

COMPLICATIONS OF THE FIRST METATARSOPHALANGEAL JOINT ARTHRODESIS: Asymptomatic Versus Symptomatic Position and Healing

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INTRODUCTION

The first metatarsophalangeal joint (MTPJ) arthrodesis is a very effective surgical procedure for not only correcting angular deformities of the first ray, but addressing any arthrosis component of the first MTPJ. The first MTPJ arthrodesis introduced by Clutton in 1894 was once thought of as primarily a salvage procedure for degenerative arthritic joint disease. Since Mckeever's publication in 1952, numerous modifications and refinements have been introduced to help surgeons achieve better surgical outcomes and higher patient satisfaction. The procedure seemed to be accepted over the years sooner by the orthopedic community than the podiatric community. Podiatric foot surgeons had long been focused on attempting to preserve first MTPJ motion to aid stability in gait and for shoe accommodation rather than risking the potential impact of no first MTPJ motion. These concepts were based on an understanding of the severity of the problems with hallux rigidus. The podiatric surgeons had overcome many of the problems associated with first MTPJ arthroplasty procedures and joint implant procedures by developing techniques to preserve muscle-tendon balance of the first MTPJ in the face of osseous joint resections.

In time the podiatric community developed an understanding of the differences of foot function associated with first MTPJ arthrodesis and hallux rigidus centered primarily on the position of the hallux. This raised the role of the first MTPJ arthrodesis from more of a salvage type procedure to a primary procedural choice in first ray surgery where severity of deformity and joint pain both required consideration. High patient satisfaction has been consistently noted by both the orthopedic and podiatric literature over the years especially as refinements in the procedure have evolved. The surgery has risks as with any surgical intervention. Complications seem to center around 2 key areas namely the position of the hallux and nonunion of the arthrodesis site.

A review of complications of first MTPJ arthrodesis is presented with suggestions to avoid and manage them. An interesting discussion is introduced on the first MTPJ

nonunion with retained internal fixation. First MTPJ nonunions with retained internal fixation seem to be much more symptomatic than nonunions without retained internal fixation. The potential impact this finding has on primary fixation choices and subsequent nonunion treatment options is introduced.

DISCUSSION

The surgical goals met with first MTPJ arthrodesis are primarily positional realignment of all segments of the first ray in all body planes and relief of first MTPJ pain. Both goals can generally be accomplished in this one procedure typically without the need for joint implants, osteotomies or muscle-tendon balancing. First MTPJ arthroplasty type procedures are indicated in similar case scenarios as first MTPJ arthrodesis with advantages and disadvantages to be considered for each (Figure 1). A joint resection arthroplasty of the base of the proximal phalanx, head of the metatarsal or both with or without joint implant can relieve pain and allow a degree of flexibility and forgiveness at the pseudo-joint area. Some degree of propulsion off the hallux is generally still possible. A degree of flexibility of the hallux to permit comfortable shoe fit is preserved. Metatarsal or phalangeal osteotomies are generally not required even in rather severe angular first ray deformities. There is no bone healing with any associated complications or need for prolonged immobilization or fixation. Disadvantages would include a weaker hallux that can shorten and weaken further over time as the proximal phalanx resorbs and shortens. The hallux can angulate with deformity recurrence or deviate into hallux varus due to the unstable nature of the pseudo-joint. Extensor contracture and resultant hallux hammertoe or flexor weakness and lack of toe purchase can likewise occur in time affecting not only first ray, but foot function in general as well.

Arthrodesis of the first MTPJ should be considered a much more rigid and permanent procedure. Once the hallux is positioned on the metatarsal and osseous union occurs, no resorption or shortening of the



Figure 1A. Reduction in angular deformity without osteotomy. A. Preoperative, and B. Postoperative Keller bunionectomy with musculotendon rebalancing. C. Preoperative, and D. Postoperative first MTPJ arthrodesis with Hoffman procedure and lesser digital arthrodeses all fixated with percutaneous pins.



Figure 1B.



Figure 1C.



Figure 1D.

first ray components are expected. The hallux will not drift to a position of recurrence or overcorrection in time. The position of the hallux is permanently fixed and acts like a rigid lever for propulsion in gait. This rigidity can be a disadvantage as well. The hallux can be expected to be unforgiving to a varied shoe style selection both in the toe box area and to heel height. Subtle malalignments of the arthrodesis site cannot be corrected postoperatively through the dressing or manipulation. There is a need for internal or percutaneous fixation and a degree of postoperative immobilization. The arthrodesis site may be slow to heal or not heal at all resulting in nonunion and the potential of loss of correction and pain. Pain seems to be a greater consideration if the nonunion occurs with retained internal fixation such as screws, pins, or staples as opposed to bone plates. Nonunions without fixation are typically not symptomatic and tend to function like a joint resection arthroplasty that is stiffer than an arthroplasty yet more forgiving than an arthrodesis.

Position of the hallux is critical to the outcome

expectations for first MTPJ arthrodesis in terms of foot function and shoe fit. Hallux position of arthrodesis affects foot function through the later phases of the gait cycle. In hallux rigidus the hallux is in a more plantarflexed than neutral position. This rigid and unforgiving hallux position encourages weight-bearing forces to roll the foot to the lateral forefoot rather than allow propulsion off the hallux from the mid-stance through the toe-off phase of gait (Figure 2). This gait pattern is similar to an overly plantarflexed first MTPJ arthrodesis. In both situations painful pressure points and callus formation can occur plantar to the interphalangeal joint of the hallux and the fifth metatarsal head area.

In first MTPJ arthrodesis the hallux is placed in a slightly more dorsiflexed than neutral position. This position encourages weight-bearing forces to continue out through the hallux like a rocker-soled shoe from the mid-stance through the toe-off phase of gait. Minimal strain is placed on the foot as a more normal foot function is permitted (Figure 3). Hallux position also affects shoe fit

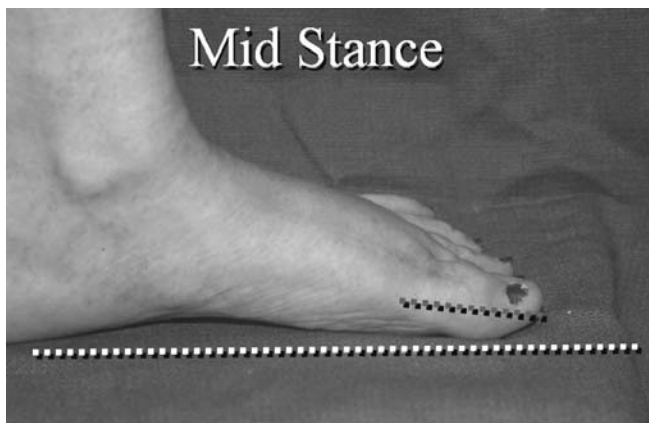


Figure 2A. Hallux rigidus or plantarflexed first MTPJ arthrodesis gait. With rigid hallux plantarflexion premature and unforgiving hallux contact has already occurred in the mid-stance phase of gait.

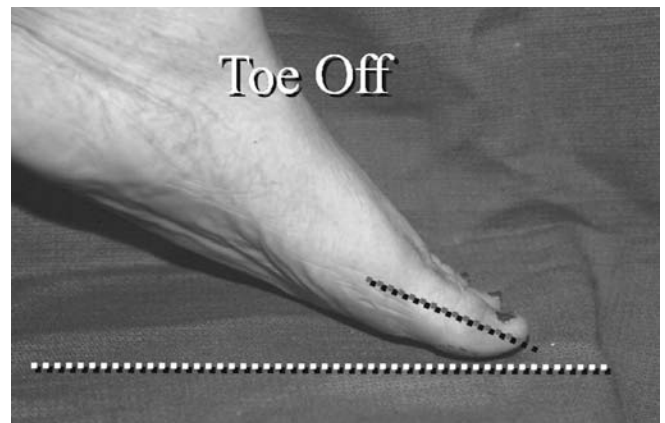


Figure 2B. By the toe-off phase of gait the rigidly plantarflexed hallux causes the foot to roll laterally.



Figure 3A. First MTPJ arthrodesis gait. With the rigid hallux slightly dorsiflexed the hallux is not yet contacting the weight-bearing surface in the mid-stance phase of gait.

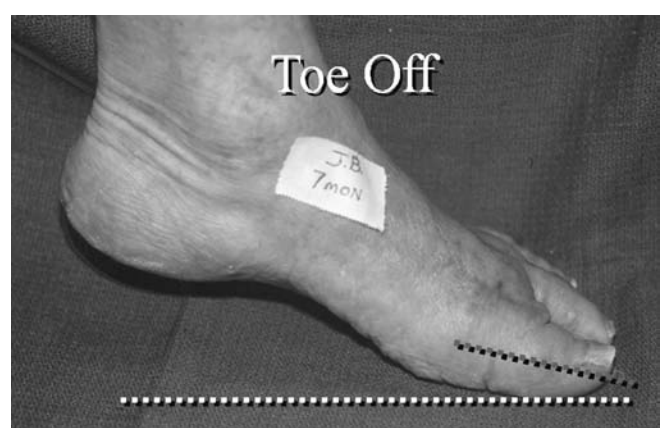


Figure 3B. By the toe-off phase of gait the hallux contacts the weight-bearing surface and can aid in propulsion.



Figure 4A. Radiographic sagittal plane hallux positioning. A. Preoperative hallux rigidus with a plantarflexed hallux position relative to the weight-bearing surface. B. Appropriate postoperative first MTPJ arthrodesis with slight dorsiflexed hallux position relative to the weight-bearing surface. C. Demonstration intraoperative evaluation sagittal plane hallux positioning. D. Comparative clinical evaluation sagittal plane hallux positioning.



Figure 4B.



Figure 4C.



Figure 4D.

and choice. Little if any accommodation in the transverse plane for snugger fitting shoes with a narrower toe-box is possible with comfort in first MTPJ arthrodesis. A fixed heel height of normal to possibly 1 inch is all that may be possible in the sagittal plane. The hallux should not be overly dorsiflexed to permit a higher heel height choice option as flexion contracture of the hallux interphalangeal joint or hallux hammertoe will typically occur in time resulting in further shoe fit and comfort issues.

In the sagittal plane, the hallux is generally placed so that the plantar tuft skin will just touch or just be off the weight-bearing surface. This position reflects slight

dorsiflexion of the hallux relative to the weight-bearing surface during both static stance and the mid-stance phase of gait. No specific phalanx to first metatarsal angle is recommended due to the variability of the first metatarsal declination angle based on foot type. The sagittal plane position of the hallux can be checked in the operating room with the assistance of a flat plate held to the plantar foot mimicking weight bearing (Figure 4).

In the transverse plane the hallux should not touch the second toe and be relatively parallel to it. Any hallux to second toe touching, overlapping, or under lapping will cause interdigital irritation as the flexible second toe rubs



Figure 5A. Sagittal plane hallux positioning in first MTPJ arthrodesis. A. Plantarflexed hallux position with resultant first metatarsal dorsiflexion as seen in hallux rigidus. B. Dorsiflexed hallux positioning with nonunion and plate fixation with hallux plantarflexion. C. Dorsiflexed hallux positioning with nonunion screw and pin fixation with absence hallux plantarflexion.



Figure 5C. Dorsiflexed hallux positioning with nonunion screw and pin fixation with absence hallux plantarflexion.

over and against the more rigid hallux. The second toe may need to be operatively positioned, if surgical correction at that level is required as well, prior to determining the appropriateness of hallux transverse plane position. A parallel alignment of the hallux to the lesser toes in general is more cosmetically appealing. In the transverse plane the hallux nail should be positioned flat and parallel to the weight-bearing surface. This position is not only cosmetically more appealing, but helps assure inadvertent rotation of the plantar interphalangeal condyles into plantar prominence creating a pressure point for pain and callus formation.

Basic surgical principles of joint arthrodesis are applicable to the first MTPJ as any other joint to be fused. All intervening nonosseous tissue whether scar, soft tissue, or cartilage needs to be completely and thoroughly removed. The thick and dense subchondral plates need to be resected and violated to good bleeding bone surfaces on both sides of the arthrodesis site to permit ingrowth of the healing cells and tissues. The joint is then



Figure 5B.

placed in the desired position and thoroughly evaluated and assessed for the appropriateness of the position of correction. A fixation construct is then applied to stabilize the arthrodesis site that can vary from percutaneous pins and external fixators; buried pins, staples, plates and screws; or any combination. Choice of fixation has not been seen in the literature to shorten clinical or radiographic healing times.

Percutaneous or buried pin fixation is the most common fixation employed in first MTPJ arthrodesis. Percutaneous pins offer the advantage not only of ease of application and removal, but seem to provide for patient comfort and satisfaction whether the arthrodesis site heals and consolidates or not. Weight bearing in a modified surgical shoe has been shown to not adversely affect the bone healing process even with pin fixation. Various bone plate systems both unlocking and the newer locking systems are available. These bone plate systems are more critically indicated in cases where interpositional bone graft is utilized at the arthrodesis site. The plates can help hold the various components of the first MTPJ arthrodesis construct in place over the longer periods of time necessary for bone graft healing. External splintage such as casts, removable walking boots, and off-loading with crutches either partial or nonweight bearing can supplement the fixation in situations where further protection of the arthrodesis site is deemed necessary.

COMPLICATIONS

Malposition of the great toe arthrodesis site can result in postoperative problems that can vary from bothersome to more severe requiring surgical repositioning. In the sagittal plane if the hallux is overly plantarflexed the foot will function like hallux rigidus (Figure 5A). Pressure points can develop on the plantar interphalangeal joint condyles of the hallux and the fifth metatarsal head area as the foot abnormally rolls laterally over the unforgiving



Figure 6A. Transverse plane hallux positioning in first MTPJ arthrodesis. A. Appropriate parallel digital positioning without interdigital abutment. B. Hallux abduction relative to second toe with resultant hallux underlapping. C. Hallux adduction positioning parallel to lesser digits for comfort and cosmesis.

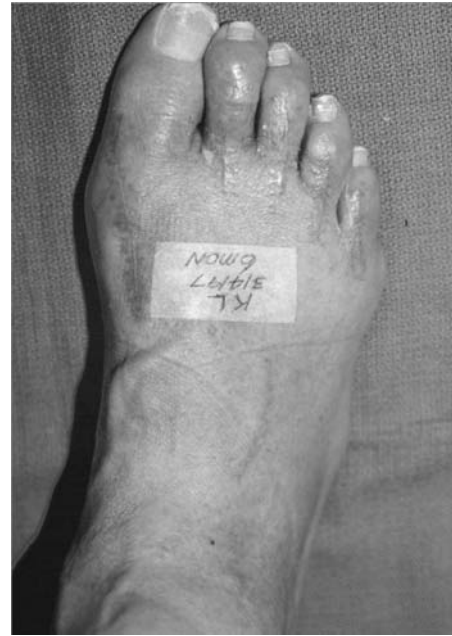


Figure 6B.

hallux through the toe-off phase of gait. Jamming of the midfoot joints can cause pain at this level as well. If the hallux is overly dorsiflexed the foot may function more normally, but the hallux can abut the toe box of the shoe causing irritation and pain. A dorsiflexed position of first MTPJ arthrodesis could cause the hallux to flex in time at the interphalangeal joint as the tuft of the toe tries to contact the floor to aid stability in stance and gait (Figures 5B and 5C). Painful distal hallux tuft calluses can develop combined with a painful exaggeration of the dorsal interphalangeal joint.

Transverse plane adduction of the hallux can be unsightly as well as less than forgiving as the great toe abuts against the medial shoe toe box or does not remain on a sandal comfortably. Transverse plane abduction of the hallux can cause the still flexible and functional second toe to abut against or rub over and under the rigidly fixed hallux resulting in irritation and pain. A degree of free interdigital mobility without interdigital abutment and pain makes gait much more comfortable.

Cosmetic appearance of the hallux and lesser toes is enhanced, whether abducted or adducted at the MTPJ level, if the hallux and lesser toes are relatively parallel (Figure 6). Frontal plane alignment of the hallux likewise has a cosmetic component in terms of hallux nail positioning. However, if the hallux is rotated into varus or



Figure 6C.

valgus painful plantar condylar prominence can occur that negates appropriate sagittal plane positioning creating painful plantar interphalangeal joint pressure points (Figure 7).

Nonunions following arthrodesis of the first MTPJ are reported in the literature with a frequency of 15-20%. Unlike other nonunion situations found in the foot and

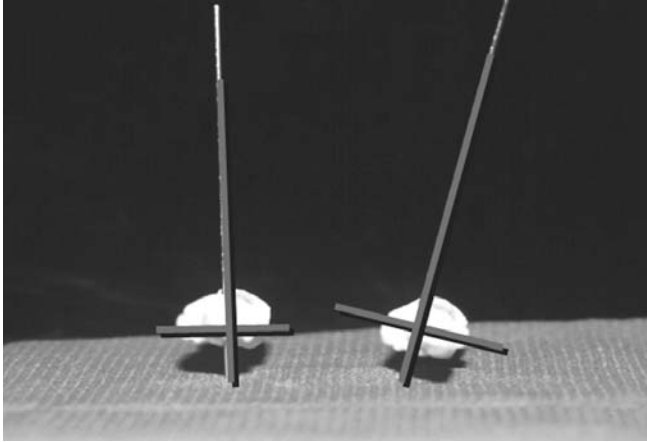


Figure 7A. Frontal plane hallux positioning in first MTPJ arthrodesis. A. Bone model comparison demonstrating increased plantar interphalangeal joint condylar prominence with rotation. B. Hallux malposition relative to clinical hallux nail alignment to the weight-bearing surface.

ankle, the nonunion of the first MTPJ arthrodesis can be either symptomatic or asymptomatic. The senior author has seen far more asymptomatic than symptomatic first MTPJ arthrodesis site nonunions. The symptomatic nonunions generally have a retained screw or pin in place across the nonunion site. Stress movement of the flexible nonunion against the rigidity of the fixation may account for the nonunion pain. Fracture at the fixation-bone interface can exaggerate the nonunion pain or may be the painful nidus in an otherwise asymptomatic nonunion (Figure 8).

The asymptomatic nonunions generally were fixed with percutaneous pins that were eventually removed. Asymptomatic nonunions typically function very well as long as there are no hallux positional problems. The pseudo-joint that develops is similar to a rigid Keller joint resection, but more forgiving than a first MTPJ arthrodesis (Figure 9). No surgical intervention is generally necessary unless the hallux should drift in time to an undesired position resulting in pain and problems much like a Keller joint arthroplasty might malalign over time. It would seem logical that if the hallux position is acceptable and a symptomatic nonunion exists with internal fixation, pain relief might be expected with simple fixation removal alone without the necessity for nonunion resection and repair. Certainly the recovery and chance for complications would be far less with this more limited approach. Little experience is available, but early indications are very hopeful for this approach as a real consideration. Otherwise the nonunion is resected and the arthrodesis site repositioned and fixated with the fixation of choice. Interpositional bone graft is a consideration if first ray length issues are a concern. Generally autograft over allograft is



Figure 7B.

recommended to facilitate and encourage the bone healing process. Percutaneous pins offer the advantage of ease of removal in the office setting with the potential for patient comfort whether the arthrodesis site has healed or not.

SURGICAL CORRECTION

Repositioning of malalignment of a first MTPJ arthrodesis can be a difficult surgical challenge. Simple osteotomy resection in any plane can further shorten the first ray bony column. Scar tissue about the arthrodesis site can inhibit the freedom of motion necessary for intraoperative repositioning. Generally a more block type resection is employed with planer surfaces that are more stable and amenable to compression screw or staple fixation than the shifting ball-and-cup situation of a primary arthrodesis. As a final solution elective hallux amputation is a consideration (Figure 10).

Surgical correction of a first MTPJ nonunion has two main challenges. The first is to effectively resect the nonunion and reoppose the bony surfaces in a stable construct for healing. Second is to ensure again an appropriate position of correction of the hallux. The principles of nonunion resection are similar to those for an effective arthrodesis. There must be good approximation of the bony surfaces after adequate resection of nonosseous tissues with a stable internal fixation construct complimented by external measures to reduce strain at the arthrodesis site.

The hallux position of correction principles are the same whether a primary arthrodesis procedure is performed or after resection of a nonunion with or without bone grafting. Careful attention to hallux



Figure 8A Symptomatic first MTPJ nonunions. A. Crossed screw fixation. B. Combination screw and pin fixation. C. Plate fixation with proximal phalanx fracture at distal screw site. Figure 8D. Plate and compression screw fixation.



Figure 8B.



Figure 8C.



Figure 8D.



Figure 9A. Asymptomatic first MTPJ nonunions. A, B, and C. Radiographic and clinical bilateral first MTPJ arthrodeses with asymptomatic nonunion of the right preferred by the patient. D and E. Bilateral first MTPJ arthrodesis with asymptomatic nonunion of the right preferred by the patient. F. Nonunion first MTPJ. All cases originally fixated with percutaneous pins with no retained internal fixation.



Figure 9B.



Figure 9C.



Figure 9D.



Figure 9E.

position is always critical to a successful outcome. Fixation choices are important to ensure a stable construct. The use of bone plates is a real consideration following nonunion resection, but not mandatory. Generally combinations of various fixation options are utilized with at least two points of fixation to prevent rotation. Plates are more of a consideration with the use of interpositional bone graft. Interpositional bone graft will help reestablish length to a shortened first ray bony column at the expense of a more prolonged immobilization necessary for graft healing.

Careful attention should be directed to assessing the interphalangeal joint of the hallux whether nonunion or a positional malalignment of the first MTPJ exists following first MTPJ arthrodesis (Figure 11). The interphalangeal joint may be flexibly or rigidly contracted in flexion. The first MTPJ likewise can be flexibly or rigidly contracted in extension. Muscle imbalance with extensor contracture of MTPJ and flexion contracture of the interphalangeal joint may coexist as well. This hallux hammertoe deformity can develop if the bony column of the first ray is shortened through the nonunion process or the nonunion resection procedure itself. Isolated interphalangeal joint flexion can be expected to occur over time if there is a dorsiflexed position of arthrodesis at the first MTPJ. Generally pain and deformity at this level is associated with an increasing degree of rigidity to the contracture. Surgical correction of associated interphalangeal joint deformity generally involves arthroplasty with resection of the head of the proximal phalanx to release contracture and correct any



Figure 9F.

angular deformity with percutaneous temporary pin fixation. In more extreme deformity or if recurrence or joint pain is a consideration, interphalangeal joint arthrodesis is considered.

The position of arthrodesis of the interphalangeal joint is not as linear as in an isolated hallux interphalangeal arthrodesis situation. The MTPJ is first positioned for arthrodesis in slight extension as typically would be



Figure 10A. Hallux amputation for malalignment first MTPJ arthrodesis. A. Painful hallux rigidus. B. Keller arthroplasty. C. First MTPJ arthrodesis to aid instability. D. Hallux amputation to relieve painful position of arthrodesis.



Figure 10B.



Figure 10C.



Figure 10D.

performed. The interphalangeal joint is then positioned in what would be slight flexion to place the tuft of the toe more relatively parallel to the weight-bearing surface not extended to it in line with the dorsiflexed proximal phalanx. If employed, a plate across both joint arthrodesis sites would need to be bent in slight extension at the MTPJ and slight flexion at the interphalangeal joint. Generally, separate fixation is employed independent to each joint such as screws and pins to the MTPJ and crossed and locked percutaneous pins to the interphalangeal joint. This fixation arrangement permits the independent positioning necessary for satisfactory double joint first ray arthrodesis.



Figure 11A. Hallux interphalangeal joint considerations. A and B. Preoperative and Postoperative first MTPJ arthrodesis with hallux interphalangeal joint arthroplasty for severe hallux varus with concomitant rigid hallux interphalangeal joint flexion. C and D. Preoperative and Postoperative first MTPJ arthrodesis for painful nonunion without the need for interphalangeal joint surgery. E and F. Asymptomatic nonunion first MTPJ arthrodesis with symptomatic fracture of the proximal phalanx at the plate distal screw site managed with fixation removal alone with eventual healing of the first MTPJ nonunion and asymptomatic nonunion of the proximal phalanx.



Figure 11C.

CONCLUSION

The first MTPJ arthrodesis is a primary procedural consideration where not only deformity of the first ray exists, but significant joint pain and arthritis as well. Two main complications specific to this procedure have been noted. The first is malposition or malunion of the first MTPJ and the second is nonunion of the first MTPJ. Prevention of first MTPJ malunion is through careful positioning of the hallux intraoperatively in all three body planes. Significant malposition of the hallux can result in digital irritation, gait abnormalities and shoe fit problems. First MTPJ malalignment may require osteotomy of the arthrodesis site with or without bone graft to accomplish



Figure 11B.



Figure 11D.



Figure 11E.

repositioning of the rigid and unforgiving malaligned hallux. Prevention of nonunion is primarily by careful preparation of the joint surfaces and a stable construct of internal or percutaneous fixation. Nonunion of the first MTPJ arthrodesis may or may not necessarily be symptomatic. The symptomatic nonunions seem to be associated more with retained internal fixation. Consideration for relief of pain in cases where the nonunion is associated with satisfactory hallux positioning may be simple fixation removal. Progression of hallux deformity may be noted or expected over time through plastic deformation of the first MTPJ nonunion site and



Figure 11F.

hallux interphalangeal joint deformity. The nonunion itself may be painful. Surgical correction of a painful or malaligned nonunion may require resection of the nonunion with or without bone grafting to re-establish first ray length and encourage bony union and healing.

Finally, care must be taken to assess the hallux interphalangeal joint in first MTPJ nonunion or malunion situations for deformity and pain. Combining surgical intervention at this level with first MTPJ nonunion repair could aid the outcome by not only reducing concomitant pain if present at this joint level, but aiding overall hallux and first ray position.