CHAPTER 12

HAMMERTOE PIP JOINT ARTHRODESIS USING ALLOFIX® CORTICAL BONE ALLOGRAFT PIN FIXATION

Stephen J. Miller, D.P.M.

INTRODUCTION

Hammertoe repair by way of PIP joint arthroplasty where the head of the proximal phalanx is removed, often leaves a very unstable digit whose final position and alignment can be affected by tendon imbalances and scar contracture. Studies have shown that PIP joint arthrodesis provides better stability, toe purchase and sagittal plane correction compared to arthroplasty alone.[1] When combined with metatarsophalangeal joint relocation, this procedure has been shown to reliably alleviate associated metatarsalgia.[2] In addition, it has demonstrated a relatively high satisfaction rate to the patients.[3]

Fixating a digital arthrodesis using a K-wire protruding out of the end of the toe presents a number of problems. Exiting the skin for a protracted period of time exposes the site to the potential for infection, pin trauma, pin bending, and accidental extraction.(Fig. 1) In addition, the patient must avoid wetting the wound for up to 6 weeks, and must wear some type of protector over the pin. Finally, there is a considerable amount of anxiety that can be generated in anticipation of the removal of the pin, while the procedure itself may be painful. All of these considerations can be frustrating to the patient and challenging to the surgeon. In response to these considerations, internally placed pins have been used to provide digital fixation.

Two types of pins have been implanted across digital arthrodesis sites for internal fixation. Patton utilized a 1.3mm poly-p-dioxanon absorbable pin which dissolved by hydrolysis approximately 6 months after placement.[4] Miller implanted a 2.4mm diameter pin fashioned out of cortical allograft bone.[5] This bone pin, placed in the intramedullary canals across the arthrodesis site is actually resorbed and incorporated into the local bone as it forms a framework for bone fusion. Small screws have also been placed internally for PIP joint fusion, the main disadvantage being that for insertion, they must pass through or across the DIP joint.[3]

INDICATIONS

Arthrodesis of the lesser toes using a cortical bone allograft pin is indicated for correction of mild to moderate hammertoe deformity involving the proximal interphalangeal joint.(Fig. 2) The deformity can be flexible or partially anklyosed, but must not involve severe hyperextension at the metatarsophalangeal joint. By itself, the procedure does not address pathology at the metatarsophalangeal joint where temporary metal pin fixation may be required.

Figure 1. Metal pin fixation for digital fusion.

Figure 2. Hammertoe deformity with minimal contracture of the metatarsophalangeal joint.

Modest contracture of the soft tissues about the associated metatarsophalangeal joint, as demonstrated by the metatarsal push-up test, requires a capsulotomy and collateral ligament release to be performed at the same time. It is usually not necessary to do so until the bone pin arthrodesis procedure has been accomplished. It is also often necessary to lengthen the extensor tendons to assure that all deforming forces have been neutralized.

SURGICAL PROCEDURE

The steps for this procedure are illustrated in Figure 3. The soft tissue dissection involves a longitudinal or serpentine incision followed by separation of the subcutaneous layer. The extensor tendons are retracted or separated for a Z-plasty lengthening with sectioning of the hood apparatus. As the collateral ligaments are incised with periarticular capsulotomies, the joint surfaces are delivered into the wound.

Using a power saw or rongeur to remove the cartilage from both surfaces of the joint, good cancellous bone is exposed with minimal sacrifice of length. At this point, the 2.4mm smooth drill is used to ream the intramedullary canals of both the proximal and middle phalanges, with care being taken not to perforate the subchondral bone into the next joint. The depth gauge is then used to determine the length of pin required to cross and sustain the arthrodesis site, by measuring the depths of the proximal and middle phalanx canals and totaling the two numbers. The desired length of the bone pin can then be marked and cut with a power saw. Cutting with a bone forceps or rongeur should be avoided as they may shatter the pin.

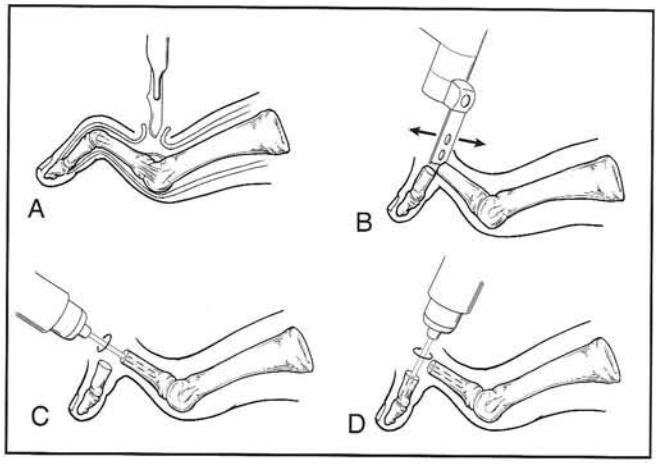


Figure 3. A. Release of the metatarsophalangeal joint. B. Exposure of the proximal phalangeal joint for denuding cartilage. C. and D. Drilling of the intramedullary canals. This uses a smooth 2.4mm pin.

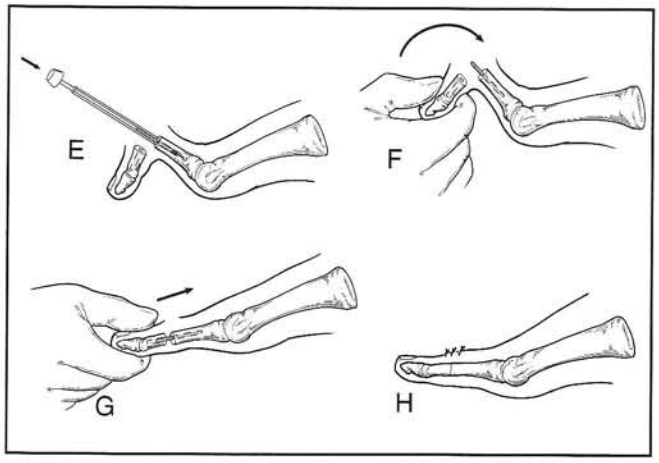


Figure 3. E. Insertion of the bone pin into the proximal phalanx medullary canal. F and G Grasp toe maneuver for inserting the pin onto the middle phalanx. H. Realign digit with cortical bone pin securing the arthrodesis site.

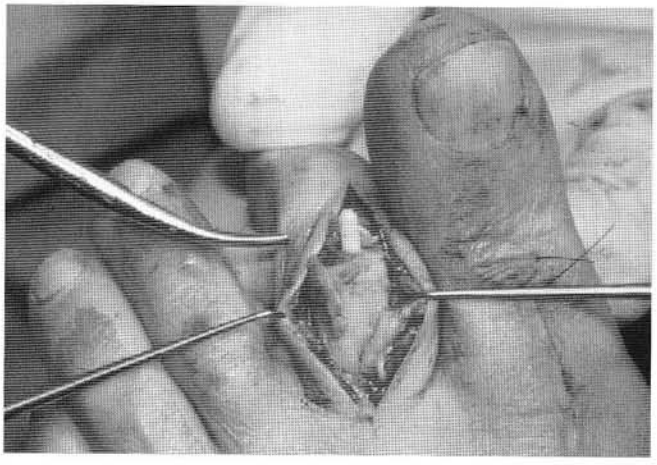


Figure 4. Intraoperative illustration of maneuvering the distal toe onto the pin.

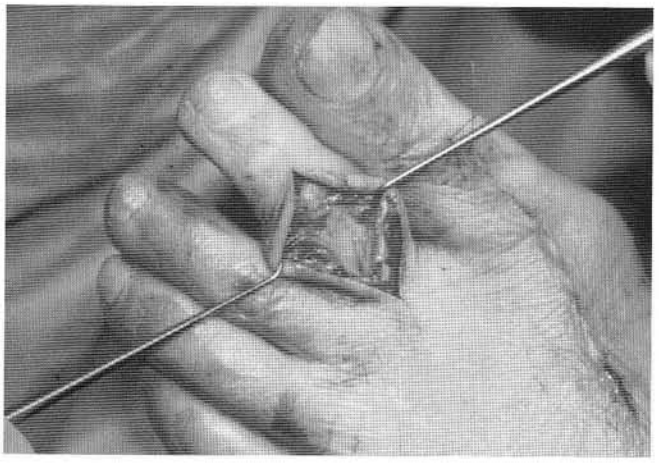


Figure 5. Straightened toe with arthrodesis fixation pin in place.

Figure 6. Loading the foot to check for reduction at the metatarsophalangeal joint.

The pin is then inserted into the medullary canal of the proximal phalanx shaft, deep enough to almost contact the subchondral plate at the opposite end. This will prevent a shallow-placed pin from slipping deeper into the canal when the middle phalanx is pushed onto the remaining exposed bone pin.

The distal toe is now firmly grasped and both distracted and plantarflexed at the same time. (Fig. 4) Maintaining the distraction, the toe is then dorsiflexed to slip over the pin, which should then glide onto the middle phalanx. The toe should now be impacted along its straightened alignment using finger pressure to drive the phalanges together. (Fig. 5) At this point, the foot is test-loaded with pressure under the metatarsal head.(Fig. 6) If the toe is still modestly contracted at the metatarsophalangeal joint, appropriate soft tissue releases can be performed. The tendons and incisions are sutured to complete the wound closure. A postoperative radiograph can be taken to confirm the position of the pin.(Fig. 7)

STUDY

Materials and Methods

The processes for freeze-drying and further preparation of the cortical bone allograft pins at the Musculoskeletal Transplant Foundation, Edison, N.J., were well described by Reed.[6] Special care was taken to test the tissues for any evidence of HIV infection, hepatitis, and other diseases.

Patients for the study were selected from a rural podiatry office practice, taken in sequence as

Figure 7A. Hammertoe correction before implantation of the cortical bone pin.

Figure 7B. Hammertoe correction after implantation of the cortical bone pin.

they presented with the surgical indications for semi-flexible and flexible correction. (Table 1) The criteria to be met included manually-reducible deformity using the Kelikian metatarsal push-up test, moderate flexible contracture at the metatarsophalangeal joint, painful symptoms that had not resolved with conservative care, and little or no transverse plane deformity.

Arthrodesis of the PIP joint of lesser digits using the 2.4mm cortical bone pin allograft was performed on 26 toes in 18 patients. There were 19 second toes, 5 third toes, and 2 fourth toes. Fifteen of the toes had the additional flexor digitorum longus tendon transfer procedure at the same time. The average age of the patients was 66 years (range 43 to 82 years), 15 being female and 3 being male. The average length of follow-up evaluation was 15 months (range 1 to 34 months).

Results

All of the fusions, with the exception of one consolidated uneventfully (25/26), with several bridging up to 4mm gaps at the arthrodesis site. Approximately half-way through the healing process, while the cortical bone pins were being resorbed and incorporated with bone, the pin fractured in two toes. One went on to full arthrodesis, while the other became a nonunion requiring a revisional surgery.

Two of the toes developed postoperative flexion contractures at the DIP joint, while three toes became hyperextended at the metatarsophalangeal joint. Other toes showed a mild propensity for the same hyperextension, but were splinted into rectus alignment. None of these toes utilized a flexor digitorum longus tendon transfer which in later cases tended to further stabilize the digit at the same time

Table 1

Digital Fusion Study Patients

Patient	M/F	Age	Toe(s)	FDL	F/U (mos)	Complications
1 NC	F	77	2L	-	33	
2 RD	F	58	2L	-	11	Mallet-toe
3 JS	F	64	3R	-	13	15 degrees MPJ extension
4 JB	M	54	2R	+	11	Pin fracture (jogger)
5 PS	F	66	2L	-	24	MPJ Hyperextension
6 LB	F	65	2L	-	29	DIPJ Flexion/MPJ extension
7 JN	F	73	2R	-	21	
8 AB	F	72	2R	-	34	
AB	F	73	2L	-	26	
9 LS	F	58	2L	+	23	
10 BK	F	75	2L	-	16	
11 JVK	M	82	2L	-	20	Nonunion/2nd surgery
JVK	M	82	2R	-	20	
12 ES	F	43	2L	+	10	
13 LB	F	76	2R	+	5	
14 CM	F	68	2L	+	7	
CM	F	68	3L	+	7	
15 MM	F	77	2R	+	5	
MM	F	77	3R	+	5	
16 JVH	M	58	2R	+	5	
JVH	M	58	3R	+	5	
JVH	M	58	4R	+	5	
17 CB	F	53	2R	+	3	
18 SS	F	68	2R	+	1	
SS	F	68	3R	+	1	
SS	F	68	4R	+	1	

as releasing additional deforming forces. One of the hyperextended toes was reduced with an extensor tenotomy/capsulotomy. With the exception of the two revisional surgeries (2/26), all the other toe fusions (24/26) resulted in patient satisfaction.

Finally using serial radiographs, it was determined that the pins were fully resorbed and incorporated into the bone by 6 to 8 months after surgery. Occasionally, remnants of bone were still visible on x-ray at one year postoperative, but this was deemed to be of no clinical significance. One advantage of using the bone pins over the synthetic pins is that the bone pins are visible on serial x-rays as they were incorporated by the healing process.

Discussion

The results of this clinical study using the 2.4mm diameter Allofix cortical bone pins for fixation and arthrodesis of digital fusions, showed the pins to be effective. Many of the potential complications and inconveniences of percutaneous pin fixation were avoided. There have been no reports to date of disease transmission following the implantation of cortical bone allograft pins. In observing the digital bone graft pins via x-ray, it was apparent that the graft was completely resorbed between 6 and 8 months postoperatively. Any remnants at one year or longer were deemed to be clinically insignificant.(Fig. 8)

Flexion at the DIP joint, or mallet-toe formation following PIP joint arthrodesis is a well-known possible complication that may require further surgery. One study has shown the incidence to be approximately 44%.[3] This potential problem and the difficulty with metatarsophalangeal joint hyperextension were solved by adding a flexor digitorum longus tendon transfer to the procedure for additional stability against the supporting surface. As the study progressed, this additional maneuver was used more frequently.

Internal fixation pins function as rigid intramedullary rods. Although both synthetic and bone pins provide rigidity and resist shearing forces, the absorbable synthetic pins lack strength related to bending and compressive forces, while the processes for preparing the bone allograft pins tend to slightly reduce their torsional and bending strength.(Tables 2A, 2B) In neither pin have these modest limitations had any effect on the success of the digital corrections.

In contrast to the polymeric pins which are hydrolyzed for linear resorption and bone replacement without incorporation, the bone pins act as a lattice on which new bone can form via osteoconduction. Interestingly, some bone morphogenic protein is preserved in the bone allograft pins so they have osteoinduction capabilities as well. The result is total incorporation and the ability to bridge gaps. Besides having low antigenicity, the risk of HIV infection from the processed bone pins is negligible, having been calculated at 1 in 1.16 million in properly screened allograft bone.[7]

Figure 8. Radiograph of cortical bone pin at 1 year showing successful arthrodesis.

Table 2A

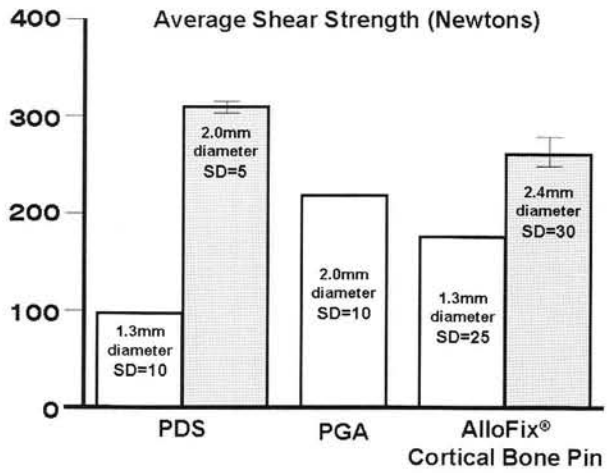
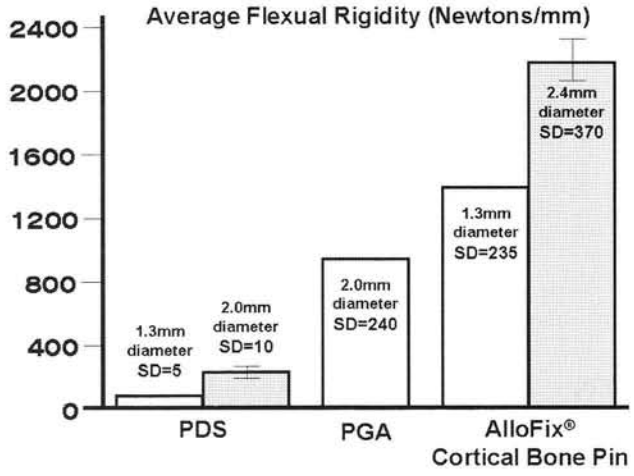


Table 2B



One disadvantage of internal fixation pins for toe surgery is the lack of interfragmentary compression for the acceleration of bone healing. As rigid devices, they can fracture, but this has not proven to be a problem. Another disadvantage is that the pins cannot cross the metatarsophalangeal joint when it is necessary to maintain the reduction of a subluxed or dislocated articulation. This problem can usually be overcome with the addition of a flexor digitorum longus tendon transfer.

CONCLUSION

Arthrodesis of the lesser PIP joint by means of internal fixation using the 2.4mm cortical bone pin allograft appears to be a reliable procedure with predictable results and minimal complication risk. The length of the toe is preserved while avoiding many of the complications encountered with transcutaneous pins. The cortical bone pin is an excellent bone graft for primary digital arthrodesis or to repair failed PIP arthrodesis, failed PIP joint arthroplasties, or unstable lesser toes where there is a need for bone graft to bridge the remaining gap.

REFERENCES

1. Lemm M, Green R, Green D: Summary of retrospective long-term review of proximal interphalangeal joint arthroplasty and arthrodesis procedures for hammertoe correction. In Vickers NS, Miller SJ, Mahan KT et al (eds) *Reconstructive Surgery of the Foot and Leg, Update '96* The Podiatry Institute, Tucker, GA pp 193-196, 1996.
2. Malay DS: An analysis of digital arthrodesis. In Vickers NS, Miller SJ, Mahan KT et al (eds) *Reconstructive Surgery of the Foot and Leg, Update '96* The Podiatry Institute, Tucker, GA pp. 209-215, 1996.
3. Lehman De, Smith RW: Treatment of symptomatic hammertoe with a proximal interphalangeal joint arthrodesis. *Foot Ankle Int* 16:535-541, 1995.
4. Patton GW, Shaffer MW, Kostakos DP: Absorbable pin. A new method of fixation for digital arthrodesis *J Foot Surg* 29:122-127, 1990.
5. Miller SJ: Hammertoe correction by arthrodesis of the PIP joint using a cortical bone allograft pin: Preliminary Study. Submitted for publication.
6. Reed TM: Allofix freeze-dried cortical bone pins as an alternative to synthetic absorbable polymeric pins: A preliminary study in short Z bunionectomies *J Foot Ankle Surg* 38:14-23, 1999.
7. Buck BE, Malinin TI, Brown MD: Bone transplantation and human immunodeficiency virus: An estimate of risk of immunodeficiency syndrome (AIDS). *Clin Orthop Rel Res* 240:129-136, 1989.