inter-fragmentary compression will be discussed.

## TMTJ1 ARTHRODESIS: 3-STAGE TECHNIQUE GUIDE

**Stage 1: Sectioning of Joint Surfaces**

Step 1. Properly align the TMTJ1 for joint sectioning. Sequentially reduce the IMA1, MTPJ1, and activate the windlass mechanism through hallux dorsiflexion (Figure 3A). Instruct the surgical assistant to hold this alignment throughout bone sectioning and during subsequent placement of temporary fixation (and during reciprocal planing if indicated).

Step 2. Visualize orientation of the TMTJ1 surfaces for precise sectioning. Appreciating the dorsal to plantar orientation of the TMTJ1 is critical for precise sectioning because the plantar margin of the TMTJ1 is typically more proximal than the dorsal. Intra-operative visualization during sectioning can be easily achieved by intermittent use of a Freer elevator to assess the joint's dorsal, medial, and plantar-medial border.

**Table 1. Biomechanical Effects of Pre-Loading TMTJ1 During Sectioning and Fixation**

- Manual IMA1 reduction eases MTPJ1 reduction
- Combining IMA1 reduction with tri-planar MTPJ1 reduction provides corrective retrograde alignment of TMTJ1 surfaces for sectioning
- Engaging the windlass mechanism supinates, stablizes, and maximally apposes TMTJ1 surfaces in a nonpronated position

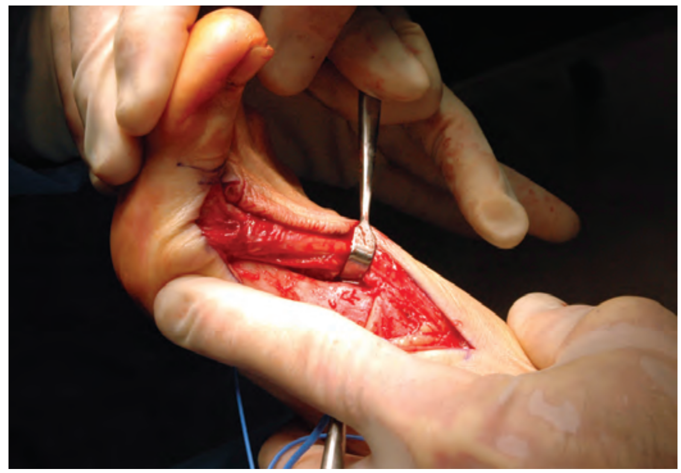

Figure 3A. Pre-load TMTJ1 for sectioning. Sequentially reduce IMA1, MTPJ1, and activate the windlass mechanism. This position is held during joint sectioning, placement of temporary fixation, and reciprocal planing (if needed).

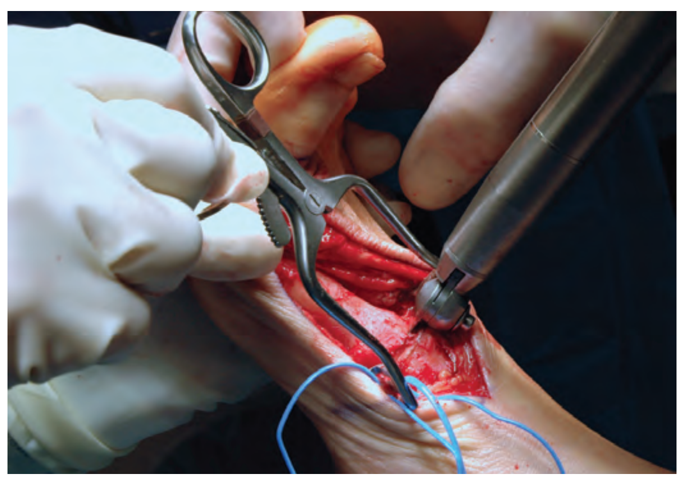

Figure 3B. Vertical sectioning of theTMTJ1 is performed with parallel 2 mm bone cuts adjacent to each articular surface. Initial dorsal to plantar bone cuts are accurately made with a short saw blade (18 mm) and completed with a long saw blade (31 mm). Use of a self-retaining retractor precludes the need for additional retraction.

Step 3. While pre-loaded, each TMTJ1 surface is vertically sectioned with power instrumentation. Utilizing a sagittal saw, the TMTJ1is sectioned from dorsal to plantar in parallel bone cuts placed 2 mm from each articular surface (Figure 3B). This depth of sectioning typically includes the entire subchondral plate.

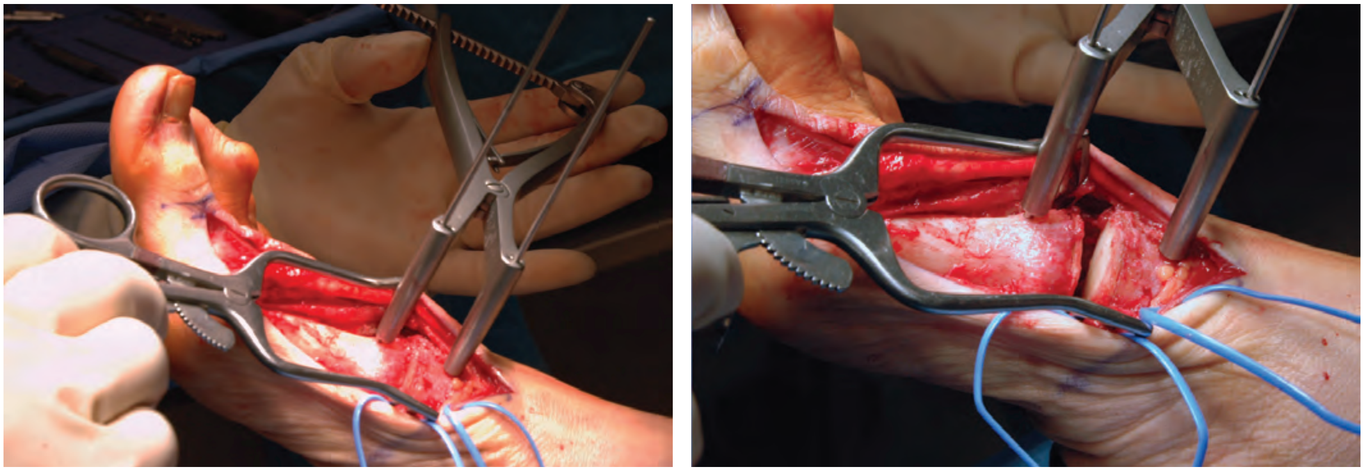

Figure 4A, B. Remove resected bone from the arthrodesis site. Using a Hintermann distractor with 2 mm pins offers unparalleled distraction power and simplifies removal of intact TMTJ1 surfaces. Pins are placed at sites conducive to temporary and/or final fixation placement (see Step 4 for full description).

Figure 5. Ideal distractor pin placement positions the 2 mm MC pin lateral to the M1. Placing pins at these relative sites simplifies final fixation, particularly when placement of a third screw is required.

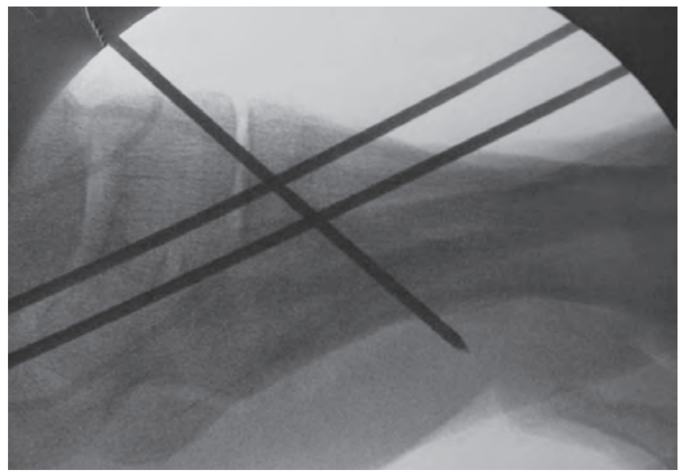

Figure 6. TMTJ1 temporary fixation. Note the M1 pins are placed parallel, the MC and distal M1 pins cross the fusion site centrally, and the distal M1 pin exits the MC plantar to the NCJ. The distal M1 pin and the MC pin are predrill sites for 4.0 mm screw placement.

The dorsal to plantar dimension of the TMTJ1 is often 3 cm or more in length. This length requires a long saw blade and occasionally an osteotome to complete the sectioning. Invariably, when using a long saw blade, undesirable blade oscillations occur, which are disruptive to accurately initiating the bone cuts. This effect is muted by the sequential use of a short saw blade (18 mm) to initiate the dorsally-based bone cuts followed by use of a long saw blade (31 mm) to complete the cuts.

**Stage 2: Resecting and Priming of Fusion Surfaces**

Step 4. Remove the sectioned bone from the arthrodesis site. These surfaces may be extracted wholly or in pieces. Resection of the intact first metatarsal (M1) and medial cuneiform (MC) surfaces allows critical assessment of bone cut precision. Utilizing a Hintermann distractor simplifies removal of the intact TMTJ1 surfaces.

Place a 2 mm pin in each arm of the Hintermann distractor at sites conducive to the M1 temporary fixation and the MC final fixation. The M1 and MC pins are positioned approximately 1cm from the TMTJ1 surface and 1cm from the NCJ surface, respectively (Figure 4).

Although not illustrated within this technique guide, ideal distractor pin placement positions the MC pin lateral to the M1. Placing pins at these relative sites simplifies the final fixation particularly when placement of a third screw is required (Figure 5). Specifically, one 2 mm pin is placed in the central one-third of the M1and the second is placed in the central-lateral one-third junction of the MC.

Step 5. Fenestrate the arthrodesis surfaces with a 2 mm drill and osteotome. Manipulate the Hintermann distractor to gain visual and working access to each fusion surface. The distractor and 2 mm pins are removed when this task is completed.

**Stage 3: Internal Fixation**

Step 6. Pre-load the fusion site and apply temporary fixation. Three smooth 1.6 mm pins are placed for temporary fixation. Two parallel pins are placed dorsally in the M1 and a third pin is placed in the MC. The MC pin and the more distal M1 pin will be used for final crossed screw placement. To ensure secure and corrected alignment 2-3 points of fixation are maintained at all times throughout the fixation process.

The first pin is placed in the M1 proximally at the site of the Hintermann 2.0 mm pin. Used only for temporary fixation, this pin is driven from the dorsal-central one-third of the M1, across the dorsal one-third of the fusion site, and towards the NCJ (Figure 6).

The second 1.6 mm pin is placed in the MC at the site of the Hintermann 2.0 mm pin. This pin is advanced plantar-distally, traverses the center of the fusion site, and exits the M1 at the central-lateral one-third junction. Ideally, the predrill pins are positioned to cross the fusion site centrally as noted on the lateral radiograph.

The final 1.6 mm pin is placed in the M1 distal to the first, and is the predrill hole for 4.0 mm screw placement. This parallel pin is driven from the dorsal-central one-third of the M1 across the center of the arthrodesis site, and exits the plantar proximal margin of the MC. Preferably this pin exits the MC at the central-medial one-third junction. This orientation allows bi-cortical compression of the arthrodesis site and extra-articular thread purchase. Traversing the center of the fusion site, this pin placement is ideal for even compression during screw placement.

Once temporary pins are placed, intraoperative radiographs are taken to evaluate deformity correction, predrill pin placement, and to ensure M1 pins are parallel. Table 2 shows temporary fixation trouble-shooting options based on radiographic findings.

Step 7: Insert a solid 4.0 mm fully threaded cancellous Synthes screw at the distal M1 predrill site. Adhering to the recommended fixation sequence offers several benefits. It maintains reduction during screw placement, maximizes the compressive utility of each screw, and optimizes bone purchase.

The first 4.0 mm screw is placed at the M1 predrill site (i.e., the distal M1 1.6 mm pin site). Prior to pin removal, consider placing a fourth temporary pin if the 1.6 mm pins are under significant tension and there is concern regarding maintenance of correction. This supplemental pin may be placed at a site conducive to inserting a third screw (Figure 7A).

Remove the distal M1 1.6 mm pin and perform the following 4.0 mm fully threaded Synthes screw insertion sequence:

2.0 mm drill thread hole
Countersink
Use a 4.0 mm oval burr to finalize countersinking

**Table 2. Temporary Fixation Trouble-Shooting Options**

- Residual IMA1/MTPJ1 deformity → Remove pins, reciprocally plane fusion surfaces, and reapply pins. (Note: Occasionally minimal reciprocal planing may be required prior to final fixation. Presumably this occurs due to incomplete pre-loaded reduction during sectioning). Reciprocal planing is to be performed with TMTJ1 held in pre-loaded alignment.
  → Re-evaluate lateral abutment of the first metatarsal base (See Figure 2). If this remains a barrier to reduction, remove temporary pins, and resect vertically.
- Pre-drill pins are positioned too close for screw placement → Redirect only the MC pin (provided M1 pins are parallel and enough space is present along the lateral margin of the arthrodesis site); otherwise medially re-position M1 pins as needed.
- Pre-drill pins are not optimally positioned → reposition pin(s) sequentially while maintaining IMA correction through 2-3 points of fixation.
- M1 pins are not parallel → provided distal M1 temporary fixation is adequate then reposition only the proximal M1 pin.

Figure 7A. Supplemental temporary pin placement. This pin may be placed at a site that both avoids interfering with crossed screw placement and is conducive to inserting a third screw.

Depth gauge
4.0 mm tap
3.5 mm over drill (glide hole)
Insert 4.0 mm screw

**Fixation Recommendations: Tips and Rationale**

A. Use a 2.0 mm drill for all thread holes. Request a 2.0 mm drill, as these are no longer included in the Synthes small fragment set. The 2.0 mm thread hole (instead of the

Figure 7B, 7C. Fixation stress (note bowing of 4.0 screw) due to incomplete counter-sinking of the dorsal M1 cortex. Bowing of fixation and/or M1 cortical stress-risers can occur when the metatarsal is incompletely countersunk. A 4.0 oval burr is recommended to finalize countersinking. Supplemental support of a third screw was indicated here.

currently recommended 2.5 drill) preserves bone for screw purchase by more precisely matching the 1.9 mm core diameter of 4.0 mm screw. For unknown reasons, this classic sequencing has been abandoned; presumably, to ease the selection of thread hole drills from the small fragment set.

B. Use a 4.0 mm oval burr to finalize countersinking of the dorsal M1 cortex to accept the large 4.0 mm screw head. Due to the obliquity of screw placement, stout M1 cortical bone, and inherently large 4.0 mm screw head, the countersink provided in the Synthes small fragment set inadequately countersinks the dorsal cortex of M1. Supplemental counter-sinking with a burr reduces stress upon both internal fixation and the M1 dorsal cortex (Figures 7B, C).

C. Performing the following maneuvers are conducive to true TMTJ1 fusion site compression: placing M1 pins in parallel alignment, stopping short of final 4.0 mm screw tightening, retrograding the MC pin proximal to the TMTJ1, engaging the windlass mechanism during tightening, and bi-cortical screw purchase (Figures 7D-F).

D. The parallel placed M1 pin allows unrestricted in-line gliding and compression of fusion surfaces during 4.0 mm screw tightening. Retrograding the MC pin (and any supplemental pins) eliminates the compression negating effect along the TMTJ1 surfaces. The final maneuver of engaging the windlass mechanism during screw tightening pre-loads the TMTJ1 once again to enhance apposition and compression of fusion surfaces. This maneuver maximizes the inter-fragmentary compressive utility of the 4.0 mm screw.

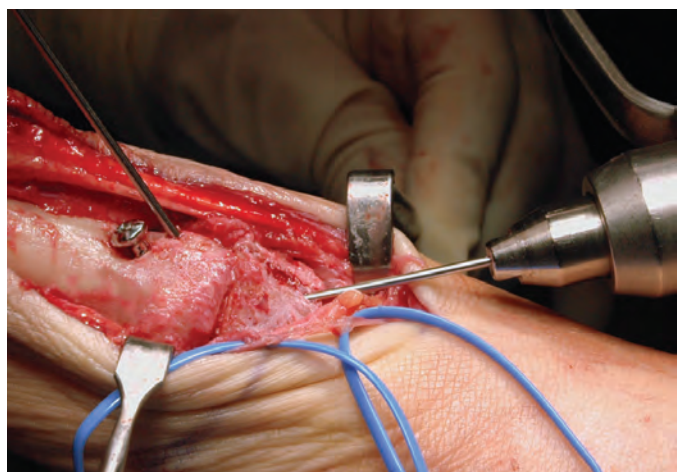

Figure 7D. Improve fusion site compression by stopping short of the final M1 4.0 mm screw tightening and retrograding the MC pin proximal to the TMTJ1. This maneuver eliminates the compression-negating effect of the MC's crossing pin. Further, the parallel placed M1 pin allows unrestricted in-line gliding and compression of fusion surfaces during 4.0 mm screw tightening.

Following final M1 screw placement, the MC 1.6 mm pin can be re-advanced across the fusion site for intra-operative radiographs. Once screw purchase is deemed adequate, the MC pin is removed and the MC screw placement is initiated.

Step 8. Insert the second solid 4.0 mm fully-threaded cancellous Synthes screw at the MC predrill site (Figure 8). To ensure secure cortical abutment of the 4.0 mm screw head, the countersinking step is typically omitted due to the soft cancellous nature of the MC. Otherwise follow the same screw insertion sequence described above.

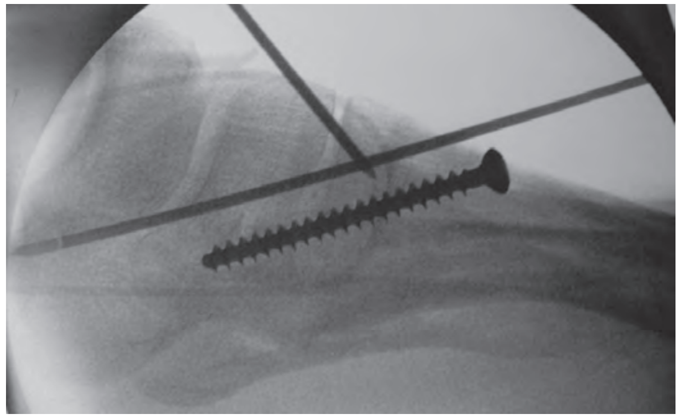

Figure 7E, 7F. Final tightening of the M1 4.0 mm screw. With the MC pin positioned proximal to TMTJ1, proceed with final screw tightening while dorsiflexing the hallux. Engaging the windlass mechanism during screw advancement enhances apposition and compression of TMTJ1 surfaces. Pre-loading the TMTJ1 in this way maximizes the 4.0 mm screw utility during tightening.

Figure 8A, 8B. Preoperative and immediate postoperative radiographs of the clinical case presented herein. The MC screw has been placed medial to the M1 in this case. This positioning may limit space for insertion of a third (supplemental) screw.

Use of a partially-threaded 4.0 mm screw may be preferable when faced with smaller/softer bone or when placed closely to the TMTJ1 surfaces (see Figure 4C). The partially-threaded 4.0 mm screw preserves bone by over drilling with a 2.5 mm drill bit (in place of the 3.5 mm). Aside from replacing the over drill, follow the same sequence and ensure that all threads are across the fusion site.

## CONCLUSION

Applicable to MTPJ1, NCJ, TMTJ1, and digital fusions, the pre-loading technique is a versatile and reproducible arthrodesis method. For TMTJ1 fusion procedures, functional loading of the arthrodesis surfaces in a corrected position during sectioning and fixation stages offers several intrinsic benefits mentioned above.

The current state of the art for TMTJ1 arthrodesis procedures is to section joint surfaces in nonreduced and nonapposed positions. This customary approach leaves the resected joint in an uncorrected position, and dictates the need for subsequent modifications to both correctively align and appose fusion surfaces. Why section joint surfaces where they lie (in an uncorrected position)? Why not section joint surfaces in a functional pre-loaded position?