Modified Bone Block Distraction Arthrodesis of the Hallux Metatarsophalangeal Joint

Jason Petroutsas, Mark Easley and Hans-Jörg Trnka

Foot Ankle Int 2006 27: 299
DOI: 10.1177/107110070602700413

FOOT & ANKLE INTERNATIONAL

Modified Bone Block Distraction Arthrodesis of the Hallux Metatarsophalangeal Joint

Jason Petroutsas, M.D.[1]; Mark Easley, M.D.[2]; Hans-Jörg Trnka, M.D.[1]
[1]*Vienna, Austria;* [2]*Durham, NC*

INTRODUCTION

First metatarsophalangeal (MTP) joint arthrodesis can be an effective revision procedure for failed surgery of the hallux MTP joint.[1,2,4] However, in some patients, substantial bone loss at the MTP joint renders the loadbearing function of the first ray ineffective, a situation that cannot be improved with in situ arthrodesis. Such challenges often are encountered after failed Keller-Brandes and Hueter-Mayo procedures and particularly after partial or complete metatarsal head resection required for iatrogenic osteonecrosis. In these situations the physiologic length of the first ray must be reestablished to avoid or resolve transfer lesions of the lesser metatarsal heads.[3]

Two methods of lengthening of the first ray have been described, both with specific advantages and disadvantages: distraction osteogenesis at the base of the first metatarsal combined with an in-situ first MTP joint arthrodesis and a bone block distraction arthrodesis, typically by creating flat cuts at the fusion surfaces and interposing an iliac crest graft.[4]

The advantages of distraction osteogenesis are: (1) length can be appropriately determined over time without the limitation of having to set the length at the time of the index procedure; (2) the shortening that is anticipated with an arthrodesis can be overcome; (3) only a single arthrodesis site is present; (4) distraction osteogenesis in the proximal part of the first metatarsal may stimulate healing distally at the arthrodesis site, and (5) gradual lengthening allows the soft tissues and neurovascular structures to gradually accommodate to the desired length. Disadvantages of distraction osteogenesis combined with in-situ arthrodesis are: (1) unless the surgeon is familiar with the technique, technical difficulties may lead to delayed healing or nonunion in a previously healthy portion of the metatarsal; (2) the regenerated bone proximally may be weak for many months after the in-situ arthrodesis has healed and with the increased stiffness at the MTP joint, the proximal site may fracture; (3) distraction typically is uniplanar and if the in-situ arthrodesis is not set properly at the index procedure the hallux may end up malaligned; (4) patient compliance is essential during the distraction phase; and (5) securing the external fixator and creating adequate fixation at the hallux MTP arthrodesis site may conflict.

Advantages of bone block distraction arthrodesis are: (1) length and hallux position can be determined at the index procedure without need for further adjustment; and (2) plate and compression screw fixation lend considerable stability to the construct. Disadvantages include: (1) two fusion sites need to heal; (2) donor site morbidity (if autograft is used); (3) acute correction may create neurovascular compromise to the hallux; (4) internal hardware may create difficulty in closing the wound; and (5) flat cuts must be perfect or adequate surface area contact will not be achieved at one or both arthrodesis sites at the MTP joint.

Given the potential complications of both methods, it is apparent that either salvage procedure is difficult. In an effort to simplify the management of this complex problem, the authors developed a modified bone bock distraction arthrodesis technique. As with in-situ MTP joint arthrodesis, the modified bone block distraction procedure uses a reamer system that establishes a congruent cup-and-cone configuration at both arthrodesis sites, thereby maximizing surface area and stability even if subtle adjustments in any plane are required before fixation. A low-profile plate with headless screws minimizes soft-tissue tension with wound closure.

OPERATIVE TECHNIQUE

In providing informed consent, patients must be made aware of potential soft-tissue complications (wound dehiscence), infection, and delayed union or nonunion. If

[1]Fusszentrum an der Wiener Privatklinik, Vienna, Austria
[2]Duke University Medical Center, Durham, NC

Corresponding Author:
Hans-Jörg Trnka, M.D.
Mariannengasse 14 1/2
1090 Vienna
Austria
E-mail: Hans4hallux@fusszentrum.at

autologous iliac crest bone graft is used (recommended), general anesthesia is necessary. However, if an allograft structural graft is used, then a regional ankle block is sufficient. A tourniquet can be used but should be released when the graft is initially inserted to ensure that the vasculature to the hallux tolerates the acute distraction. If there is a history of previous infection or a concern about residual infection, the surgeon should be prepared to send a frozen section for immediate pathologic analysis and bone cultures should be sent. Furthermore, if persistent or residual infection is suspected, preoperative antibiotics should be delayed until cultures are obtained.

Since these procedures are almost exclusively revisions, the operative approach depends on the prior incision(s). A dorsomedial incision is favored. If a previous medial incision exists as is often the case after hallux valgus surgery, a dorsal incision is still feasible, but attempts must be made to optimize the skin bridge between the new and old incisions. This procedure can be done through a medial approach, but the exposure is not as good as the dorsal approach. The incision extends from 4 cm proximal to the MTP joint to the hallux interphalangeal joint. Regardless of approach, the dorsomedial sensory nerve to the hallux must be identified and protected. The nerve may be encased in scar tissue, but careful dissection at the proximal wound allows satisfactory release of the nerve. In most patients, the extensor hallucis longus tendon is contracted and must be lengthened with Z-plasty.

We prefer a longitudinal capsulotomy and subperiosteal dissection of both the proximal phalanx and metatarsal; however, periosteal stripping should be kept to a minimum that will permit adequate mobilization and exposure. The goal is to create the thickest soft-tissue flaps possible to allow for adequate coverage of the interposed graft and fixation. Residual attachments of the adductor hallucis must be released to permit anatomic realignment of the hallux. Plantar soft-tissue releases are necessary only at the bone margins; deeper dissection is unnecessary and may risk injury to the plantar neurovasculature and the flexor hallucis longus tendon. However, all interposed fibrous tissue must be removed. The bony surfaces are prepared for arthrodesis. If the tourniquet has been used, it should be released at this point to ensure that healthy bleeding cancellous surfaces are present both on the residual proximal phalanx and metatarsal head. Only the fibrous tissue should be removed at this time; the reamers will be used to expose the bleeding cancellous surfaces. By releasing the tourniquet, the bone ends will bleed, thereby helping to reduce the heat generated by the reaming. This may minimize the potential risk of heat necrosis. In cases of osteonecrosis, it may be necessary to remove a considerable amount of nonviable bone.

To test the resilience of the hallucal blood supply, a lamina spreader can be introduced, the arthrodesis site distracted to the desired length, and left in place while the bone graft is harvested and prepared. With the tourniquet deflated, the toe should not blanch. If there is concern, then less distraction must be accepted. At the appropriate amount of distraction, a ruler is used to determine the exact graft size with regard not only for longitudinal length, but also depth. Width usually is not altered; the maximal width of the iliac crest graft, whether autograft or allograft, can typically be accommodated.

Once the exact dimensions for the graft are determined, the graft is harvested with the intent of placing cortical bone on all sides except the plantar surface. This orientation of the graft places the structurally sound aspects of the graft where the greatest stress will be applied. Cortical bone must be present particularly on the dorsal surface where compression will be the greatest. It is recommended to harvest a graft that is larger than the desired size, since the reamer will be used to contour the graft appropriately. Most reamer systems have a range of sizes and all exposed surfaces should be assessed with the reamers to determine the proper reamer size. Although there can be variability from one end of the graft to the other, the matching set of reamers must be used at each respective arthrodesis site to guarantee congruency of the bony surfaces. The hallux is then placed into maximal plantarflexion and a guide pin from the reamer set is inserted longitudinally into the center of the transverse axis of the proximal phalanx. The appropriate male reamer is then placed over the guide pin and, with the soft tissues well protected, the sclerotic bone surface is removed until a cancellous bleeding surface is developed (Figure 1). The residual head of the first metatarsal is prepared in a similar manner but using the appropriate sized female reamer (Figure 2). The desired distraction should then be double-checked and the tricortical graft harvested and prepared. In general a graft length of not more than 3.5 cm is recommended. This is determined by the possible distraction and lengthening of the skin and neurovascular structures.

The harvested graft is secured on the back table with a forceps and then pinned longitudinally through the center of the transverse axis. The respective female and male reamers

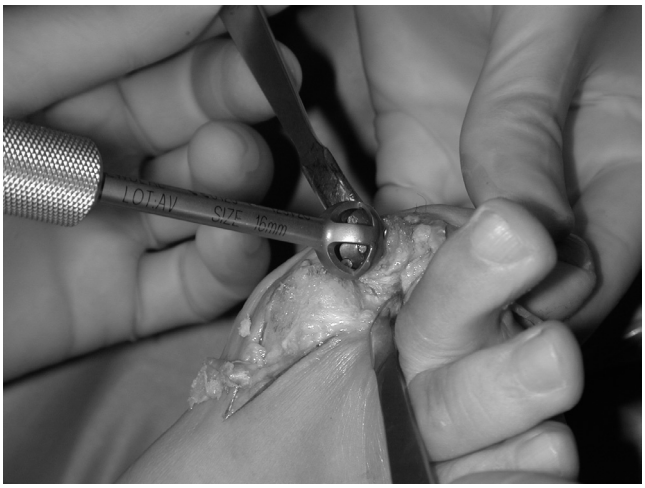

Fig. 1: Insertion of the reamer into the proximal phalanx.

Fig. 2: Insertion of the reamer into the first metatarsal.

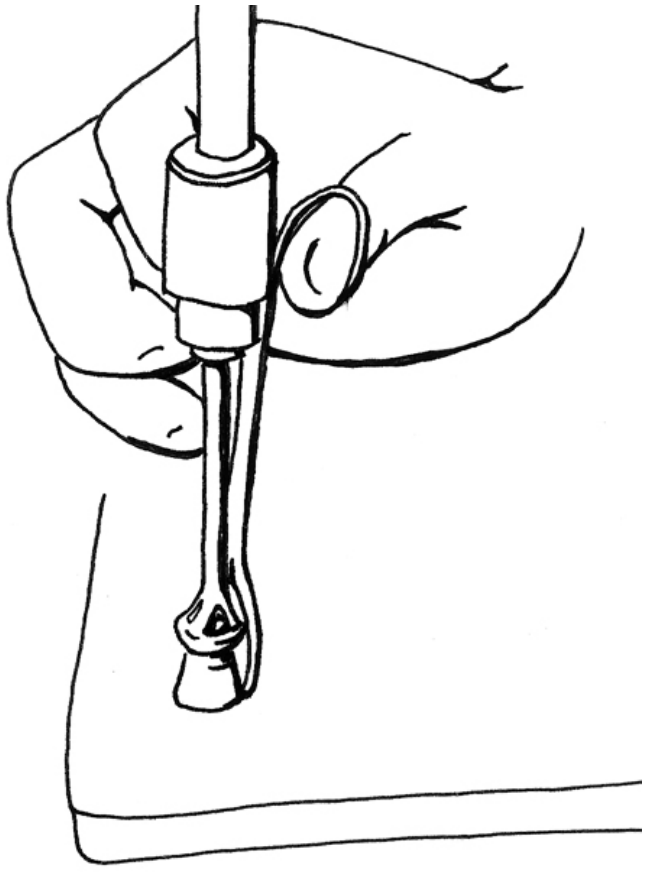

Fig. 3: The graft is prepared with the reamers.

are then used in succession to prepare the graft for implantation (Figures 3 and 4). To lessen the risk of osteonecrosis, cooled saline can be used to cool the graft during the reaming. The hallux is then distracted and plantarflexed to allow insertion of the prepared graft (Figure 5). The prepared surfaces should be perfectly congruent at both arthrodesis sites; toe

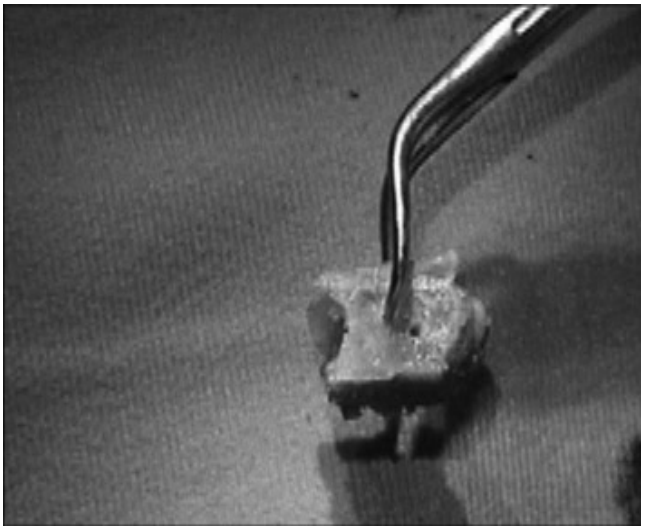

Fig. 4: The graft after preparation.

Fig. 5: The graft is inserted.

position can then be adjusted without compromising stability or contact surface. Just as for in-situ arthrodesis of the first MTP joint, the toe 10 to 15 degrees dorsiflexed relative to the shaft of the first metatarsal, is placed in slight valgus, and neutral rotation. Kirschner wires are inserted for provisional fixation, and proper toe position is confirmed with the image intensifier. If the distraction by the graft and congruency of the surfaces fail to provide adequate stability or compression of the arthrodesis sites, then a small fragment screw should be placed in lag mode obliquely across both arthrodesis sites from either the medial proximal phalanx to the lateral distal metatarsal or from the medial distal metatarsal to the lateral proximal phalanx. A small fragment plate can be applied dorsally, but we recommend a lower contour plate that accepts headless screws to decompress the potential space between bone and skin to diminish the risk of wound tension. Some plate systems allow eccentric screw placement that provides further compression. Although this

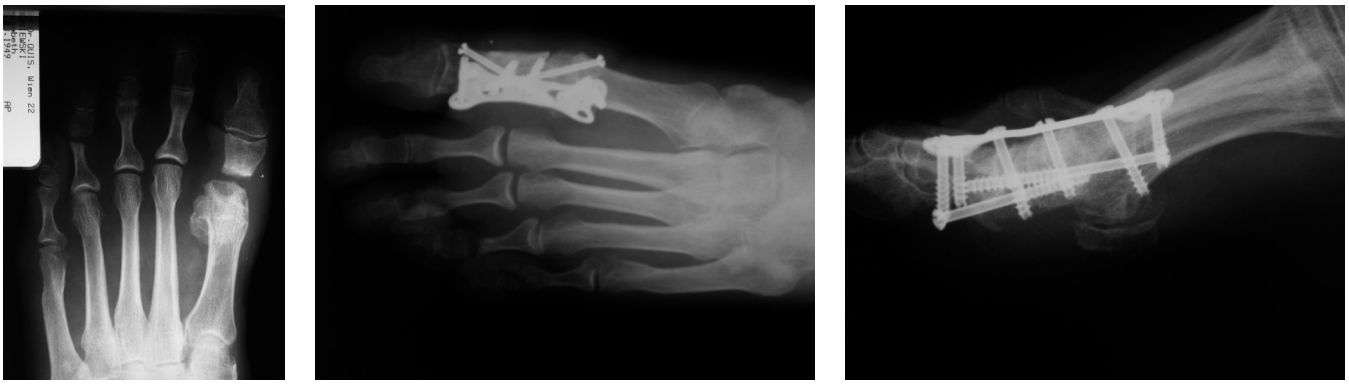

Fig. 6: A, Failed first MTP joint arthroplasty in a 53-year-old woman after failed first MTP arthroplasty. **B,** Postoperative anteroposterior radiograph. **C,** After bone block arthrodesis.

technique can be effective, if the plate is used without a lag screw being inserted first, dorsal compression may lead to plantar gapping and reduction of the surface area available for fusion. Position of the first ray and hardware is finally confirmed with the image intensifier.

In patients who may have a compromised ability to heal, consideration can be given to adding cancellous bone graft from the iliac crest to the arthrodesis sites or platelet-rich preparations may be distributed over the healing surfaces before graft placement.

The wound is closed in layers with absorbable deeper sutures and nonabsorbable skin sutures. The extensor hallucis longus must be repaired side-to-side with adequate tension before closure. Skin tension should be minimized and handling of the skin should avoid excessive compression at the wound margins. A deeper layer of periosteum and residual capsule may exist, but approximating these layers often is challenging, and the closure often relies heavily on adequate apposition of the subcutaneous layers. We prefer placing a small drain before closure. The wound and distal toe should be checked after closure to be certain there is adequate perfusion at the wound margins and distal hallux. Sterile dressings are applied, followed by adequate padding, and a splint extending beyond the toes and above the ankle with the ankle in neutral position. A small plaster toe spica splint also can be placed to protect the hallux further. Before introducing cast materials into the operating room, the iliac crest wound should be irrigated and closed in standard fashion. Nonweightbearing or toe-touch weightbearing is maintained until suture removal, after which weightbearing is gradually progressed to the forefoot in a short-leg cast. If there is evidence of progression toward fusion of the interpositional graft, the patient can transfer from cast into cam walker or postsurgical shoe. Adequate fusion to allow resumption of use of regular footwear usually takes 10 to 12 weeks.

The advantage of this technique is the congruity of the reamed surfaces that gives flexibility in positioning the pieces relative to one another. The special prebent plate helps to achieve the optimal position (Figure 6).

REFERENCES

1. **Coughlin, MJ; Mann, RA:** Arthrodesis of the first metatarsophalangeal joint as salvage for the failed Keller procedure. J. Bone Joint Surg. **69-A**:68–75, 1987.
2. **Machacek, F, Jr; Easley, ME; Gruber, F; Ritschl, P; Trnka, HJ:** Salvage of a failed Keller resection arthroplasty. J. Bone Joint Surg. **86-A**:1131–1138, 2004.
3. **Myerson, MS; Schon, LC; McGuigan, FX; Oznur, A:** Result of arthrodesis of the hallux metatarsophalangeal joint using bone graft for restoration of length. Foot Ankle Int. **21**:297–306, 2000.
4. **Trnka, HJ:** Arthrodesis procedures for salvage of the hallux metatarsophalangeal joint. Foot Ankle Clin. **5**:673–686, 2000.