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Distraction osteogenesis for treatment of a shortened first metatarsal after failed first metatarsophalangeal joint arthroplasty

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Distraction osteogenesis is well documented in the literature as a viable treatment option for large bony defects and brachymetatarsia. Few studies have examined the use of this technique after failed arthrodesis or arthroplasty of the 1st metatarsophalangeal joint (MPJ). Acute correction with autograft is typically the procedure of choice for treatment of defects of the 1st MPJ. However, the amount of length that can be achieved is limited in acute correction and distraction osteogenesis should be considered for larger defects. This case study presents our treatment of a failed first MPJ arthroplasty that resulted in a defect at the 1st MPJ of greater than 2 centimeters and our technique of using external fixation followed by internal fixation to regain desired length and minimize time in the external fixator.

Keywords: Distraction osteogenesis, external fixation, monolateral rail, mini rail, failed 1st metatarsal arthroplasty, infected implant

Failed arthrodesis or arthroplasty of the first MPJ can often leave the revision surgeon with limited surgical options. The literature recommends, when possible, acute correction of bony defect over distraction osteogenesis due to decreased complication rates, faster time to healing, and reduced psychological strain that an external fixator can potentially cause a patient [1-3]. However, acute correction is limited by the soft tissues with potential neurovascular compromise. In these instances, distraction osteogenesis should be considered as it allows for the soft tissues to adapt as the bone lengthens [4].Distraction osteogenesis by external fixation has been widely used and studied since Dr. Ilizarov first described his technique in the 1950's. Dr. Illizarov described two main phases: the first being distraction where he determined the ideal rate was 1 mm per day and the second being consolidation wherein the newly formed regenerate gains strength [5-7]. In the standard technique, the patient spends the entire consolidation period in the external fixator and this can more than double the amount of time the patient spends in the fixator. A new technique that is gaining popularity is the conversion of the external fixation to internal fixation to limit the duration the patient spends in the fixator, and this technique was used in this case [8-9]. This case study presents our treatment of a failed first MPJ arthroplasty from deep infection after a failed first MPJ arthrodesis due to a non-union that left a defect at the 1st MPJ of 22 millimeters.

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Figure 1 (A) Preoperative clinical photo (B) Preoperative X-ray with antibiotic spacer.

The objective of this case study is to present our surgical technique for lengthening of the first metatarsal by distraction osteogenesis with external fixation to show its use as a viable treatment option for a shortened first metatarsal.

Case Study

A case is presented of a 52-year-old female who failed all conservative care for 1st MPJ arthritis of the left foot and underwent a 1st MPJ fusion. The 1st MPJ fusion failed due to a non-union and the decision was made to convert to a first MPJ arthroplasty. Infection of the implant with osteomyelitis was subsequently diagnosed with MRI at 3 months post-arthroplasty. The implant was removed at 3 months postoperative and was replaced by an antibiotic spacer and the patient was able to tolerate the spacer for two years (Figure 1). The area eventually became painful and removal of the antibiotic spacer was deemed necessary. Labs were obtained for vitamin D, prealbumin, comprehensive metabolic panel, parathyroid, and thyroid panel which were all within normal range. The length able to be achieved with acute correction was not felt to be adequate to restore proper function of the first ray, so distraction osteogenesis was selected as the treatment option. After removal of the antibiotic spacer, a mono-lateral external fixator was applied and used to lengthen the first metatarsal 22 millimeters of length, which was achieved after 26 days of distraction.

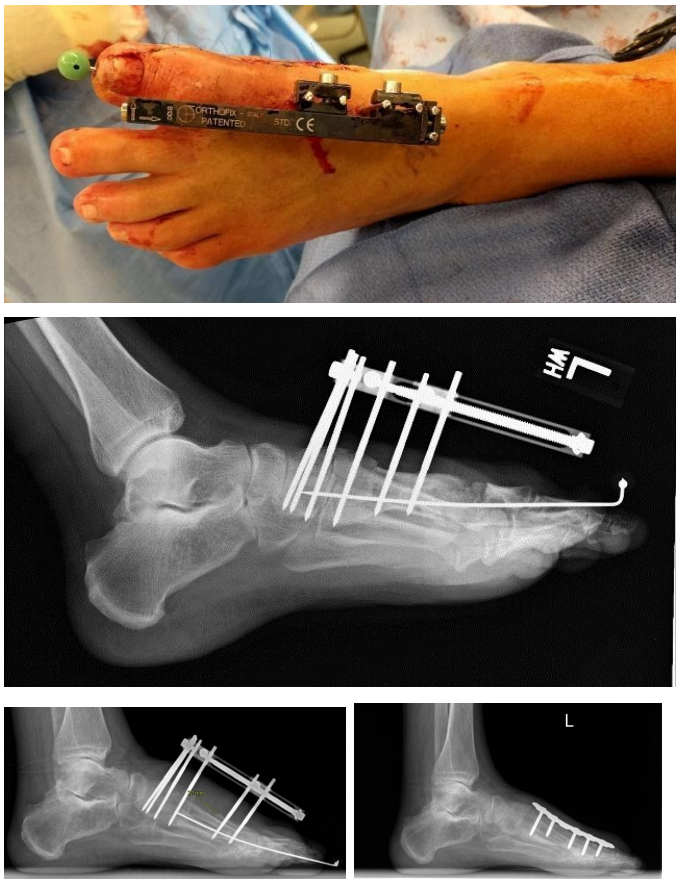

Figure 2 (A)Intraoperative, Closure with External fixator application (B) Immediate postoperative with compression at corticotomy site (C) X-ray after 26 days distraction, 22mm of lengthening (D) Consolidation period post external fixator removal and internal fixation.

The external fixator remained on for an additional month to allow consolidation of the regenerate, but was removed at the patients request and was replaced with a locking plate. After five months, the locking plate was removed due to hardware irritation. A CT confirmed partial union of the first MPJ prior to hardware removal and the fusion site was stressed intraoperatively and found to be stable. The locking plate and screws were then removed. The patient was able to ambulate in tennis shoes without pain and was able to perform activities of daily living 1 year postoperatively.

Surgical Technique

A longitudinal incision was made medially over the 1st metatarsocuneiform joint extending distally to the medial hallux interphalangeal joint. Layered dissection was carried along the length of the incision down to the level of the antibiotic spacer within the 1st metatarsophalangeal joint site.

Figure 3 (A) CT scan 14 weeks status post 1st MTPJ fusion showing osseous consolidation at the first MPJ (B) Immediate post-op hardware removal.

The spacer was removed and the nonunion margins were curetted and fenestrated down to healthy bleeding bone. Orthobiologics were used to augment the fusion site. A 0.062" K-wire was inserted through the tip of the distal hallux, crossing the hallux interphalangeal joint, and into the 1st metatarsophalangeal nonunion site. Correct placement of this K-wire is key to help guide the axis of regenerate formation as the bone is lengthened.

An osteotomy was made 1 centimeter distal to the base of the first metatarsal by perforating the bone with a k-wire and then completing the osteotomy with an osteotome. Intraoperative fluoroscopy was used to confirm the completion of the osteotomy.

Thereafter, a monolateral external fixator was applied to the dorsal aspect of the foot with 3 proximal pins within the medial cuneiform, 1 pin in the base of the first metatarsal, and 2 distal pins in the midshaft of the metatarsal. The osteotomy site was then compressed utilizing the external fixator and the 0.062" K-wire was driven across the osteotomy and into the base of the first metatarsal.

The patient began lengthening at POD #12 at a distraction rate of 0.25 millimeters four times per day. After 26 days of distraction, there was 22 millimeters of length achieved and distraction was discontinued. One month into the consolidation phase the external fixator and K-wire were removed at the patients request. The metatarsal was docked to the proximal phalanx at this time after fenestrating the opposing bony surfaces and a locking plate was used to span the regenerate and provide stability (Figure 3).

Discussion

This case study supports the current literature that distraction osteogenesis is a viable option for treatment of a large bony defect at the 1st MPJ. The patient was able to gain 22 millimeters of length through distraction osteogenesis and was able to undergo a successful fusion at the 1st MPJ with a stable fusion site and regenerate bone at the time of hardware removal. Placement of the K-wire so that it parallels the first metatarsal in both the sagittal and transverse planes is key in order to avoid malalignment of the newly formed regenerate. Although the patient did require removal of her hardware, she was able to return to normal shoe gear without pain and was able to perform her activities of daily living that had previously been limited at her one-year follow-up.

The literature currently supports single-stage procedures over distraction osteogenesis when possible. Jones, et al., in 2015 performed a systematic review of the literature comparing single stage vs distraction osteogenesis in the treatment of brachymetatarsia. They found that the overall major complication rate of distraction osteogenesis was 12.62% compared to 3.72% with single stage procedures and the minor complications rate was 39.18% for distraction osteogenesis compared to 15.76% for single stage. They also found that distraction osteogenesis is associated with a greater time to heal with an average of 2.31 months for every centimeter gained compared to 1.9 month per centimeter with a single stage procedure [1].

Even with these disadvantages, distraction osteogenesis does have a major advantage over single stage bone grafting in that much greater length can be achieved and donor site complications can be avoided. Recommendations have been made that no more than 15 millimeters or 25% of the original length of the bone be attempted with a bone graft. With callus distraction, the recommendation has been that the metatarsal can be increased in length up to 40% of its original length [11-12].

This case study also supports the conversion to internal fixation at the time of external fixation removal during the consolidation period. This allows for the benefits of external fixation in being able to gain greater lengths of correction while also limiting the time the patient spends in the external fixator. This technique is well supported in the literature and can help make external fixation more tolerable for the patient [8-9].

In any patient with a history of a non-union it is important to rule out any underlying conditions that may have caused the non-union. There are a variety of different causes for a non-union from improper joint preparation, improper/loss of fixation, smoking, low vitamin D levels, underlying metabolic disorders, among others [14-15]. It is important to order the appropriate labs pre-operatively and medically optimize the patient before considering return to the OR for surgical intervention. The protocol for ruling out underlying metabolic bone conditions for the senior author in our study (C.C.) is to order labs for vitamin D, prealbumin, a comprehensive metabolic panel, parathyroid, and a thyroid panel. In our patient these labs all came back normal indicating they most likely did not contribute to the patient's original non-union.

In conclusion, bony defects too large for acute correction in the 1st MPJ provide difficult challenges to the surgeon but distraction osteogenesis is a viable option. Converting the external fixation to internal fixation can also help make distraction osteogenesis more tolerable to patients that are hesitant to spend extended periods of time in an external fixator.

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