

CORRECTING HAMMERTOE DEFORMITIES UTILIZING AN INTRAMEDULLARY DEVICE: Case Reports

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INTRODUCTION

The most common fixation method following the surgical correction of a hammertoe deformity remains the Kirschner wire (K-wire) (1, 2). The challenges of the K-wire techniques, whether percutaneous and external or completely buried, have led to the design and development of alternative fixation devices that provide more secure fixation, are completely intramedullary (IM) and remain permanently implanted (3). As IM fusion devices receive increasingly widespread adoption, surgeons are expanding the scope of applications for which they find this technology effective. This article provides case reports illustrating several examples of how such an implant may be utilized.

DESIGN RATIONALE FOR AN IM DIGITAL FIXATION DEVICE

The ARROW-LOK Hybrid implant of the ARROW-LOK Digital Fusion System (Arrowhead Medical Device Technologies) is the specific implant (Figure 1) referenced in this article. The ARROW-LOK was designed to improve upon the performance of the K-wire yet retain as closely as possible the simplicity and ease-of-use of this familiar procedure.

Machined from a single piece of ASTM F-138 stainless steel, the ARROW-LOK Hybrid has a solid, 1.5 mm (0.059") diameter shaft with three-dimensional arrowhead tips at each end: the proximal tip with a diameter of 2.5 mm and a distal tip with a diameter of 3.5 mm. The implants are available in lengths from 19 mm to 35 mm to fit the lesser toes of a wide range of patients and to address a wide range of clinical requirements. It also offers the surgeon the option of two different implant alternatives: one with a neutral orientation, the other with a 10° plantar grade angle.

The ARROW-LOK Hybrid implant, available in longer lengths than other IM designs (3), achieves initial fixation by embedding the 2.5 mm arrowhead tip in the dense

subchondral bone at the base of the proximal phalanx (Figure 2). The 3.5 mm arrowhead tip more readily fits the IM dimensions of the middle and distal phalanges. The tip design and implant lengths enable the ARROW-LOK Hybrid implant to provide fixation of the proximal interphalangeal joint (PIPJ), the distal interphalangeal joint (DIPJ) and even both the PIPJ and DIPJ with only one implant as described in the first case report below. The 2.5 mm diameter of the proximal tip and the long lengths enable the implant to pass through the narrow isthmus of the proximal phalanx in order to achieve initial fixation in the subchondral bone at the base of the proximal phalanx. Because this is a region of the phalanx not involved in the fixation provided by other IM implants, this subchondral bone enables the ARROW-LOK Hybrid implant to provide firm initial fixation when revising other IM implant designs that may need to be revised, if, for example, the original

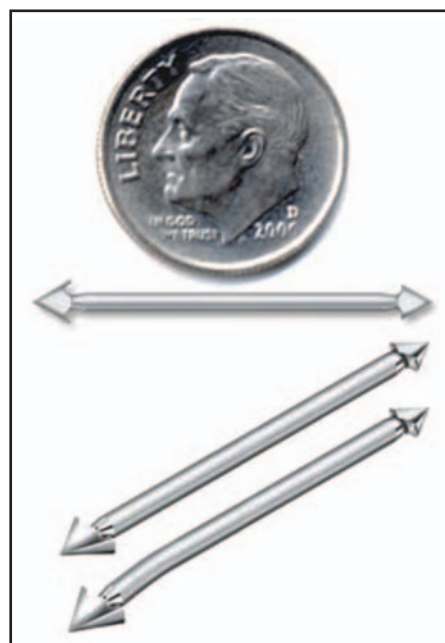


Figure 1. ARROW-LOK Hybrid Implant (30 mm).

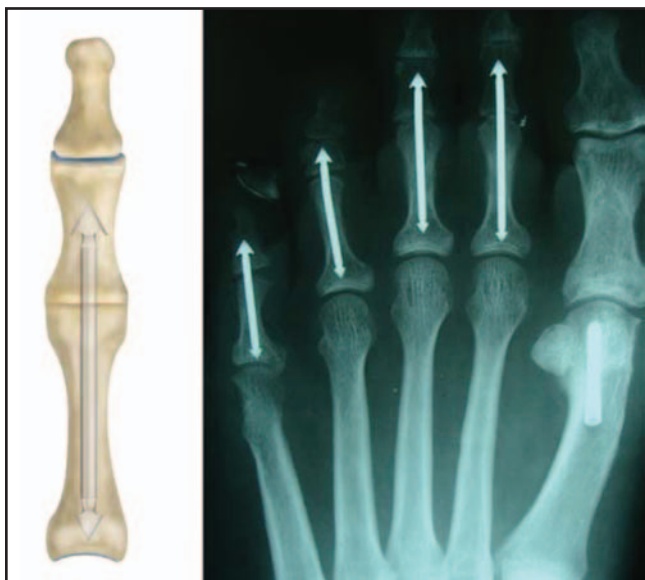


Figure 2. The ARROW-LOK achieves initial fixation with the 2.5 mm diameter arrowhead tip in the subchondral bone at the base of the proximal phalanx.

implant fractures. If necessary, the ARROW-LOK implants may be removed with a simple technique that will not disturb the cortices (4). It should be noted that ARROW-LOK implants were designed to provide uniform strength throughout the implant, exhibiting no signs of fatigue or cracking following 4-point bend fatigue testing after a quarter of a million cycles at peak loads of 89N (4).

CASE REPORTS

Fixation of the PIPJ and DIPJ With a Single Implant

Preoperative notes. The patient was a healthy 19-year-old male with a long history of pain in the left foot. He first noticed the bunion and hammertoes as a young child and commented that they seemed to be getting worse. He began experiencing increased pain in the distal foot and the inability to wear desired shoe gear without pain. On examination it was noted that the patient had a significant bunion deformity that had laterally deviated into the second toe. The lateral deviation of the great toe had significantly increased the amount of contracture in the second toe. The patient had hammertoes on digits two, three, four, and five. The deformity was at both the PIPJ and DIPJ and had caused friction lesions on the dorsal aspect of the digits that were painful to touch and painful in shoe gear. With manual reduction of the hammertoes it was noted that he had an excessively long second toe that created a problematic digital parabola.



Figure 3. Case report 1. Preoperative radiograph of a patient with a significant bunion deformity and hammertoes on digits two, three, four, and five.

The preoperative radiographs showed that the patient had an increased IM angle and a laterally deviated great toe (Figure 3). The patient also had significant contracture of the PIPJ and DIPJ of digits two, three, and four. He had PIPJ contracture of the fifth toe. He had an elongated second toe, but no other osseous abnormalities were noted. The patient tried digital splinting and accommodative shoe gear. After failure to respond to conservative care, he chose to proceed with definitive treatment.

The decision was made to take him to the operating room for correction of the bunion deformity as well as hammertoe deformity involving digits two, three, four, and five. The elongated second toe would also be addressed to correct the abnormal digital parabola. Because of the contracture at the PIPJ and DIPJ on digits two, three, and four he had correction of both joints using the ARROW-LOK Hybrid implant to cross both the PIPJ and DIPJ. No implant was used in the fifth toe on this case.

Operative notes. The bunion deformity was corrected with a standard Austin type bunionectomy and fixated with a 4-0 dual thread screw in standard AO technique. Attention was then directed to the dorsal aspect of the lesser digits. A linear incision was made from the metatarsophalangeal joint (MPJ) distally across the DIPJ. Care was taken to avoid disruption of the collateral ligaments around the joint spaces. The extensor tendons were then transected at the PIPJ and reflected back to the MPJ. Each MPJ of the lesser digits was released plantar

with a McGlamry elevator giving good range of motion at the MPJ and releasing any contracture in this area.

The extensor tendon was then transected at the DIPJ on digits two, three, and four. The collateral ligaments at the PIPJ and DIPJ were then transected with care to leave as much collateral ligament to repair as possible. The cartilaginous surfaces were then removed from the PIPJ and DIPJ of digits two, three, and four, and the PIPJ of the fifth digit. The length of the overly elongated second toe was corrected by removing bone from the middle, intermediate, and distal phalanges creating a normal digital parabola. Only enough bone and cartilage to correct the contracture was removed from digits three, four, and five.

ARROW-LOK Hybrid devices were implanted utilizing recommended operative technique. The decision was made to cross both the PIPJ and DIPJ with one implant. This technique eliminated the concern of not having enough bone in the intermediate phalanx to use one implant for the PIPJ and another implant for the DIPJ. Prior to closure, all wounds were flushed with copious amounts of normal sterile saline. The collateral ligaments were then reapproximated with 4-0 Vicryl. The extensor tendons were reapproximated with 4-0 Vicryl. The subcutaneous tissue was closed in layers and the skin was closed with 4-0 nylon in a running interlocking fashion. The forefoot was then loaded to verify that the contracture was reduced and the digits were in good alignment. Skin closure strips were applied in the sagittal and transverse planes around the lesser digits to maintain stability. A light compressive dressing was then applied. The patient was placed in a postoperative walking boot.

Postoperative notes. The normal postoperative course is to perform a simple bandage change and replace the skin closure strips at 1 week postoperative and again at 2 weeks postoperative. At 3 weeks the sutures are removed. If edema is present at 2 weeks, a silicone sleeve is placed on the toes to maintain light compression until 4 weeks postoperative. The patient wears a postoperative shoe or walking boot until 6 weeks postoperative after which normal shoes are acceptable as tolerated.

The postoperative course of this patient demonstrates the strength and stability of the implant when treating a patient who is overactive postoperatively. The patient came in for his first follow-up visit and was noted to have extreme edema and erythema. The digits were in good alignment although the edema was concerning due to the extreme pressure on the incision line. With the degree of edema present, and the admission by the patient of excessive activity, there was no doubt that the repair of the collateral



Figure 4. Case report 1. The first postoperative radiograph showed some gapping at the PIPJ and DIPJ attributed to excessive patient activity. However, the digits were in good alignment and the hardware was not compromised.

ligaments had been compromised. The first postoperative radiographs showed some radiographic gapping at the PIPJ and DIPJ. However, the digits were in good alignment and the hardware was not compromised (Figure 4).

There was no subsequent change in the postoperative course. The application of the skin closure strips in the sagittal and transverse plane helped in this case, to prevent wound dehiscence as well. The patient returned weekly for bandage and skin closure strip changes. The sutures remained in place due to the edema and the knowledge of the patient being overly active in the walking boot. The 10-week follow-up radiographs showed that he maintained good alignment during the healing process. After reduction in edema, the second, fourth, and fifth toes healed as expected. The third toe healed with some radiographic gapping (Figure 5). He was released to normal activity in shoe gear as tolerated at approximately 6 weeks. He went on to be pain free with no evidence of recurrence of the deformities.

Surgeon's comments (BCB). I chose this case to show two important qualities of the ARROW-LOK Hybrid implant. First, both joint spaces of a toe can be corrected with one implant. Second, with the use of this implant, the presence of radiographic gapping does not



Figure 5. Case report 1. Follow-up radiograph at 10 weeks shows the patient maintained good alignment during the healing process. After reduction in edema, the second, fourth, and fifth toes healed as expected. The third toe healed with some radiographic gapping.

compromise the long-term stability of the toe. The implant, even in the presence of some radiographic gapping, will not allow sagittal and transverse plane angulation. If osseous union does not occur, the space will at the very least consolidate with fibrous tissue as if an arthroplasty were done. The difference with using the implant is that you have a rigid implant preventing recurrence of the deformity. It is strong enough to withstand inadvertent early post-operative loading of the toe, and it eliminates the concern with post-operative pin tract infections.

When shortening a grossly elongated digit, the amount of bone needing to be removed should be distributed among all joint surfaces. Be sure to leave enough bone in the distal phalanx to accommodate the ARROW-LOK implant. Trying to take all of the length from the proximal phalanx will lead to a short wide toe, which is as cosmetically displeasing as an overly elongated toe. If the hammertoe contracture is severe or has been present for an extended period of time, the plantar fibrous plate of tissue covering the flexor tendons at the level of the joint can be problematic and, if so will need to be removed. If the plantar plate is thick and sponge-like, it can prevent achieving bone-on-bone contact of the phalanges. A sesamoid is often present at this level and if problematic should be removed as well.

Always look at the lateral view while placing the guide wire and after implant placement to make sure the implant has not broken through the bone and pierced the nail bed. Such an event could lead to a very painful postoperative complication that would require a return trip to the operating room. The repair of the collateral ligaments will reduce the chance of phalangeal migration. This case shows that phalangeal migration may not cause a long-term problem when using this implant. Our goal, of course, is to achieve fusion. Although, one of the highlights of using this implant is that a good result can be achieved even if you have radiographic gapping at the site of desired fusion. The design of the implant will allow for a stable rectus toe even in the presence of a fibrous union. We never know when we will have a problematic situation or a noncompliant patient. It is desirable to know that the implant will allow for a rectus stable toe even in less than desirable situations.

The use of skin closure strips significantly reduces the chance of damage to the alignment of the toe should the patient have an injury to the foot. The skin closure strips are essential if it is not possible to repair the collateral ligaments. If the skin closure strips are not available, a betadine splint can be substituted.

If you do hammertoe surgery long enough you know that even when you do everything right complications arise. We have all seen patients, whether our own or those of another physician, 2 to 3 years postoperative with recurrent hammertoe deformities. If the K-wire is removed prior to fusion, there is little hope of a successful long-term outcome. It is an issue that we as foot and ankle surgeons have been trying to address for years. In my hands, the ARROW-LOK implant is easy to use, and eliminates the concern with a nonunion and recurrent angular deformity.

Revision of Failed IM Implant

Preoperative notes. A 40-year-old woman with Type 2 diabetes presented to our clinic for postoperative evaluation with continued pain and swelling of 2-months duration following digital surgery. The patient was noted to have considerably more swelling and tenderness in her third toe than her second toe on her right foot. Weightbearing anteroposterior and lateral radiographs of her right foot showed separation of the proximal and middle phalanx in the third toe at the surgical fusion site (Figure 6). The patient failed to achieve reduction of gapping with closed reduction and digital taping. The decision was made to revise the current implant with the ARROW-LOK Hybrid implant.



Figure 6. Case report 2. Patient presented with pain and swelling in 3rd toe at 2 months.

Operative notes. The proximal interphalangeal joint was incised using a transverse incision over a previous surgical scar. The extensor tendon was transected. Following digital distraction, the prior malfunctioning implant was visualized. Removal of the existing implant was performed with simple distraction using the ARROW-LOK insertion forceps. The ARROW-LOK Hybrid implant was inserted utilizing the recommended operative technique (Figure 7). Skin closure strips were applied over the toe along with a betadine gauze splint to provide additional stability.

Postoperative notes. The patient was kept non-weight-bearing until the first postoperative evaluation and then was permitted weightbearing as tolerated in off-loading footwear for 4 weeks.

Surgeon's comments (RKC). The alignment was anatomic. Pain following the procedure was minimal and the postoperative course was uneventful.

Treating Postoperative Trauma to the Affected Toe

Preoperative Notes. A 52-year-old woman presented to the office with a primary concern of a painful bunion and a second hammertoe deformity. Upon examination, the patient related pain with palpation of the dorsomedial aspect of the first MPJ and pain with end range of motion of the first MPJ. Additionally, pain was elicited along the dorsal aspect of the second proximal interphalangeal joint (PIPJ), which revealed a semi-rigid hammertoe deformity with flexor stabilization-type pathology. A small heloma durum was seen overlying the second PIPJ. The patient had sought care from other podiatric physicians and was offered changes in her shoe gear, padding, lamb's wool, and silicone molds



Figure 7. Case report 2. Both arrowhead tips were implanted in subchondral bone of both proximal and middle phalanges, regions untouched by the revised implant.

with no relief. One surgeon recommended correction of the bunion deformity and pinning of the second toe with a non-weightbearing time of 4-6 weeks. Following a recommendation from a friend, the patient sought another opinion as she became aware based on internet research that hammertoes could be fixed without external pins. After a thorough discussion of all options, both conservative and surgical, the patient opted for correction of the bunion deformity and internal beaming of the second PIPJ hammertoe deformity utilizing an IM implant. Perioperative care was discussed in detail and informed consent was obtained.

Operative notes. The surgical plan involved correction of the hammertoe utilizing the ARROW-LOK Hybrid implant (30 mm, angled) and two 3.0 mm screws to fixate an offset V type bunionectomy with lateral release. A transverse skin incision closed with 4-0 nylon was chosen for this patient overlying the second PIPJ to reduce scarring and to remove the corn. The procedure was uneventful and the ankle tourniquet was released at 40 minutes.

Postoperative notes. The patient was placed into a surgical shoe with the bunion site and second toe splinted firmly in the corrected position. She was instructed to utilize crutches for the first postoperative week then gradually transition to full heel weightbearing with the surgical shoe. At postoperative day 5, the patient called and reported an injury to the surgical foot. She was scheduled for an emergency follow-up and upon intake to the office had radiographs taken. She reported getting her foot caught on a rug and feeling a "pulling sensation" in the second toe. She fell forward during the incident but denied any other injuries. She recalls possibly "jamming" the toe upon falling followed by pain in the digit. Radiographs revealed that the second



Figure 8A. Case report 3. Patient reported falling 5 days postoperative causing distraction of the PIPJ. Radiograph taken prior to the patient being treated in the office by repositioning the second toe into the correct alignment.

toe ARROW-LOK implant was in place but the toe had “migrated” on the implant allowing distraction of the PIPJ (Figure 8). After thorough discussion, the patient opted to allow us to reposition the second toe into the correct alignment in the office. The patient was given 5cc of 1% xylocaine plain in a standard digital block. After adequate anesthesia was obtained, the toe was held firmly at the proximal phalanx while the middle and distal phalanges were firmly grasped in toto and gently but firmly retrograded back against the proximal phalanx. Some resistance was encountered, but the digit appeared to shorten back to the immediate postoperative length. The post-reduction radiographs revealed good apposition and the digit was firmly re-splinted (Figure 9).

Subsequent suture removal from the second digit was performed at 2 weeks. At 3 weeks, the standard dressing splintage was exchanged for Velcro removable splinting for the bunion and second digit with a return to regular bathing. The patient’s radiographs at 6 weeks revealed partial bridging of the second PIPJ fusion site and pain-free ambulation in sneakers at this time (Figure 10). Standard physical therapy was employed to mobilize the first MPJ and normalize the gait. By week 8, the patient was back into normal shoe gear, and by week 10, reported wearing 2-inch heels without problems.

Surgeon’s comments (JRM). This case indicates that while internal beaming of digits typically is more aesthetically pleasing to patients and can reduce postoperative



Figure 8B. Case report 3.



Figure 9. Case report 3. The toe was held at the proximal phalanx while the middle and distal phalanges were gently but firmly retrograded back against the proximal phalanx. Post reduction radiographs revealed good apposition and the digit was firmly re-splinted.

complications, the surgeon may still be presented with challenges in the perioperative arena. The surgeon must be prepared to deal with these rare events in order to ensure successful outcomes. Often, the solutions are simple and can be easily handled in the surgeon’s office without a return to the operating room. As always, the patient needs to be counseled on all their options. Appropriate preoperative selection and postoperative care continue to be of utmost importance. In this author’s experience, the ARROW-LOK implant affords the surgeon a highly reproducible and predictable result for semi-rigid and rigid hammertoe deformities.



Figure 10. Case report 3. Radiographs at 6 weeks revealed partial bridging of the second PIPJ fusion site. She was ambulating in sneakers pain free at this time.

Treating the DIPJ

Preoperative notes. The patient was a 42-year-old woman with painful second digits on both the right and left foot. She related always having a long second toe but had noticed it curling down over the past few years. She began having pain at the tip of the toe due to the pressures of her shoes. The pain continued at the dorsal aspect of the DIPJ and at the tip of the digit despite the patient wearing longer shoes to alleviate the pressure on the toes. There is a flexion contracture at the DIPJ only with no contracture at the proximal or MPJs. The deformity is fully reducible with substantial force placed upon the contracted joint. The second digit is significantly longer bilaterally in comparison to the other lesser toes.

Operative notes. Surgical intervention consisted of planned hammertoe repair of the DIPJ. The goal of the procedure was to correct the digital contracture and shorten the digit. An arthrodesis with internal fixation was planned because the procedure can provide stability to straighten and shorten the toe that is superior to an arthroplasty.

Two semi-elliptical incisions were placed over the DIPJ to resect redundant skin for the shortening of the digit (Figure 11). The joint was opened and resected with power instrumentation per standard surgical protocol. Preparation for the fusion consisted of reaming down the center of the medullary canals of both the distal and middle phalanges. The reamed canals were then broached and depth was measured from the laser markings on the broach. The ARROW-LOK implant was then grasped with the insertion

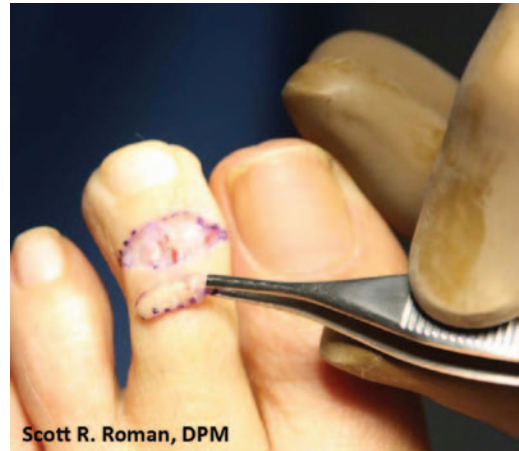


Figure 11. Case report 4. Two semi-elliptical incisions are placed over the DIPJ.

forceps and inserted down the broached canal of the distal phalanx (Figure 12A). The distal phalanx with the implant already inserted was then distracted to enable the exposed portion of the implant to be inserted into the middle phalanx. The fusion site was compressed together to approximate the bone ends (Figure 12B). Intra-operative fluoroscopy was utilized to verify placement and position of the ARROW-LOK Implant (Figure 13). Care was taken to re-approximate the extensor tendon and both the medial and lateral collateral ligaments. Once the closure was complete with the subcutaneous tissues and skin, skin closure strips were applied across the incision and from distal to proximal on both the dorsal and plantar aspect of the digit to offset the skin forces from digital shortening (Figure 14). The surgical sites were dressed with a moist to dry sterile dressing and a modified Jones compressive bandage for edema control and stability.

Postoperative notes. The patient was full weightbearing in an air-inflated walking boot for 4 weeks postoperatively.

Surgeon's comments (SRR). The ARROW-LOK implant with two 3.5 mm diameter arrowhead tips and in lengths of 13 mm and 16 mm work well for the DIPJ fusion. The operative technique for the DIPJ fusion has a slightly different order than the standard PIPJ fusion technique. We find that by inserting the implant as deeply as possible in the distal phalanx first, the insertion forceps can then be removed prior to bringing the exposed end of the implant into the broached cavity in the middle phalanx. This creates a little more room to work at the operative site. Because the implant is as far into the distal phalanx as it possibly can go, the insertion forceps is not needed to serve as a positive stop during insertion of the implant into the middle phalanx.



Figure 12A. Case report 4. Insert the implant into the distal phalanx.



Figure 12B. Case report 4. Distract to insert the exposed implant into the middle phalanx.



Figure 13. Case report 4. Verify placement with intraoperative fluoroscopy.



Figure 14. Case report 4. Re-approximate the extensor tendon and both the medial and lateral collateral ligaments and complete the closure.

Fusion in Spite of a Noncompliant Patient

Preoperative notes. The patient is a 56-year-old female complaining of a painful bunion with a second digital hammertoe deformity. She has worn very high heels all her adult life and has experienced increasing foot pain for about a year. She noted that in the past month her second toe feels like it is “floating.” There was no recent history of trauma.

Previous conservative care consisted of shoe and activity modification, which initially offered some benefit but was no longer helpful. Pain increased with high heeled shoes and progressively worsened throughout the day. Evaluation of the foot indicated moderate to severe bunion deformity that was mostly reducible. The second digit had a flexor contracture at the PIPJ. The digit appeared dorsally displaced compared to the other digits with weightbearing. There was a positive Lachman test indicating loss of

integrity/stability of the plantar plate at the MPJ. Radiographic evaluation indicated an increase in intermetatarsal angle 1 and 2, and increase in the hallux abductus angle. Digital contracture was noted of the PIPJ second digit along with complete dislocation of the second digit at the MPJ with full rupture of the plantar plate, collateral ligaments, and capsular structures. The base of the proximal phalanx was dorsal and medial to the metatarsal head (Figure 15).

Operative notes. Surgical treatment was indicated for the correction of the bunion and hammertoe with special attention to relocating the MPJ and repair of the plantar plate. The bunion deformity was addressed with a modified McBride bunionectomy with Austin-type osteotomy and screw fixation. An arthrodesis of the PIPJ of the second digit was performed utilizing the ARROW-LOK Digital Fusion System. In order to utilize a permanent intramedullary



Figure 15. Case report 5. 56 year-old woman with a painful bunion with a second digital hammertoe deformity. Plantar plate was completely ruptured with MPJ dislocation.



Figure 16. Case report 5. Radiograph at first postoperative appointment shows moderate radiographic gapping due to noncompliance.

device to correct the hammertoe, the ruptured plantar plate was repaired. The ARROW-LOK device was implanted according to the standard operative technique. Intra-operative fluoroscopy was utilized to verify placement and position of the implant. Care was taken to re-approximate the extensor tendon and both the medial and lateral collateral ligaments. Once the closure was complete with the subcutaneous tissues and skin, skin closure strips were applied across the incision and from distal to proximal on both the dorsal and plantar aspect of the digit.

Postoperative notes. At the first postoperative visit, the patient presented to the office ambulating in the air-inflated walking boot but with a very distressed bandage. Upon questioning, she related being very active since surgery. Radiographs indicated some gapping at the digital fusion site (Figure 16). The plantar plate repair appeared to be intact. The patient was told to limit her activities. At the second postoperative visit she presented ambulating without the walking boot, commenting that she had actually increased her activities since the week before. Radiographs indicated significant radiographic gapping, estimated to be about 4 mm (Figure 17). However the implant was still purchased into both the proximal and middle phalanges. The digit was anesthetized and a closed reduction to reduce the gap was attempted without success. The digit was further stabilized and the patient was given instructions to limit activities and use the walking boot for ambulation. From this point she was compliant and followed instructions. Even with



Figure 17. Case Report 5. Second postoperative appointment shows increased radiographic gapping due to continued non-compliance.

the large radiographic gap, the toe went on to full consolidation (Figure 18).

Surgeon's comments (SRR). While radiographic gapping is not ideal, the existence of it is not a cause for great concern. In our experience, incidental radiographic gapping has gone on to full consolidation including the extreme case as described in this case report.

Repairing a ruptured plantar plate is critical when



Figure 18A. Case report 5. Postoperative visit 3. Radiographic gapping moving to full consolidation in a non-compliant patient.



Figure 18B. Postoperative visit 4.

utilizing an IM hammertoe implant. Historically, a 0.062 inch K-wire would be placed across the MPJ to stabilize the joint until enough scar tissue could form at the plantar plate. The K-wire would be pulled out of the digit between the 4th and 6th week. If the K-wire is removed prior to the plantar plate healing properly, the digit can migrate at the MPJ level. In this case, the plantar plate was primarily repaired to obtain full integrity of the tissues to keep the MPJ stable. The plantar plate repair can be accomplished from either the dorsal incision carried proximal to the MPJ or through a plantar incision directly over the affected MPJ. In this case the repair was accomplished through the dorsal incision prior to the hammertoe repair.

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