

Callus Distraction In Brachymetatarsia

A Clinical Update And Pearls In Operative Technique

Dennis E. Martin, D.P.M.

Although relatively rare in clinical practice, the surgical repair of brachymetatarsia remains one of the most popular topics in podiatric literature. Several papers are published each year describing new techniques or modifications of traditional techniques to address this difficult deformity. A majority of these papers emphasize osseous correction only. However, several authors have appreciated the effects of the shortened soft tissues along the shortened ray, and described procedures addressing both components¹⁻⁴.

Martin and Kalish¹ proposed a two-stage correction technique. The soft tissues were initially lengthened using serial distraction with an axial lengthening external fixator. The osseous segment was then lengthened two weeks later by either a slide osteotomy or traditional bone grafting maneuvers. Although this method adequately addresses both components of the deformity, the two-stage correction falls short of the one-stage procedure described by other authors.

In this one-stage procedure, the soft tissues and metatarsal bone are gradually lengthened simultaneously by serial callus distraction using a mini-external axial lengthening device. It is this one-stage callus distraction process that will be described in this paper.

PATHOANATOMY

The complexity of this deformity becomes readily apparent when reviewing the host of osseous and soft tissue contractures which comprise it. Soft tissue considerations include all dorsal and plantar structures from the skin to bone. Tendons which are typically shortened include the long and short flexors, and the long and short extensors. Although not mentioned in prior literature, it must also be assumed that the interossei and lumbricales are also deficient. Despite the clinical appearance of a contracted and floating digit, the metatarsophalangeal joint maintains in a relatively rectus alignment and rarely needs to be released.

The dorsal and plantar neurovascular elements are important soft tissue structures that cannot be lengthened with the traditional techniques. The risk of vascular embarrassment is significant if these structures are lengthened excessively or too rapidly (Fig. 1A, B). With this particular set of soft tissues, the gradual callus distraction method yields results that are far superior to those of a one-stage lengthening.

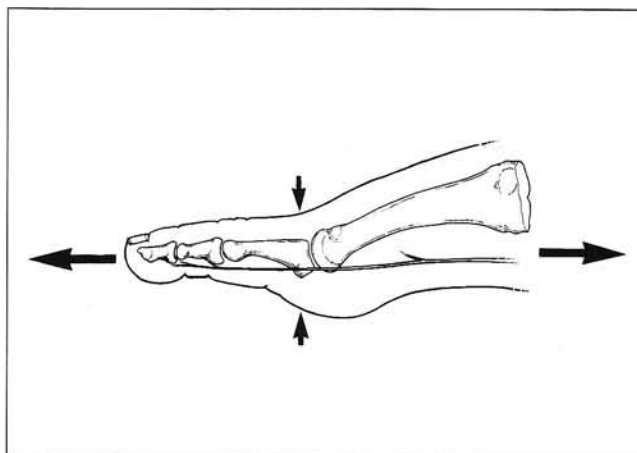


Figure 1A. Rapid and excessive lengthening can lead to vessel narrowing and vascular compromise.

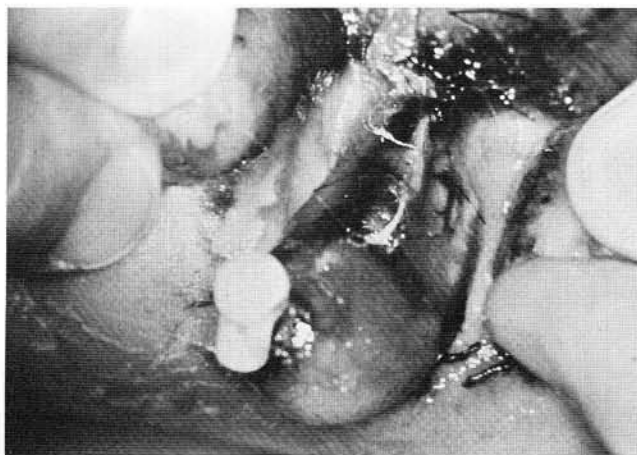


Figure 1B. Over-extensive lengthening has led to a dysvascular episode in the fourth digit.

The osseous anatomy that needs to be evaluated includes not only the obvious shortened metatarsal bone, but in many cases the phalangeal segments as well. If this is the case, it has not been standard practice to lengthen the shortened digital segment. This will result in a shorter digit postoperatively despite a well-balanced metatarsal parabola (Fig. 2A, B). Although rarely symptomatic, this may be a cosmetic disappointment for the patient and should be discussed preoperatively.



Figure 2A. Postoperative brachymetatarsia repair. Note the residual abnormal digital parabola despite relatively accurate metatarsal reconstruction.

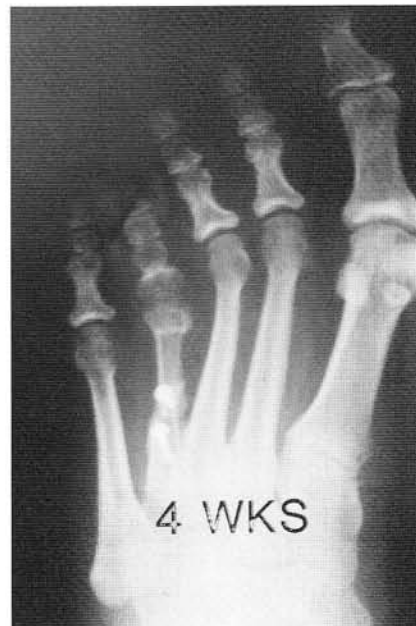


Figure 2B. Radiograph of postoperative brachymetatarsia repair. Note that the fourth metatarsal is not in line with the metatarsal parabola.

PROCEDURE

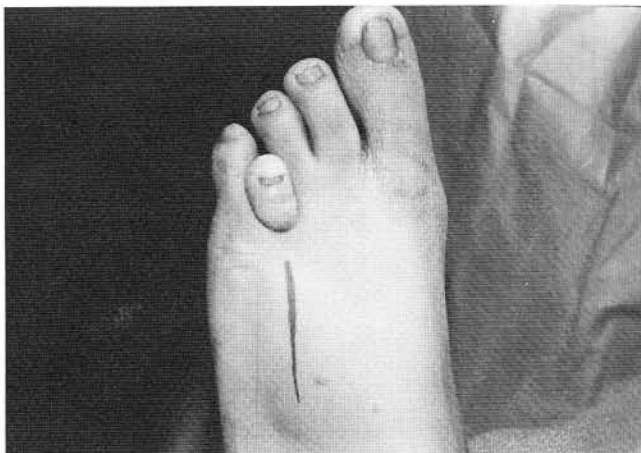


Figure 3. A 6 cm dorsal-linear incision is the most common approach to access the shortened ray.

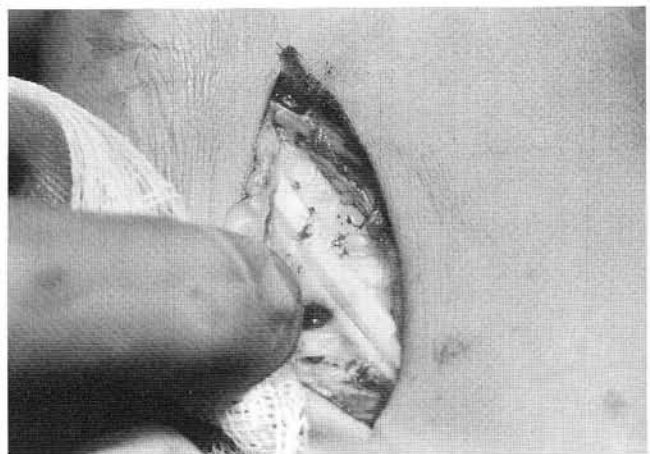


Figure 4. Once the subcutaneous layer is dissected, it is gently gleaned from the underlying deep fascia with a moistened saline sponge.

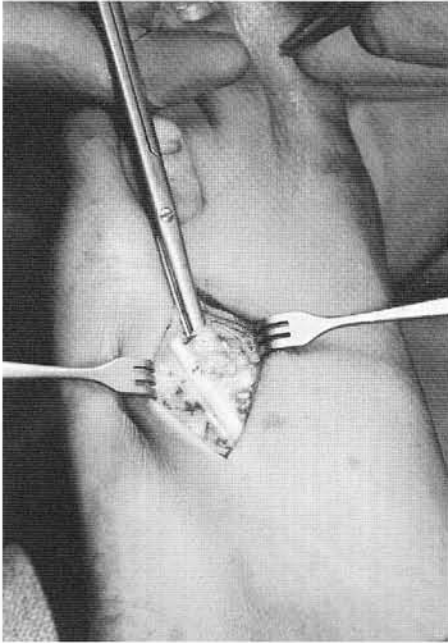


Figure 5. As the deep fascia is encountered, it can be opened between the lateral two slips of the long extensor tendon.

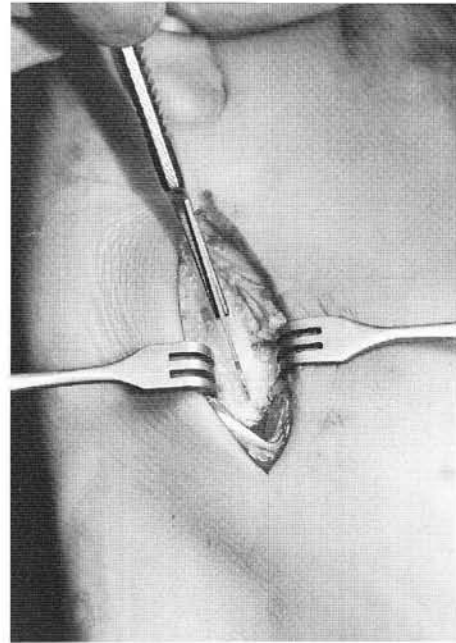


Figure 6. The underlying metatarsal shaft and periosteum are exposed by reflecting the deep fascial layer with the extensor tendons retracted medially and laterally.

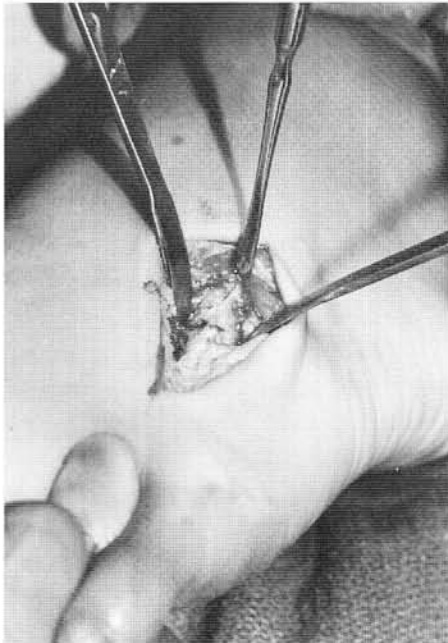


Figure 7. The periosteum is incised linearly, and gently reflected medially and laterally so that it may be sutured following osteotomy. Although some controversy does exist regarding this issue, this technique is the most widely supported in the literature. The metatarsal is now prepared for osteotomy and pin insertion.

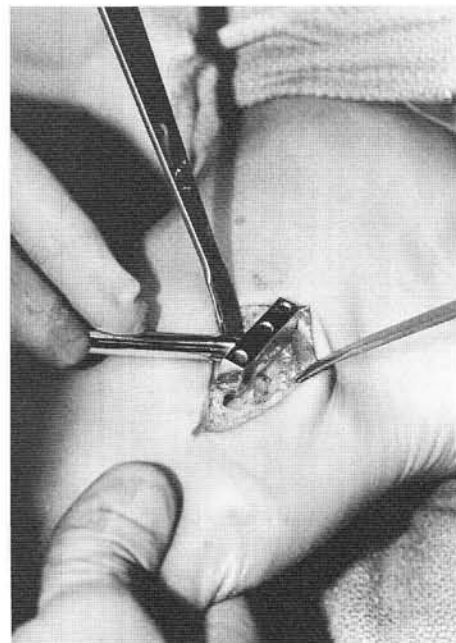


Figure 8. Prior to performing corticotomy or osteotomy, the threaded pins should be inserted in the proper position. This maneuver allows for minimal manipulation of the fragments following division. Typically, two pins are inserted on either side of the osteotomy. However, due to inadequate space, one screw has been successfully used proximally. This commonly occurs when the osteotomy is performed in the proximal metaphysis, which in the author's experience is the desired location due to more predictable bone remodeling during distraction. A pin guide should be used to allow for accurate pin placement.

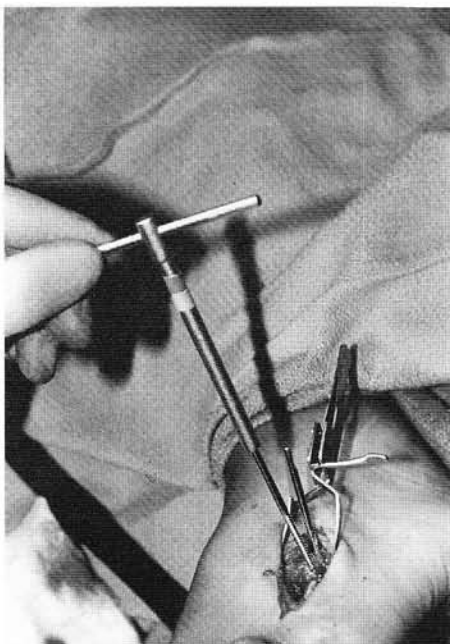


Figure 9. To facilitate pin insertion with minimal trauma to the bone, a .062 k-wire is used as a pre-drill in each of the four holes. The pins can then be easily inserted by hand.



Figure 10. Layered closure of the wound is performed prior to placement of the external frame.

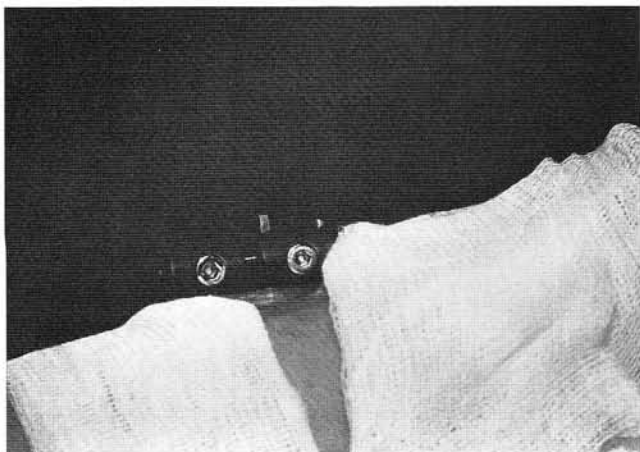


Figure 11. As the foot is dressed, extra padding is applied between the skin and the external frame. Following the sterile dressing, a compression cast is typically applied to afford protection prior to beginning the distraction process.

The latency period, or the time from surgery to the initiation of distraction, is quite variable throughout the literature. However, most authorities agree that between 5 days and two weeks is optimal. The radiographic appearance of bone callus can help guide this decision. The type of bone (long or short) as well as the level of osteotomy

(metaphyseal versus diaphyseal) will also influence this decision. As a general rule, distraction of metaphyseal bone should be initiated earlier to prevent premature consolidation. Therefore, if the osteotomy is performed in the proximal metaphyseal region, distraction is typically started at approximately 7 days. The rate and amount of distraction is also debated in the literature. However, the rate of .25mm every 6 hours for a total of 1 mm a day has shown to produce more predictable and histologically accurate bone remodeling. This is supported by the results of a prospective study conducted by Ilizarov⁵. The author's experience with this rate of repair in the surgical correction of four brachymetatarsia deformities has produced similar success without complication.

Throughout the early phases of distraction, a large radiographic lucency may be seen between bone ends (Fig. 12). This can be quite disconcerting when first encountered, and thoughts of stopping distraction are understandably entertained. However, the histologic repair is still ongoing and should not be interrupted until the desired length is obtained. By evaluating radiographs on a regular basis (every 2 weeks), callus formation can be closely followed (Fig. 13A-D). Once the desired length has been obtained, the external fixator is left in place until radiographic evidence of complete consolidation is present.



Figure 12. Early phases of callus distraction. Note the radiolucent gap between bone ends representing immature callus formation.



Figure 13A. Serial radiographs taken at 2 week intervals allow close monitoring of the callus remodeling.



Figure 13B. Six week radiograph.

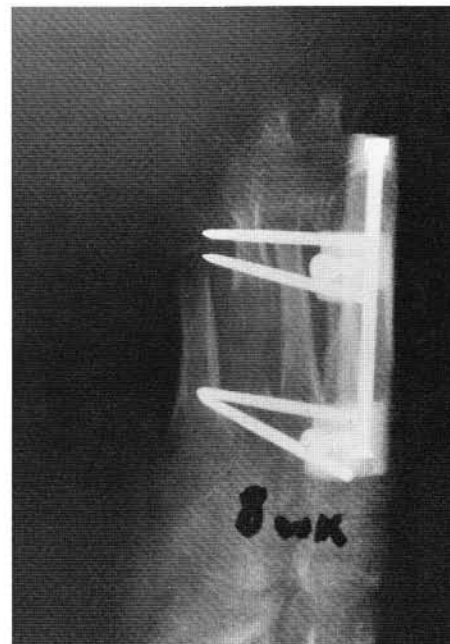


Figure 13C. Eight week radiograph.

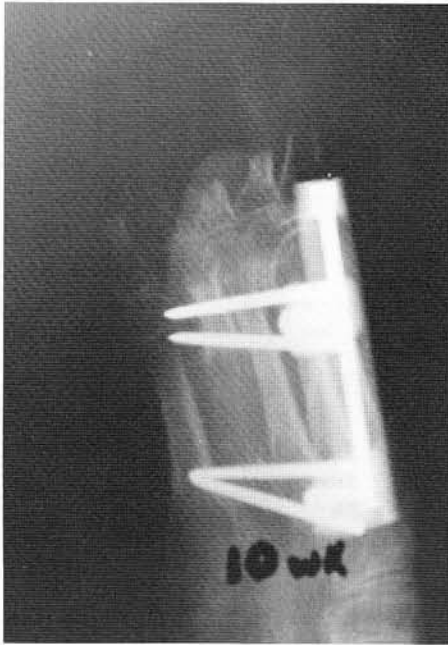


Figure 13D. Note the radiolucent void in Figure 13A as compared to this 10 week radiograph which demonstrates osseous bridging of the repair site.

One should not use the clinical appearance of the digit as a guide for when to cease distraction. Remember, an accurate metatarsal parabola does not always correspond to a normal digital parabola. Depending on the rapidity of callus repair, this entire procedure may take anywhere from 8-14 weeks (Fig. 14A, B).



Figure 14B. Postoperative radiographic appearance at 4 months.



Figure 14A. Postoperative clinical appearance at 4 months.

SUMMARY

Although traditional techniques for brachymetatarsia repair have yielded fair success over the years, they inadequately deal with the surrounding soft tissues. Neurovascular embarrassment and lesser metatarsophalangeal joint limitus are potential complications associated with traditional procedures that have been addressed with the gradual callus distraction technique. As the scientific principles and technical pearls become more familiar to foot surgeons, this technique will undoubtedly become the standard of care for the treatment of this deformity.

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