CHAPTER **5**

PHALANGEAL BASE AUTOGRAFT FOR THE CORRECTION OF THE SUBLUXED HAMMERTOE

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INTRODUCTION

Hammertoes can be classified as simple, moderate, and severe. The deformities can be flexible, semi-rigid or rigid. As hammertoe deformities progress, deformity of the metatarsophalangeal joints (MPJ) are more common. These deformities involve deviations in all 3 cardinal body planes. The more planes involved, the more difficult the deformity is to correct. Again, one can attribute a certain amount of flexibility or rigidity in describing the deformity. The more longstanding a deformity, generally the more rigid it tends to be.

Simple hammertoes may be corrected by arthroplasy or arthrodesis at the proximal interphalangeal joint. Moderate and severe hammertoes usually require arthrodesis for correction. Ancillary procedure may include extensor hood release, extensor tendon lengthening, MPJ dorsal release, and perhaps release of the plantar plate. Transverse MPJ deformity may require selective release of the medial or lateral MPJ capsule and or collateral ligaments. At times, the insertion of the lumbrical and interosseous muscles must be resected.

Flexor tendon transfers have been used extensively to provide stability to the MPJ in cases involving flexible deformties where muscle tendon balance can be restored.

When end-stage subluxation or dislocation of the MPJ exists, options remaining at this point are few. If the joint is reduced and remains at a moderate degree of tension, then redeformity is likely. Sufficient decompression is necessary to achieve a stable result. In contrast, sufficient postoperative stability is needed to maintain correction and allow for appropriate long term functioning. Stability postoperatively often comes from scarring and local fibrosis. Resection of the metatarsal head (partial or complete) is an option; however, it is not without complications. Stiffness and pain can result in cases of minimal resection, while short and floppy toes with transfer metatarsalgia may result when too much bone is resected.

An alternative is resection of the base of the proximal phalanx. This procedure was first described by Kreuz in 1923.[1] It was described for correction of dislocation of the MPJ. The procedure is designed to increase motion at the MPJ. McGlamry states that "performing resection of the proximal phalangeal base is contrary to all logic in trying to maintain digital stability."[2] The digit loses its intrinsic muscular attachments and instability is created. Often times, the result is a flail, shortened, and retracted toe. The toe is nonpurchasing and generally functionless. Plantar protrusion of the metatarsal head with discrete plantar hyperkeratosis can occur. McGlamry appropriately points to certain legitimate clinical situations where phalangeal base resection is appropriate: osteomyelitis, bone tumor, and as an ancillary procedure in rheumatoid forefoot reconstruction (Figure 1).

Kelikian[3] recommended webbing or syndactylization in an effort to improve digital stability. "Since the interphalangeal joints of neighboring toes are not on the same coronal plane, the phalanx of one digit stabilizes the joint of the other."[3] The combined action of their long flexor tendons does transfer some plantarflexory strength to the MPJ level. While I agree that resection of the proximal phalangeal base destroys much of the digital stability, I contend that frequently, the same thing happens when aggressive soft tissue releases are performed. Other factors are at play here that include digital length, postoperative scaring, and persistent deforming forces.

Figure 1. Unstable second toe following base resection.

Performance of base resection is a necessary procedure in cases of severe, irreducible hammertoe with MPJ contracture and subsequent arthrosis. The procedure allows for correction of the deformity without undue tension. By using the resected base as an autograft, some of the digital length can be returned and preserved. The graft is placed at the interphalangeal joint fusion site and fixated with a Kirschner-wire. Ancillary procedures include soft tissue interposition at the metatarsophalangeal pseudojoint as well as extensor tendon transfer to the first metatarsal neck. These procedures can provide digital stability and function.

ANATOMY, BIOMECHANICS, AND PATHOPHYSIOLOGY

The second toe and MPJ are the most commonly dislocated joints in the foot. This is attributed to its relative length, juxtaposition to the great toe, and muscular imbalance. Trauma serves an important role here, however other causes can exist such as synovitis from rheumatoid arthritis and other arthritides.

Toes are exposed to high compressive and shear forces as 40% of the stance phase of gait, the forefoot functions in weight transfer.[4] The function of the toes is to off-load the metatarsal heads. Lambrinudi[5] postulated that this occurs only when the toes were maintained flat on the ground, with synergistic contraction of the long toe flexors and the intrinsics. Normal toe alignment is a combination of competent extrinsic and intrinsic muscle function coupled with competent static joint restraints. The extensor digitorum longus functions to dorsiflex the proximal phalanx by its attachments to the fibroaponeurotic sling that suspends the phalanx. It is only able to extend the proximal interphalangeal joint when the proximal phalanx is in a flexed or neutral position. The extensor digitorum longus, therefore becomes an ineffective extensor of the PIP joint if the MPJ is fixed in hyperextension.

The work of Coughlin and Mann[6] shows that the extensor digitorum longus may become the single most deforming force leading to subluxation and dislocation of the MPJ. Intrinsic muscles flex the MPJ while long and short flexors are responsible for PIP and DIP joint flexion. The second toe has 2 dorsal interossei and one unopposed medial lumbrical muscle. This may become an important pathologic force, when lateral restraints become torn or lax. Static restraints include capsule, collateral ligaments, and plantar plate. A recent biomechanic study of the static restraints to dorsal dislocation of the second MPJ demonstrated a 48% reduction in the force required to dislocate the joint when both the collateral ligaments were sectioned, compared with a mean reduction in force of only 29% when the plantar plate alone was sectioned.[7] The collateral ligaments extend from the tubercles of the metatarsal head to attach on the inferior base of the proximal phalanx. The plantar plate is formed by the plantar aponeurosis and plantar capsule. It originates on the plantar metatarsal neck and inserts on the plantar aspect of the proximal phalangeal base. It supports the metatarsal head and resists hyperextension of the MPJ.

Synovitis of the MPJ (most often the second) may be associated with a long toe and or metatarsal, as well as repetitive trauma as seen with inappropriate shoe gear. Other causes of hammertoe include age-related attrition in the plantar capsule, plantar aponeurosis, and intrinsic flexors. Hallux valgus or hallux abductus interphalangeus can also play a role (Figure 2). Neuromuscular disease causing muscular imbalance is another etiology.

PHALANGEAL BASE AUTOGRAFT

Numerous surgical procedures have been described to correct the chronically subluxed or dislocated toe with secondary deformity. Common to all procedures is a sequential release of the pathologic deformed/shortened soft tissues. The initial skin incision is one of a curvilinear approach, thereby avoiding dorsal scar contracture (Figure 3). It is rare to encounter the need for skin lengthening such as a V to Y advancement or Z-plasty procedure.

Careful blunt dissection through the subcutaneous tissues allows for identification of veins and arteriole bleeders. Controlling blood pooling is necessary to prevent excessive postoperative edema. Meticulous operative technique is utilized so that potential complications can be avoided (Figure 4). The extensor tendon complex is

Figure 2. Hallux valgus and associated digital deformities and forefoot contractures.

Figure 3. Curvilinear approach to joint contracture. Preoperative radiograph showing significant metatarsophalangeal arthrosis and deformity.

Figure 4. Blue toe immediately postoperatively. Causes are multifactorial and often non-avoidable.

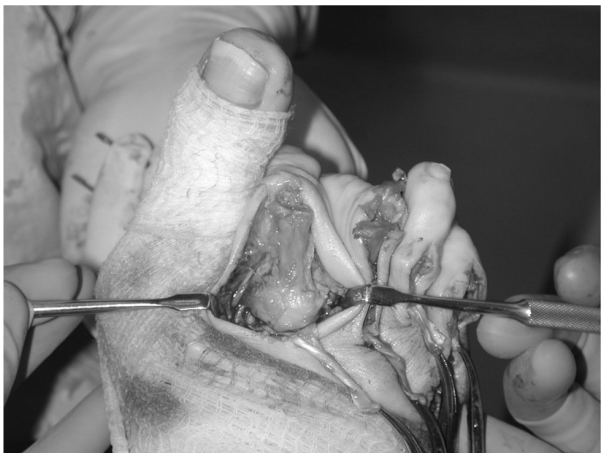

Figure 5. Complete release of dorsal contracture. Minimal proximal interphalangeal joint resection maintains digital length and stability.

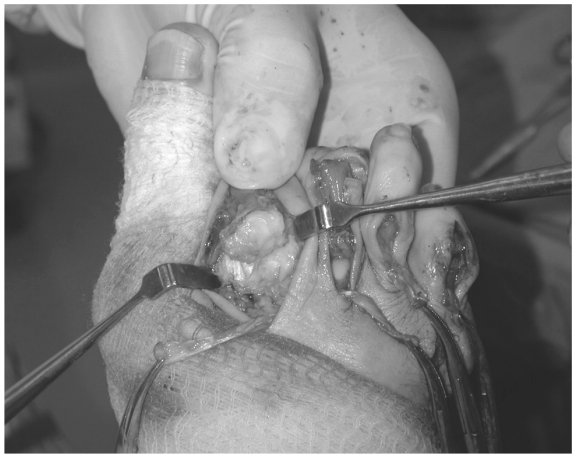

Figure 6. Subluxation of long flexor tendon seen. Note advanced arthrosis at basilar cartilage of the proximal phalanx.

generally lengthened by Z-plasty and the extensor hood is released entirely. The extent of deformity is always reassessed by forefoot loading. The dorsal capsule and superficial medial and lateral capsular tissues are often released as well (Figure 5). When necessary, the collateral ligaments, the interossei, and the lumbrical may need release (Figure 6). Plantar plate release, stripping adhesions from the plantar plate and metatarsal head may be performed. The metatarsal elevator is indispensable for this task (Figure 7). On occasion, the flexor tendons may be dislocated and must be addressed in order for a successful re-establishment of extensor and flexor balance to be restored (Figures 8, 9).

When reduction of the MPJ contracture cannot be obtained, either due to severe contracture or most often due to deformity at the basilar cartilage; then base resection is necessary (Figure 10). Consequences of base resection include weakness, instability, and poor cosmesis. This is partially due to loss of length of the toe thereby not allowing proper loading during weightbearing. The use of the phalangeal base as an autograft at the level of the proximal interphalangeal arthrodesis site will return some of the digital length (Figure 11). Not all of the resected base can be used due to excessive tension at the digital level. Attempts at over-lengthening will result in arterial compromise (Figure 12).

The bone graft is secured with a Kirschner-wire and the wire is then advanced across the psuedojoint. Soft tissue interposition is performed at this level so as to maintain length and preserve painless motion postoperatively. Capsular tissue, if available can be used, or a tendon packet may be used (extensor brevis or graft)(Figure 13). The extensor tendon is generally sutured to deep soft tissue at the dorsal surface of the metatarsal neck (Figure 14). Ganley reported on this and also preserved the extensor digitorum brevis, allowing for continued dorsiflexion power.[8] Simple extensor tendon repair also allows for some

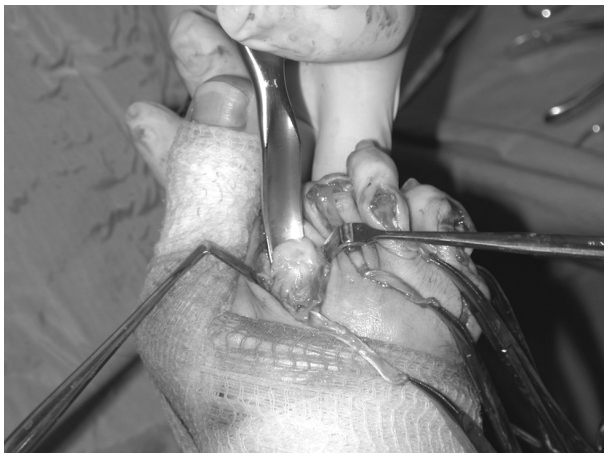

Figure 7. Plantar adhesiotomy utilizing metatarsal elevator.

Figure 8. Relocation of flexor digitorum longus.

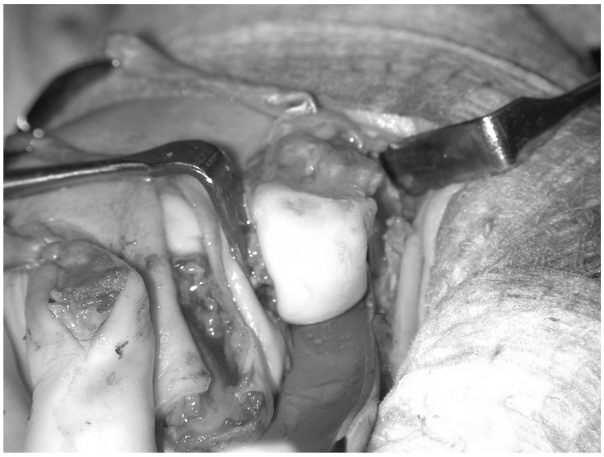

Figure 9. Relocation of flexor digitorum longus.

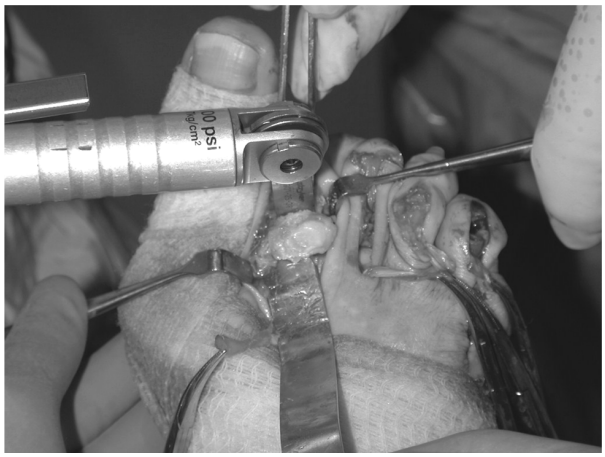

Figure 10. Phalangeal base resection is necessary to correct contracture when deformity of the basilar cartilage is present.

extension function, albeit minimal. McGlamry, Jimenez, and Green discussed the flexor digitorum longus re-insertion into the remaining base of the proximal phalanx as part of muscle tendon re-balancing (as routinely performed in the Keller arthroplasty).

The patient can usually be maintained weightbearing postoperatively. The use of a walking cast or cam walker should protect the Kirschner-wire adequately. If this level of immobilization is not tolerated, then a rigid sole surgical shoe with off-loading felt padding should be used. Crutch, cane or walker assistance is helpful. The Kirschner-wire is generally left in place until full bone graft incorporation is noted on radiograph. This can be from 4 to 12 weeks (Figure 15). After removal of the Kirschner-wire, passive restraint of the toe is recommended until complete stabilization is appreciated. While full function of the toe is never realized, the patient is content with return of a plantigrade and stable digit (Figure 16).

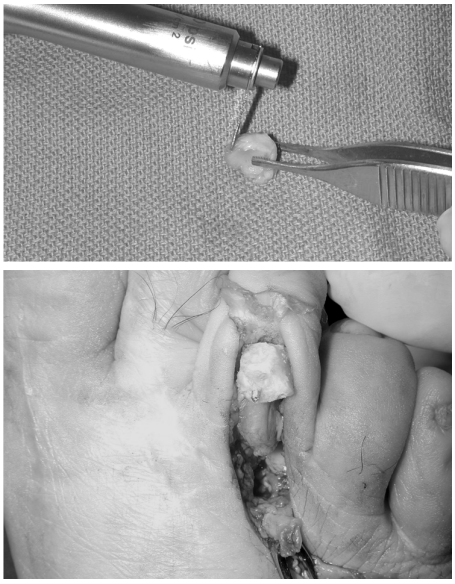

Figure 11. Proximal phalangeal base is remodeled and placed as an autograft at the proximal interphalangeal joint fusion site.

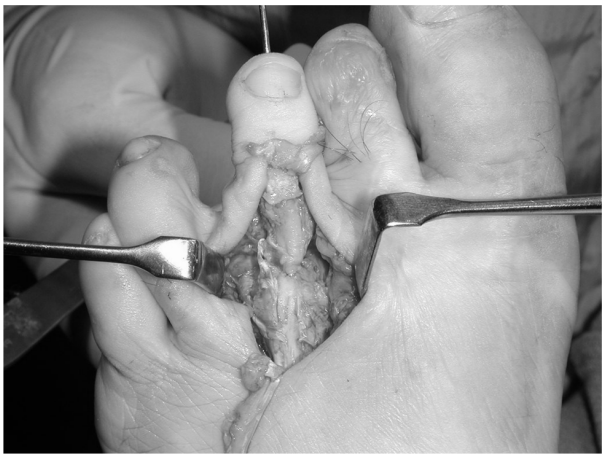

Figure 12. Over-lengthening of the toe may lead to arterial compromise.

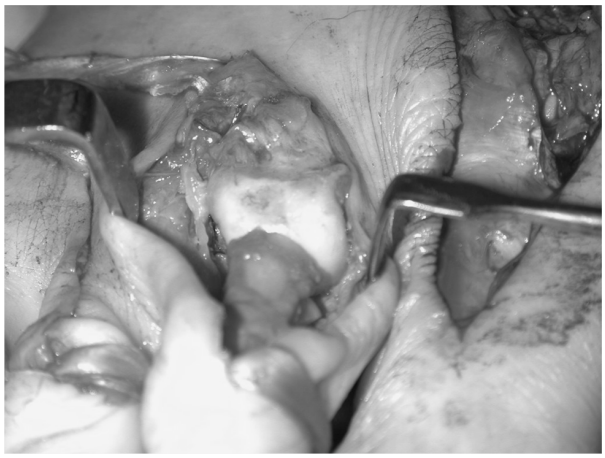

Figure 13. Soft tissue is placed within the joint providing protective interface.

Figure 14. Extensor tendon is sutured to the dorsal deep fascial tissue.

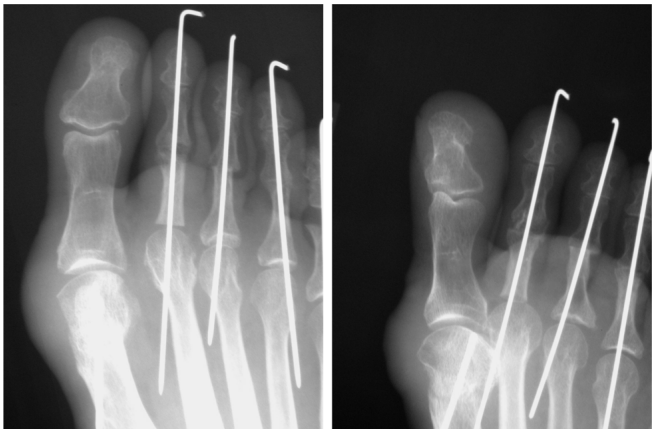

Figure 15. Bone graft is incorporated and digital length maintained.

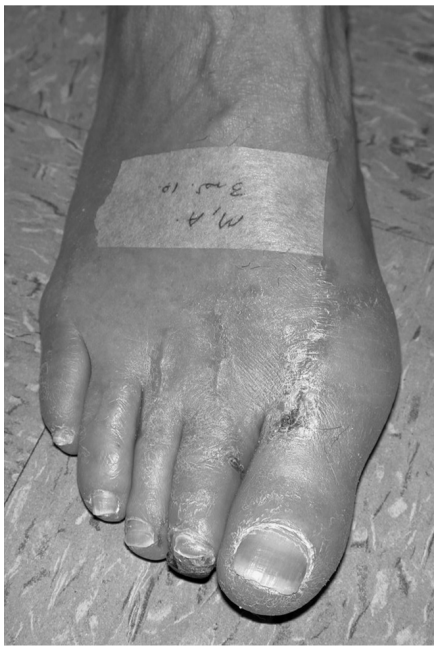

Figure 16. Second toe is stable with full purchase.

EVALUATION

Twelve patients (13 hammertoes) were evaluated both preoperatively and postoperatively. All patients ranged from 50-78 years of age. Ten of the patients were female. All patients had preoperative readiographs to assess arthrosis and deformity. The preoperative sagittal plane deviation of the proximal phalanx to the metatarsal as well as the proximal phalanx to the middle phalanx was assessed. A mean of 44.33 degrees was found for the preoperative value of the proximal phalanx to the metatarsal, which indicated severe sagittal plane deformity. The middle phalanx to proximal phalanx deviation was 48.33 degrees. Postoperative measurements were 15.54 degrees and 3.3 degrees respectfully. These values show a reduction in deformity of approximately 65% and 93%, respectively. All patients showed improvement in their deformities and had reduction in pain.

SUMMARY

When end-stage arthrosis is present at the level of the MPJ, resection of the basilar portion of the proximal phalanx, provides correction of deformity. Using the resected bone as an autograft returns some length to the shortened toe. Mahan has shown that returning length to a toe will re-establish function.[9] The advantages to this procedure are that the deformity is corrected, the digit is lengthened, some function of the toe restored, dynamic forces across the joint are neutralized, pain is abolished and functional weight bearing of the metatarsal head spared.

REFERENCES

1. Kreuz L. Die Hammerzehen und ihre Operation nach. *Gocht Arch Orthop Infall-Chir* 1923;21:459-572.
2. McGlamry ED. Comprehensive textbook of foot surgery, Second Edition. Baltimore: Williams and Wilkins; 1992. p. 348.
3. Kelikian H. Hallux valgus, allied deformities of the forefoot and metatarsalgia. Philadelphia: WB Saunders;1965. p. 314.
4. Bojsen-Moller F. Anatomy of the forefoot, normal and pathologic. *Clin Orthop* 1979;142:10-18.
5. Lambrinudi L. Use and abuse of toes. *Postgrad Med J* 1932;8:459-64.
6. Coughlin MJ. Subluxation and dislocation of the second metatarsophalangeal joint. *Orthop Clin North Am* 1989;20:535-51.
7. Bhatia D, Myerson MS, Curtis MJ, Cunningham BW, Jinnah RH. Anatomic retstraints to dislocation of the second metatarsophalangeal joint and assessment of a repair technique. *J Bone Joint Surg Am* 1994;76:3711-5.
8. McGlamry ED, Jimenez AL, GreenD , In: McGlamry's comprehensive textbook of foot and ankle surgery, Third Edition. Philadelphia: Lippincott Williams and Wilkins; 2001. p. 289.
9. Mahan K. Bone graft reconstruction of a flail digit. *J Am Podiatr Med Assoc* 1992;82:264-8.