A CRITIQUE OF SURGICAL TECHNIQUE

D. Scot Malay, D.P.M.

Refinements in the techniques of foot surgery are continually evolving. Minimal Incision Surgery (M.I.S.) is a technical development that has gained the favor of many podiatric surgeons over the past ten to fifteen years. Controversy over these developments has divided the podiatric profession into groups of surgeons that either use and recommend M.I.S. techniques, and those that prefer the traditional techniques of "open" surgery. The purpose of this paper is to analyze M.I.S. by means of literature review and retrospective case evaluation, and to comment on the potential advantages and disadvantages that this technique has to offer the foot surgeon. It should be noted that this paper represents the views of a surgeon trained in the techniques of traditional "open" surgery for the correction of the majority of forefoot deformities, and attempts to objectively assess the merits of M.I.S. based on an understanding of basic surgical principles. Moreover, the majority of the author's experience with these techniques has been in the form of revisional surgery in patients suffering complications following M.I.S.

There are a number of different publications espousing the benefits and describing the techniques of M.I.S. as an alternative to "open" surgery for correction of forefoot deformities.[1,2,3,4] The proposed benefits of M.I.S. include better cosmetic results; as well as decreased risk of poor scar formation, postoperative soft tissue entrapment, infection, excessive postoperative pain and disability. Proponents of M.I.S. also generally feel that the technique requires a very high level of surgical skill and previous mastery of "open" methods in order to avoid complications such as excessive soft tissue and/or osseous injury, infection, and inadequate correction. (It should be noted that the same types of complications are possible when traditional "open" surgery is performed.) None of these publications reveal detailed statistical analysis of the procedures recommended, however anecdotal references are made to large numbers of satisfied patients having had forefoot M.I.S. performed. The actual M.I.S. procedures are described in great detail.

Complications are an unfortunate occurrence that can be associated with any type of foot surgery. For this reason, podiatric surgeons must constantly monitor their operative patients for the development of irregularities and abnormalities in the perioperative period. We can consider surgical complications as being those that occur intraoperatively or postoperatively, those that affect soft tissues or bone, and those that occur locally or systemically. It is also well known that many complications originate in the preoperative period. These may be derived from an incomplete history and physical exam, and/or improper judgment regarding patient and/or procedure selection.

Intraoperative soft tissue complications include direct injury secondary to inappropriate use of instrumentation. Such injuries may be the result of heavy-handed retraction, inadvertent laceration with the scalpel, and thermal damage induced by high speed rotary or reciprocating power instruments or the electro-coagulator. Failure to achieve proper intraoperative hemostasis can also hinder visualization of the surgical field, as well as predispose to dehiscence and infection in the postoperative period. Moreover, inadequate exposure of target structures prevents intraoperative visualization of pathological anatomy and makes the appropriate release and balancing of soft tissues difficult. A case in point would be release of pathologically contracted soft tissues (adductor hallucis and fibular sesamoidal ligament) at the lateral aspect of the first metatarsophalangeal joint, followed by articular rebalancing and adductor tendon transfer in the correction of hallux abducto valgus. Inadequate exposure complicates the dissection and decreases the likelihood of achieving appropriate positional correction. Additionally, it increases the likelihood of injuring the soft tissues with surgical instrumentation or being unable to achieve adequate hemostasis. Obviously, the degree of surgical exposure (size and design of the incision) varies with the size and location of the underlying target tissues, as well as with the number and size of instruments required to properly perform the procedure.

Intraoperative osseous complications include improper osteotomy technique, whether that be secondary to incorrect location, osteotomy design, or choice and use of instrumentation. Specific examples may include mid-diaphyseal osteotomies, an unstable osteotomy

interface (sliding surfaces and/or irregularities), inadvertent cortical (hinge) fracture, soft tissue interposition, any type of structural malposition, and thermal osteonecrosis due to excessively high saw or rotary osteotome speed or dull cutting edges. Structural malposition commonly presents as elevatus, under correction, over correction, and frontal plane rotational abnormalities. Sufficient osseous exposure should allow the surgeon to readily visualize the bone, the cutting instrument, and the resultant structural alignment following osseous manipulation. Intraoperative radiographs can also assist the surgeon in achieving the desired osteotomy result. Finally, improper osteosynthesis techniques can create intraoperative osseous complications, and also directly impact the postoperative phase of surgical management. Generally speaking, all osteotomies used for structural realignment in forefoot surgery should be managed with some form of fixation device.

Postoperative soft tissue complications include hematoma, dehiscence, infection, hypertrophic scar or keloid, pathological scar contracture, excessive wound collagenation with entrapment of neighboring vital structures, and periarticular soft tissues or tendons. Clearly, many of these complications originate in the operating room, only to become problematic in the postoperative period. Sensible protection of the operative site in the acute phase of wound healing may require bandaging and the use of a surgical shoe, or cast for immobilization. Prolonged immobilization, on the other hand, can effect arthrosis, tendon and periarticular soft tissue adhesion, and peripheral nerve entrapment. Similarly, prolonged non-weight bearing can lead to significant osteoporosis. Therefore, early range of motion exercises and other forms of physical therapy, as well as return to weight bearing are desired. In general, all metatarsal osteotomies used for structural realignment, particularly those located proximal to the distal metaphysis of the metatarsal, require six to eight weeks of non-weight bearing. Guarded weight bearing may be initiated any time after six weeks, as long as radiographic assessment reveals adequate bone healing and alignment. Inappropriate weight bearing, even in the presence of fixation devices (wires, pins, screws, etc.), will typically induce motion at the osteotomy interface. This will increase the likelihood of exuberant bone callus formation, delayed or nonunion, and/or, most commonly, osseous malalignment (usually elevatus). Osteomyelitis may also complicate postoperative bone healing.

CASE PRESENTATION

J.M., a 45 year old female, presented on 12/19/88, with a chief complaint of a very painful "knot" located on the bottom of her second toe, a hallux that would not contact the ground, and a moderate-severe submetatarsal two hyperkeratosis. All of her complaints focused on the right foot. She was approximately two years post M.I.S. bunionectomy and hammertoe repair of the second and fourth digits. She related that her symptoms began approximately six months following the M.I.S. She also related that the surgery was performed without the use of intraoperative radiographs, that her foot was wrapped in a very "snug" bandage during the immediate postoperative phase, and that she was encouraged to walk on the operated foot immediately following surgery with the use of a surgical shoe. Unrestricted ambulation was interrupted at four weeks postoperative, when the foot was placed into a below-the-knee cast "to help the bone heal." The cast was worn for one month while maintaining full weight bearing ambulation, after which ambulation in the surgical shoe was resumed. She was discharged at three months postoperative, ambulating satisfactorily in a soft shoe (running flat).

The patient's past medical history was remarkable for peptic ulcer disease; she was medicated with Premarin and Flexeril; and she denied any known drug allergies. She was employed as an office manager and she regularly wore fashionable shoes with moderate heel elevation, narrow toe box, and thin soles. She also related that she did not wish to follow-up with her previous surgeon. The patient was informed that her case would be discussed with the previous surgeon, and she agreed to obtain her previous operative report and radiographs.

Examination of the right foot (Figure 1) revealed the neurovascular status to be fully intact. Well-healed postoperative scars were noted at the mid-diaphyseal level on the medial aspect of the proximal phalanx of the hallux (about 5 mm in length), at the medial aspect of the distal metaphyseal and head region of the first metatarsal (about 5 mm in length), and at the medial aspect of the proximal phalangeal head level of the fourth toe (about 3-4 mm in length). The medial aspect of the second toe displayed an ulcer at the level of the phalangeal head, with no evidence of sinus tract nor drainage, and a mildly hypertrophic transverse scar extending from the dorsal margin of the ulcer for approximately 3 mm. The plantar aspect of the second toe, at the level of the proximal phalanx revealed a grossly indurated, nonfluctuant, exquisitely tender, and bulbous subcutaneous nodule. A moderately severe and tender hyperkeratosis existed plantar to the second metatarsal head; and a similarly tender heloma durum was present on the dorsolateral aspect of the fifth toe at the level of the proximal interphalangeal joint.

Weight bearing inspection of the right foot revealed a nonpurchasing hallux and second toe, with gross im-

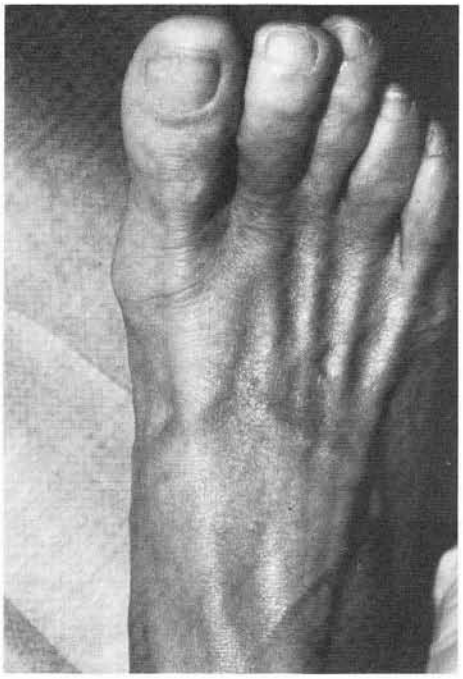

Fig. 1. Clinical appearance of right foot (non-weight bearing) two years following M.I.S. bunionectomy via proximal phalangeal and first metatarsal osteotomy, and second and fourth toe proximal interphalangeal arthroplasties. Note impingement of hallux upon the second toe, and the elevatus of these digits relative to the remaining toes.

Fig. 2A. Dorsoplantar radiograph displaying previous osteotomy sites along the first ray, and the second and fourth toe arthroplasties. Note the slightly negative first intermetatarsal angle (not necessarily problematic), shortened first metatarsal, subluxed sesamoid apparatus, and increased soft tissue density and volume at the base of the second toe.

pingement of the hallux against the ulcerated medial aspect of the second toe. The range of motion of the first metatarsophalangeal joint was limited to approximately twenty degrees of dorsiflexion and thirty degrees of plantarflexion. The sesamoids glided freely against the metatarsal head, and metatarsophalangeal motion was smooth and non-tender until soft tissue constraints prevented further excursion. The dorsal aspect of the first metatarsal head was grossly prominent and tender to direct deep palpation dorsally. Motion at the second metatarsophalangeal joint was essentially normal, and the Kellikian push-up test indicated dorsal subluxation of both the hallux and second toe. The second proximal interphalangeal region was rigid and tender to attempted manipulation. The fourth toe was non-tender to manipulation and deep palpation. The fifth toe displayed an adducto varus proximal interphalangeal contracture with normal metatarsophalangeal range of motion. The head of the fifth metatarsal was mildly prominent plantarlaterally, and non-tender to deep palpation.

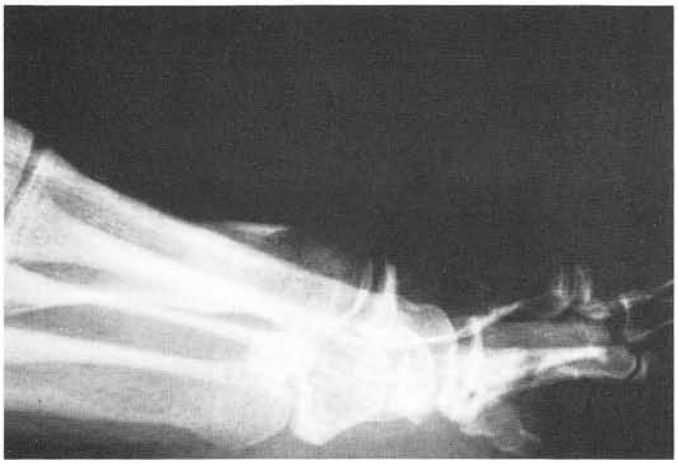

Fig. 2B. Lateral radiograph showing extreme metatarsus primus elevatus and marked dorsal angulation of the distal portion of the proximal phalanx of the hallux.

Radiographic examination (Figure 2A, B) revealed healed osteotomies at the junction of the middle and distal thirds of the first metatarsal, and the mid-diaphyseal level of the hallucial proximal phalanx. Both of these osteotomies displayed marked elevatus of the distal segments in the sagittal plane, while a near rectus alignment existed in the transverse plane. The first intermetatarsal angle was slightly negative, and the first metatarsal appeared to be markedly shortened. The second toe displayed a marked increase in soft tissue density and volume. The head of the proximal phalanx of the second toe was absent, and the residual stump of the phalanx revealed new bone formation. There was no evidence of osteomyelitis of the second toe. The head of the proximal phalanx of the fourth toe was also absent. The

proximal interphalangeal joints of both the second and fourth toes were narrowed and irregular. An adductus deformity existed at the proximal interphalangeal joint of the fifth toe, and there was an increase in the lateral deviation angle of the fifth metatarsal.

Initial diagnoses included ulcer of the second toe secondary to impingement by the hallux, subcutaneous scar with flexor tendon and nerve entrapment second toe, floating hallux with metatarsophalangeal limitus, metatarsus primus elevatus, sub-second lesser metatarsalgia, floating second toe, fifth digit hammertoe secondary to flexor stabilization, and tailor's bunion. With the exception of the fifth toe and tailor's bunion deformities, all of this patient's symptoms appeared to be iatrogenic in origin. Conservative management of the ulcer was initiated in the form of debridement, interspace padding, and daily soaks in dilute povidone iodine, and the use of a Darco shoe. The lesion rapidly responded to this treatment and resolved after two weeks of therapy. A foam interspace pad was maintained between the first and second toes and the patient returned to her regular shoe gear.

On 4/4/89, the patient underwent revisional reconstruction of her right forefoot. This was performed on an inpatient basis, under general anesthesia, using a pneumatic thigh tourniquet. Operative procedures (Figure 3A, B, C, 4A, B) included transpositional sliding (plantarflexory, elongational, and adductory) osteotomy of the first metatarsal with allogeneic bone graft and screw fixation, hallucial proximal phalangeal enclavement with crossed Kirschner wire fixation, revisional second toe proximal interphalangeal arthroplasty with Kirschner wire stabilization, excisional biopsy of the plantar nodular mass of the second toe, and proximal interphalangeal arthroplasty with middle-distal hemiphalangectomy of the fifth toe. A 7 French T.L.S. drain was used in the first metatarsal operative site.

Postoperative management included absolute nonweight bearing in a below-the-knee synthetic cast. Pathological analysis of the second toe biopsy specimen indicated scar tissue with elements of tendon and entrapped nerve. The closed suction drain was discontinued on the second postoperative day, and the patient was discharged on the third postoperative day. The cast was bivalved and range of motion exercises for the first

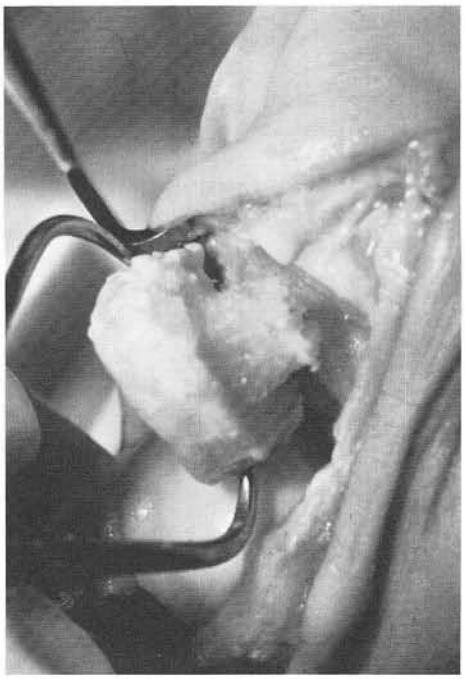

Fig. 3A. Phalangeal base autograft harvested and prepared for seating in the distal remnant of the hallucial proximal phalanx.

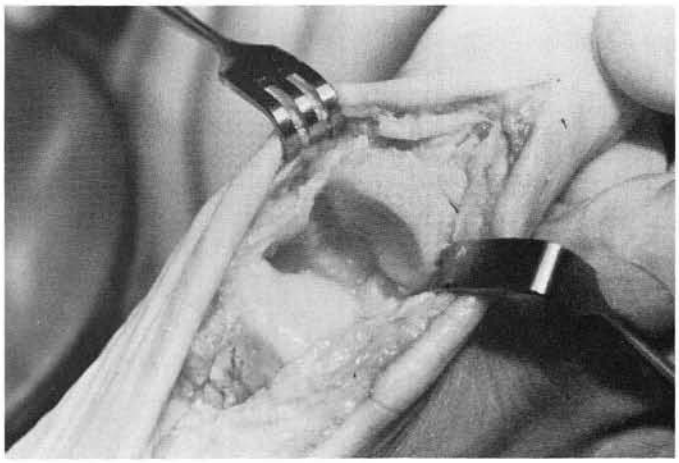

Fig. 3B. Base enclavement seated.

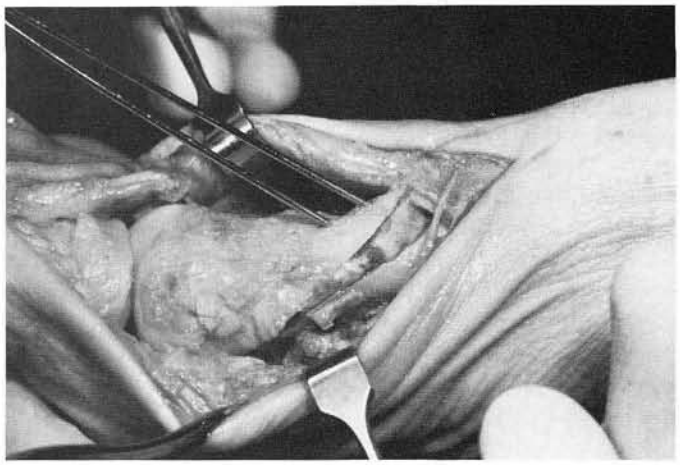

Fig. 3C. Oblique translocational first metatarsal osteotomy performed at the apex of the iatrogenic elevatus deformity, with allogeneic intercalary graft.

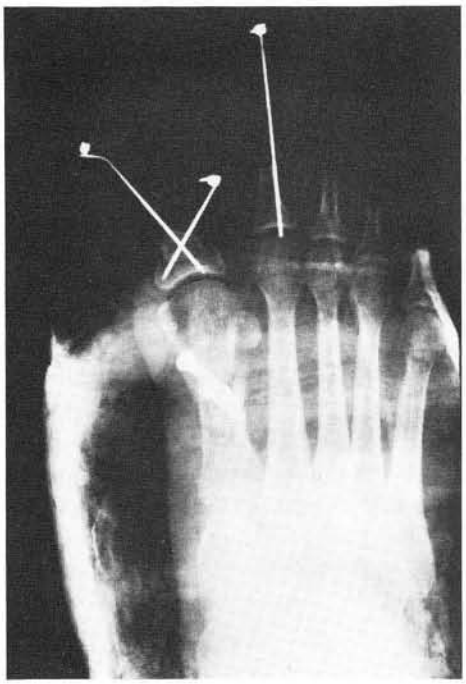

Fig. 4A. Immediate postoperative radiographs. A. Dorsoplantar view.

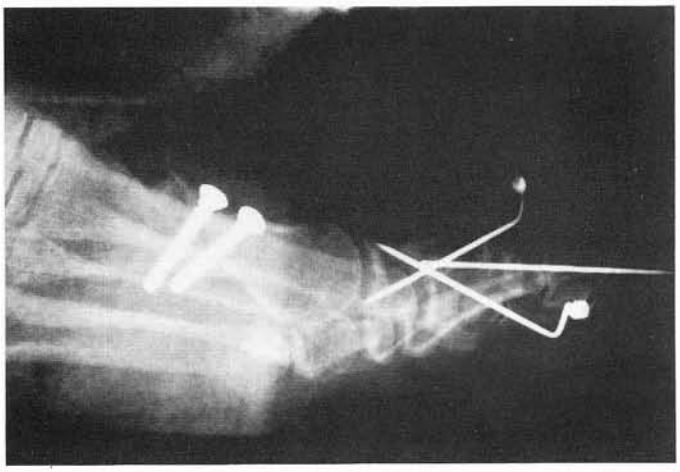

Fig. 4B. Lateral view.

and second metatarsophalangeal joints were initiated two weeks postoperatively. The K-wire in the second toe and the lateral K-wire in the hallux were pulled three weeks postoperatively, and the medial K-wire in the hallux was removed five weeks postoperatively. Gradual protected weight bearing was resumed in a removable walking cast eight weeks postoperatively, and full weight bearing ambulation in a running shoe was resumed eleven weeks postoperatively. She proceeded to follow an unremarkable rehabilitative course, after resuming full activities three and a half months postoperatively, until five months postoperatively (Figure 5A, B) when she complained of mild tenderness at the lateral aspect of the hallux in the first interspace. Inspection of this area revealed a fold of redundant skin with pliable, robust subcutaneous tissue that was "pinched" in the interdigital space when she wore high heel shoes with a narrow toe box. This complaint was alleviated with the use of a narrow foam interspace pad, which she uses whenever she wears shoes with a narrow, closed toe box. At seven months follow-up (the time of this writing), she ambulates in any type of shoe that she desires and has maintained full daily activity without restrictions.

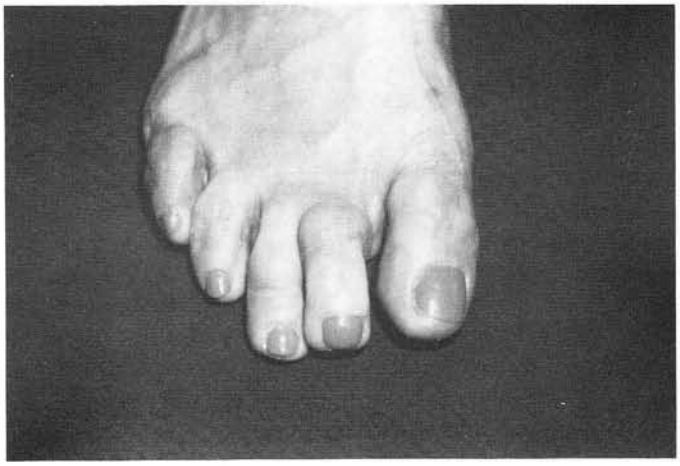

Fig. 5A. Five month postoperative follow-up. A. Weight bearing stance reveals mild residual floating hallux with slight valgus rotation. Hallux no longer contacts the second toe.

Fig. 5B. Dorsoplantar radiograph.

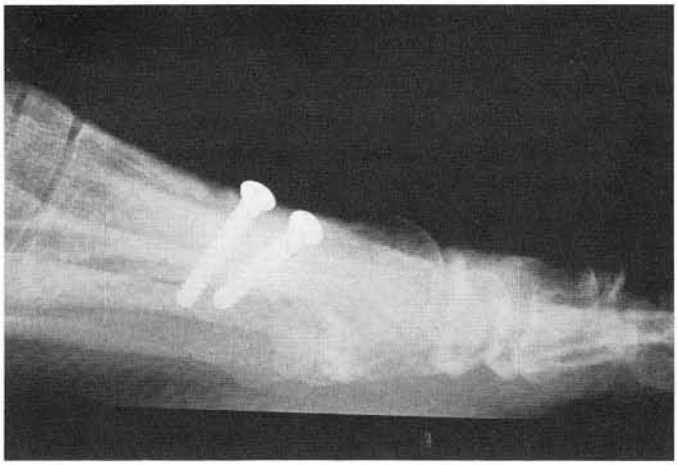

Fig. 5C. Lateral radiograph.

CASE ANALYSIS

Critical retrospective analysis of the above mentioned case may provide insight into the possible reasons for failure of the M.I.S. that was originally performed. Speculation regarding errors that may have occurred intraoperatively include inadequate exposure of target structures resulting in poor osteotomy placement, as well as the inability to satisfactorily retract and protect vulnerable soft tissues. In this particular case, the hallucial proximal phalanx was osteotomized at the mid-diaphyseal level, and the first metatarsal was osteotomized at the junction of the distal metaphysis and the diaphysis. The diaphysis is usually comprised of thicker cortical bone and is prone to delayed or nonunion, in comparison to the highly cancellous metaphysis. Moreover, limited osseous exposure prevents direct intraoperative visualization of structural realignment following osteotomy, and overcorrection of the first intermetatarsal angle may have occurred and not been recognized. This may have contributed, to a slight degree, to the iatrogenic impingement of the hallux against the enlarged second toe. Intraoperative radiographic or fluoroscopic evaluation may have been useful.[5] Furthermore, neglecting to stabilize either of the osteotomies, especially the through-and-through first metatarsal osteotomy, greatly increased the likelihood of delayed or malunion. Perhaps some form of percutaneous pinning could have been used. Still further, the flexor tendons and the medial plantar proper digital nerve to the second toe were evidently damaged and subsequently incarcerated in postsurgical scar tissue as a result of the meager exposure and lack of subcutaneous retraction. This resulted in a markedly indurated, tender, and bulbous second toe that ulcerated medially due to chronic pressure from the hallux. This toe also lost flexor function and failed to purchase the ground.

Errors that may have been made in the management of this patient during the postoperative period obviously include early weight bearing ambulation. This practice, following unstable and unfixated metatarsal osteotomies, clearly indicates a gross misunderstanding of the effects of weight bearing on the first ray. In this particular case, unsupported weight bearing was probably the single most disruptive force acting upon both the first metatarsal and the hallux. This resulted in gross iatrogenic elevatus, hallux limitus, and a floating great toe. Even in the presence of a wide variety of fixation devices, weight bearing remains a severely disruptive force in the postoperative phase. The use of soft or gel-type postoperative dressings does not adequately resist the forces of weight bearing, and more rigid materials are recommended when unstable (by design) and unfixated osteotomies are performed. Lastly, this patient was discharged long before osseous remodeling took place. Early discharge, even before routine bone healing has occurred (six weeks), has been advocated following M.I.S. proximal phalangeal osteotomy.[6]

In the case described above, it seems that some problem with bone healing was identified four weeks following the surgery, and treated with weight bearing cast immobilization for four weeks. The patient was discharged two months following cast removal, and subsequently developed significant lesser metatarsalgia.

CONCLUSION

M.I.S. may be a useful alternative for the reduction of certain pedal, primarily digital, prominences. The indications for the use of this technique for osteotomy must be extremely limited. The most notable shortcoming of this technique is inadequate exposure of target tissues. Inadequate exposure prevents visualization and manipulation of pathological anatomy; and predisposes to incorrect osteotomy placement, osseous malalignment and instability, overaggressive skin retraction, and subcutaneous soft tissue destruction. Furthermore, this type of surgical reconstruction is often combined with inappropriate postoperative management, namely weight bearing ambulation without adequate osseous stabilization. Iatrogenic deformities complicating foot surgery, M.I.S. or otherwise, may require revisional reconstruction in an effort to eliminate symptomatology.

References

1. Hymes L: *Forefoot Minimum Incision Surgery in Podiatric Medicine*. Futura Publishing Co., Mt. Kisco, N.Y., 1977.
2. Cangiolosi CP (ed.): *Clin Podiatry*, Vol. 2, No. 3, WB Saunders Co., Philadelphia, 1985, pp. 413-535.

3. White DL: Minimal incision techniques for digital deformities. *Clin Podiatrc Med Surg,* 3:103-120, 1986.
4. Bycura BM: Bycura on Minimal Incision Surgery. Weissman SD (ed), No publisher, no place of publication, 1986.
5. George FW: The lixiscope: use in examination and surgery. *Clin Podiatry* 2:511-518, 1985.
6. Donahue WE, Donahue WE, Jr.: The proximal phalangeal osteotomy: a technically advanced approach. *Clin Podiatry* 2:449-455, 1985.