SURGICAL PRINCIPLES IN THE MANAGEMENT OF IATROGENIC FOREFOOT DEFORMITIES

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INTRODUCTION

The forefoot is a complex combination of form and function. A myriad of osseous and soft tissues must act in concert in a variety of gait and activity situations. Surgical interventions are intended to correct deformities that have resulted in symptomatic forefoot complaints. At the same time surgery is planned to preserve function. Occasionally, the outcome of forefoot surgery provides unwanted results. These can be classified in two broad categories. The original problem may return or a new area of deformity and pain may develop. The etiology or reasons for unwanted results are of extreme importance. The reasons for the postoperative problems will greatly influence the approach to secondary surgical repair.

A pathological process that has been influenced by earlier surgery exists for the patient. Understanding and appreciating this dynamic evolutionary process within the forefoot is critical to any practitioner involved in the repair of iatrogenic deformities. A thorough review of this process is presented. A review of surgical principles is presented as a logical progression from evaluation. The basis for the principles of repair centers on the goal of restoring forefoot function. Ultimately, a functional asymptomatic foot is the objective. This chapter will be limited to the lesser rays and digits. A discussion of iatrogenic deformities of the first ray is outside the scope of this presentation. Certainly adequate control of first ray function is a paramount concern in any iatrogenic problems involving the forefoot. The assumption has been made for this presentation that first ray function is adequate.

METAPHYSICS OF DEFORMITY

By the time secondary surgical intervention is considered for iatrogenic lesser metatarsal and digital complaints, multiple forces have acted upon the forefoot. The evolution of foot pathology, although it may appear simplistic, is vital to the evaluation process. At some point a normal or functionally asymptomatic forefoot existed. Through a variety of biomechanical, pathological, traumatic, or other mechanisms, a pathologic forefoot resulted which produced complaints of pain, discomfort, and deformity for the patient. At some point in the evolution of this foot a surgical intervention occurred that altered the pathological course. The pathological force may have been totally abated or may have continued in spite of the surgical intervention. The goal of the original surgical procedure was to alter the pathological course in some way and produce an asymptomatic result. The surgical result may have succeeded or it may have failed. In the case of iatrogenic deformities the result was obviously unwanted and considered a failure.

Many former forces can continue to act upon the forefoot to affect the surgical result. New forces, as a result of the surgical intervention, may also act on the foot and affect the surgical result. Progressive disease states can continue to affect the forefoot and the results. For example, rheumatoid arthritis is not cured by forefoot surgery. The pathological process involving bone and soft tissue continues to affect surgical results. The surgical methods used in the original operative repair may not have been adequate for the pathology present. Such complications as nonunion, infection, and wound dehisence adversely affect the course of an otherwise successful operative repair. The original evaluation and procedure selection process may have been inappropriate. The patient may not have understood, or poorly followed postoperative instructions. A noncompliant patient opens the way for many unwanted postoperative complications.

What is important to understand at this point is that two distinct forces have and may continue to act on the forefoot. The first is the original pathological force that created deformity. The second is the surgical intervention that somehow altered this pathological force.

The first has a poor prognosis and is the reason surgical intervention was considered. The second or surgical force has two possibilities, one good and one bad. The surgery may succeed by altering the pathological force and affect correction. Surgical correction, for a multitude of reasons may fail to alter the course effectively and may thus result in secondary problems. The decision for the examiner here is obvious: Is the current secondary pa-

tient complaint and deformity the result of continued pathological influences or the result of the surgical influence or both?

This distinction is very relevant. It provides an aid in the evaluation process and in selection of the secondary surgical procedure. It forces the examiner to consider the original pathological process and symptom complex that presented. Next the influence of the surgical procedure is added and the current foot status analyzed. It is important to understand that a time-line of events has and continues to occur. Secondary surgical procedures may need to consider affecting the ongoing pathological process. The surgical procedures may only need to counteract the original surgical repair in some manner. Both processes or forces may need to be counteracted in some way in the second surgical repair.

Many such examples of neglecting to observe this time-line approach to iatrogenic foot deformity can be cited. The patient may present with a simple plantar fourth metatarsal hyperkeratosis. An osteotomy is performed to affect the hyperkeratosis, but the osteotomy results in transfer of stress to the third metatarsal. An unrecognized varus deformity of the rearfoot influenced the midtarsus resulting in the original lesion and its transfer pattern. To relate our discussion to the preceding example, originally an asymptomatic foot existed that became influenced by the rearfoot varus. As a result of this influence, a metatarsal lesion developed plantar to the fourth metatarsal in the presence of hypermobility of the fifth metatarsal. This was unrecognized by the original practitioner. The fourth metatarsal osteotomy only transferred the pressure of weightbearing to the third metatarsal. The pathological course of rearfoot varus was not affected by the surgical intervention to the fourth metatarsal. The resultant deformity presently existing is a third metatarsal lesion in the presence of continued rearfoot varus influences. Repair of the iatrogenic problem may not be directed at the third metatarsal. The rearfoot varus is the primary force influencing the original pathologic process. Secondary repair should strongly consider a calcaneal osteotomy. Once this deformity has been corrected it may be necessary to plantarflex the fourth metatarsal back to its normal position. The original pathology was not in the fourth metatarsal but in the rearfoot.

To summarize, a normal forefoot existed which was adversely influenced by rearfoot forces. The foot was affected by surgical intervention and continued to be influenced by the original varus rearfoot. Correction of the iatrogenic deformity should be directed at the rearfoot pathology and re-establishing the balance of the forefoot.

MANAGEMENT

The surgical management of iatrogenic deformities requires understanding the basics of foot function. The goal of creating a functional asymptomatic foot may result in one which in no way resembles the original God-given model, but which functions under principles that permit pain free activity.

These basic goals of repair in iatrogenic deformities help in reconstructive surgical planning. As in primary forefoot complaints, aggressive conservative treatment is appropriate to avoid additional surgical treatment.

General medical considerations are of extreme importance in evaluating iatrogenic deformities. Certain systemic disease processes may affect bone and soft tissue healing and the results of surgical repair. Unrecognized systemic disease may have affected an otherwise satisfactory original procedure.

Certainly any superstructural consideration should be carefully examined. Existence of thigh, leg, or tarsal pathology can significantly affect the outcome of forefoot surgery. New pathologies may have developed in progressive disease states that were not present during the original surgical evaluation. A review of the office and hospital records of such patients is of potential value in considering possible change in general medical status. The original surgical repair may have considered all these aspects adequately. There may have been a change in the patient in terms of general medical, superstructural, or biomechanical status that has influenced the surgical result.

Once all these factors have been evaluated then basic forefoot function is assessed. Three basic goals of forefoot function have been identified to help the practitioner in selection of reconstructive surgical procedures. If these goals are achieved, even in the most basic of situations, then a functional forefoot can be produced. It is not always possible to recreate surgically a foot that has been severely deformed by earlier treatment.

The goals include: 1) balancing metatarsal loading, 2) establishing functional metatarsophalangeal joints, and 3) creating flexor power to a stable digit.

These goals are basic in terms of forefoot function. No mention is made, for example, of how much load or at what stage in the gait cycle it should be placed on a metatarsal. The implication is clearly that metatarsal loading is balanced as evidenced by the absence of lesions or metatarsalgia. The metatarsophalangeal joints

must only provide an excursion point about which the digit and metatarsal may move. No mention is made of range of motion, only that a stable point of movement exists. Absence of a portion of a joint either proximally or distally can be accepted as long as a stable point of motion exists. The digit needs to be stable and to have flexor purchase power. This enables the digits to remain functional and opposed in terms of plantar weight-bearing pressure acceptance. The surgical decision process then is based on achieving these goals at the point in the time-line that the patient presents.

BALANCE METATARSAL LOAD

We will assume here that superstructural, tarsal, and other influences on the forefoot have either been corrected or compensated. What remains following this compensation then is an imbalance in metatarsal loading. The patient may complain of a recurrent lesion following metatarsal surgery or a transfer lesion to another metatarsal area (Fig. 1).

The surgical result may have been affected by trauma or problems with bone healing. The examiner must now decide on what plane the metatarsals should lie. It is necessary to determine whether metatarsals have been elevated too high or remain plantarflexed. Rarely, following metatarsal osteotomy with resultant transfer lesion, is an additional metatarsal plantarflexed (Fig. 2). The original metatarsal is rarely in isolated equinus. This condition may exist in the third metatarsal in certain situations. Generally, metatarsals may be considered to lie on a relatively even plane. To affect that plane by surgical osteotomy can result in transfer of pressure.

Transfer lesions do not necessarily mean that the metatarsal to which the lesion has transferred is likewise plantarflexed. Generally, the implication is that the original metatarsal was raised too high. The prudent operative decision may be to plantarflex the original metatarsal back to a position of loading (Fig. 3).

Many clinical signs exist to help establish the diagnosis of absent metatarsal loading. The transfer of pressure to adjacent metatarsals is generally evidenced by a transfer lesion and hyperkeratosis. The digit of the metatarsal that does not load is generally non-purchasing or floating. After a long time, contracture at the metatarsophalangeal joint may ensue. The metatarsal loading phenomenon is very easily influenced by other tarsal and forefoot deformities. The presence of hallux valgus or hallux limitus can greatly influence lesser metatarsal pathology. If such deformities exist, they must be corrected prior to any consideration of osteotomizing further lesser metatarsals.

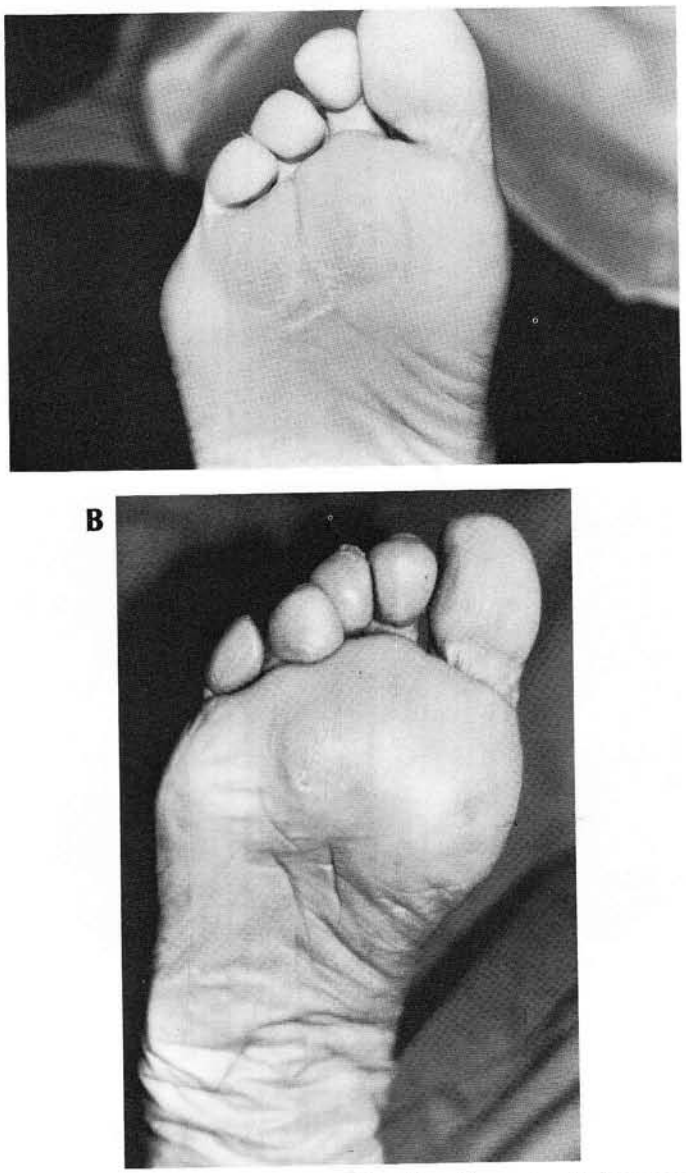

Fig. 1. A. Transfer lesions to second and fourth metatarsals following resection of third. B. Transfer to fourth metatarsal following dorsiflexory osteotomy of third metatarsal.

Generally, it has been found that the original metatarsal surgery may need to be reversed and the original pathological force on the forefoot repaired. Ignoring such influences greatly reduces the chances for successful operative repair on the lesser metatarsals.

A difficult repair of an iatrogenic surgical deformity is faced when attempting to balance metatarsal loading as compensation for absent metatarsals. Metatarsals may have been removed in treatment of plantar lesions or as

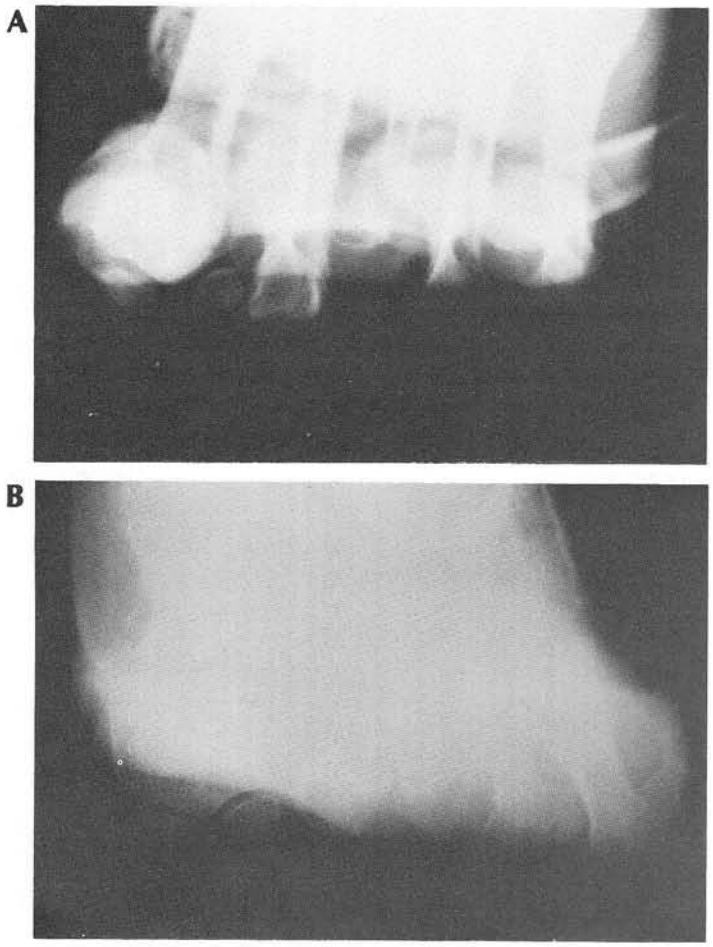

Fig. 2. Axial radiographic representation of Figure 1. A. Third metatarsal head resection. B. Third metatarsal osteotomy.

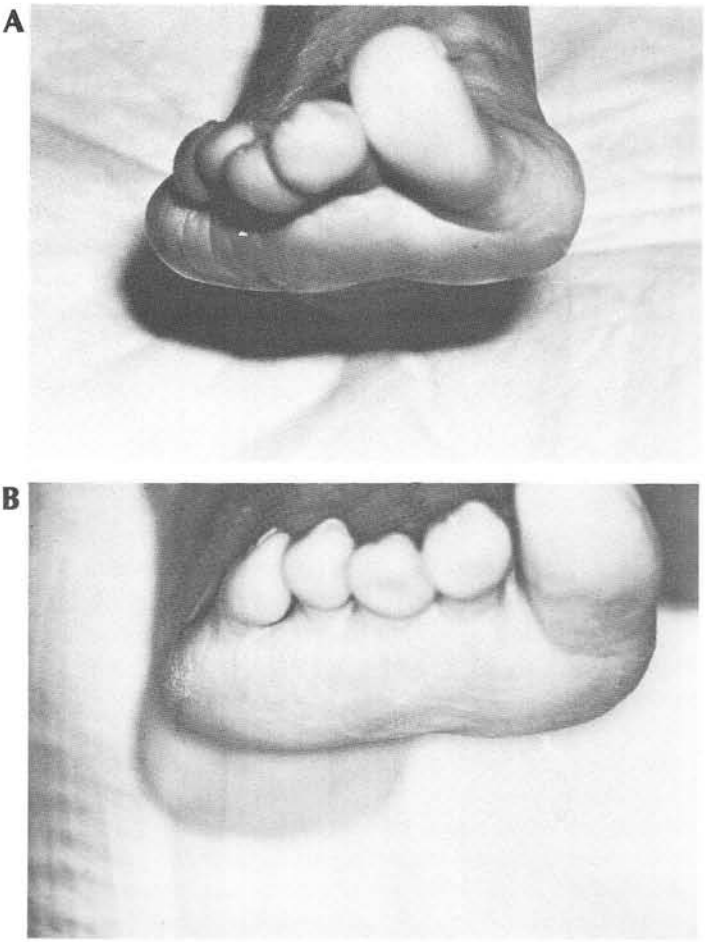

Fig. 3. A. Recurrent bunion and excessively elevated second metatarsal following osteotomy. B. Postoperative bunion correction and plantarflexory osteotomy second metatarsal.

a result of pathological states such as osteomyelitis. Transfer lesions may occur medial and lateral to the resected member. Judicious use of metatarsal osteotomies may help compensate and promote balanced metatarsal loading. In such cases, special attention to the metatarsophalangeal joint and digital stability goals is paramount. The use of osteochondral grafts as metatarsal head replacements is on the forefront of iatrogenic repair. With perfection of grafting and fixation techniques such procedures may become commonplace in podiatric surgery. Success has been obtained with the use of osteochondral metatarsal head replacements at the Podiatry Institute in selected cases (Fig. 4).

Of consideration with the absence of one or more metatarsal heads, is the pan metatarsal head resection procedure. Balancing a forefoot on three or fewer metatarsals is virtually impossible. The foot functions much more comfortably in the absence of all metatarsals. Occasionally, balanced metatarsal loading can be achieved in the absence of one metatarsal. If such balance can not be obtained, then the only remaining surgical option may be pan metatarsal head resection.

Presently, there does not exist an adequate weight-bearing implant to replace an absent metatarsal head. The lesser metatarsophalangeal implants that are presently available only help in establishing pain-free range of motion and some stability for this motion. They cannot be expected to act as weight-bearing portions of the ray. Insertion of an implant should in no way be considered to help redistribute weight-bearing load. Neither is lesser metatarsophalangeal joint implant arthroplasty considered a part of the approach to restoring balanced metatarsal loading. At some point, an implant may be available to aid in balanced metatarsal loading. Presently, the osteochondral grafting procedures are seen as far superior to any implant material. The role of the implant may be to assist in metatarsophalangeal joint stability following such grafting procedures (Fig. 5).

Fig. 4. Osteochondral graft as replacement for absent second metatarsal.

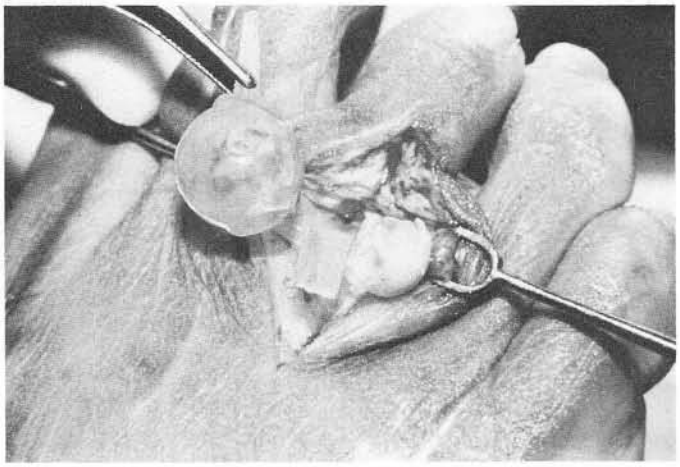

Fig. 5. Fractured implant used as weightbearing replacement for metatarsal head.

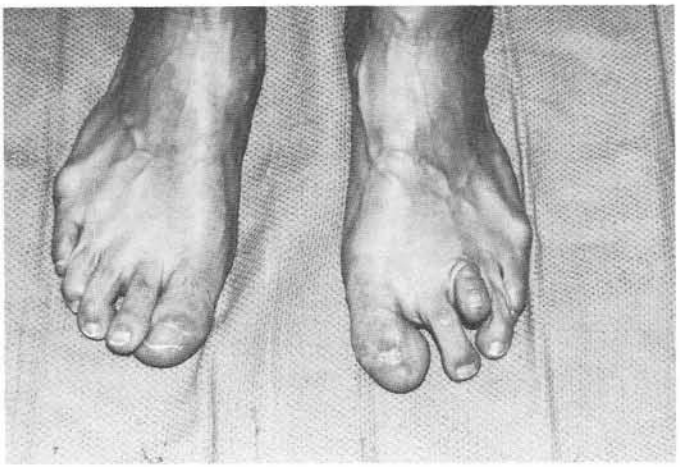

Fig. 6. Extensive soft tissue contracture following proximal phalangectomy.

ESTABLISH A FUNCTIONAL METATARSOPHALANGEAL JOINT

Once balance has been established through the five metatarsals, attention is directed to the metatarsophalangeal joint (MTPJ). The inter-relationship between the joint and the metatarsal is significant. Occasionally what appears to be a plantarflexed metatarsal is in reality a metatarsal locked in plantarflexion by a rigidly contracted metatarsophalangeal joint. Accurate ray assessment for the metatarsal weight-bearing plane can often be evaluated only after release of the metatarsophalangeal joint.

The metatarsophalangeal joints must be thoroughly evaluated. Any tissues on the dorsum of the joint can result in contracture following operative repairs. It can never be assumed that an adequate metatarsophalangeal joint release was performed during the original operative repair.

Inadequate release can result in significant complications at the digital level. Dorsal adhesion and scarring can result in recurrence of extensor contracture. An adequate sequential release of the metatarsophalangeal joint is necessary as a primary operative repair. If inadequate release was performed, any tissue released in the sequential release from the extensor hood to the capsule may again be in a contractured state. Contracture of cutaneous scar can result in digital deformity (Fig. 6).

The stability of the metatarsophalangeal joint ligamentous and capsular structures must be evaluated. Whether or not a joint can be dislocated or is excessively mobile in any plane needs to be carefully assessed. Pain on range of motion and evaluation of joint contours through the range of motion is important. Structural adaptation can occur at the metatarsophalangeal joint level just as it is seen in hallux valgus deformity with proximal articular set angle adaptation. Joint adaptation can result in seating of the proximal phalanx in an abnormally dorsiflexed position. Following the best operative release of the joint, reseating and recurrence of deformity can occur (Fig. 7).

A portion of the joint may have been removed through prior operative repair. Occasionally such joint resections result in a stable scarring at the metatarsophalangeal joint level. All that is needed is a point about which motion of the phalanx can occur with some stability to the metatarsal. If such stability has been created, there is no need for further operative repair.

Resection of a portion of the joint results in some degree of laxity for the digit and nonpurchase. Flexor and

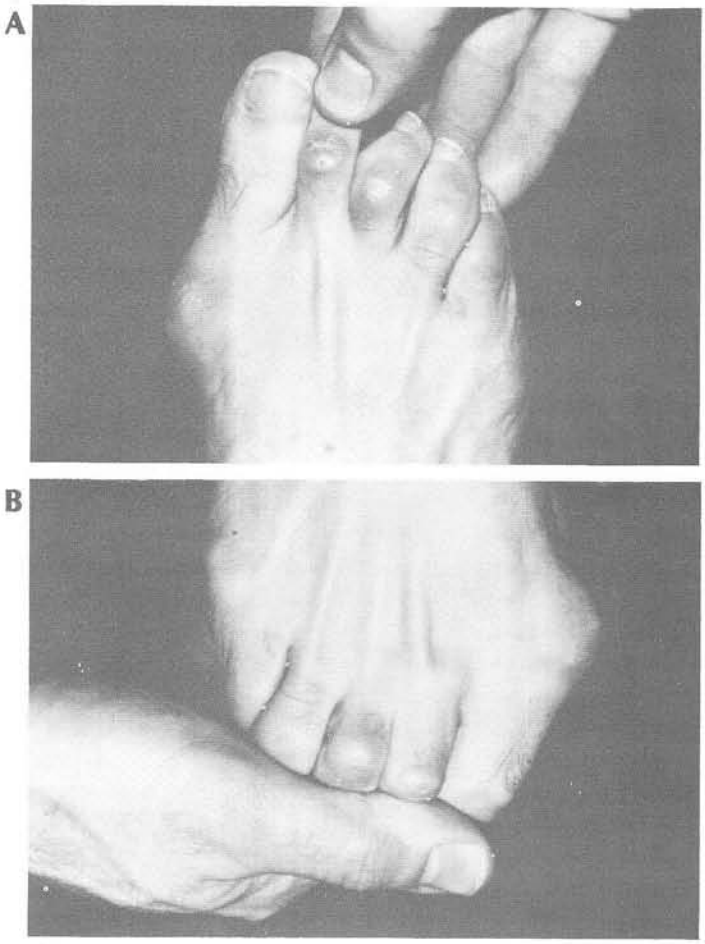

Fig. 7. Clinical maneuver demonstrating ease of dislocation of second metatarsophalangeal joint.

extensor power may be adequate but there is no fixed stable point about which the motion can occur. The loss of a proximal phalangeal base releases the intrinsic muscles as well as the plantar fascial attachments that aid in digital purchase. Lost also are the insertions of the ligamentous structures that give the joint stability. Normally, such procedures as proximal phalangeal base resection are performed with syndactally to provide stability from the adjacent digit.

The final assessment included under the metatarsophalangeal joint level is the flexor and extensor power. Following operative repairs, tendon healing cannot be assumed. Tendon rupture at sites of transection can result in a nonfunctional digit. Binding of the tendons within scar either dorsally or plantarly can likewise result in difficulties postoperatively. Free mobility of the tendons is needed to provide adequate excursion for range of motion.

Intrinsic muscle function to a digit is difficult to assess. If a toe floats or there is a gentle rise of the toe from the weight-bearing surface, or loss of plantarflexory stability to the proximal phalanx intrinsic loss may be assumed. Certainly resection of the proximal phalangeal base does result in loss of the plantarflexory stability to the digit.

CREATE FLEXOR POWER TO A STABLE DIGIT

Flexor power provides for digital purchase and assumption of weightbearing through the tufts of the digits. This helps distribute the forces of weightbearing to a greater surface area of the forefoot.

Following extensive complications from forefoot surgery, flexor power can be difficult to re-establish. It can usually be re-established by fusion of the proximal interphalangeal joint. By creating a two phalangeal system, the long and short flexors will act more readily as plantarflexory stabilizers of the digit through the metatarsophalangeal joint. As long as a three phalangeal system exists within the digit, the chance for buckling at the proximal interphalangeal joint level is present.

In essence a flexor tendon transfer has been performed wherein the flexor will act through the arthrodesis as a plantarflexor of the metatarsophalangeal joint. This is quite effective in relieving metatarsalgia and buckling of the metatarsophalangeal joint. The metatarsophalangeal joint must be functional to permit this plantarflexory power to occur. All that is needed is a point that is stable about which the flexor power can act. The use of silastic implants can be helpful in creating some degree of stability at the metatarsophalangeal joint level once digital stability has been achieved. The implant appears to help provide some degree of stability about which motion can occur (Fig. 8).

In correction of iatrogenic recurrent digital deformities, arthrodesis is usually indicated. The proximal interphalangeal joint arthroplasty results in a three phalangeal system within the digit where one of the joints is a pseudo joint. Once an arthroplasty has been performed, compromise to the capsular and ligamentous tissues has been affected. This is usually not a problem in single digit deformities. In the face of progressive disease or uncontrollable biomechanical forces, arthroplasty can prove to be a very disabling procedure. The pseudo joint created at the proximal interphalangeal joint level has a high degree of instability and may result in recurrence of deformity. The two phalangeal system created by a proximal interphalangeal joint arthrodesis creates a much greater degree of stability (Fig. 9).

With proximal interphalangeal joint arthrodesis no pseudo joint exists. All joints within the system are naturally occurring joints including the distal interphalangeal joint and the metatarsophalangeal joint. The joints contain cartilage, subchondral bone, and some degree of stability even though capsulorrhaphy and

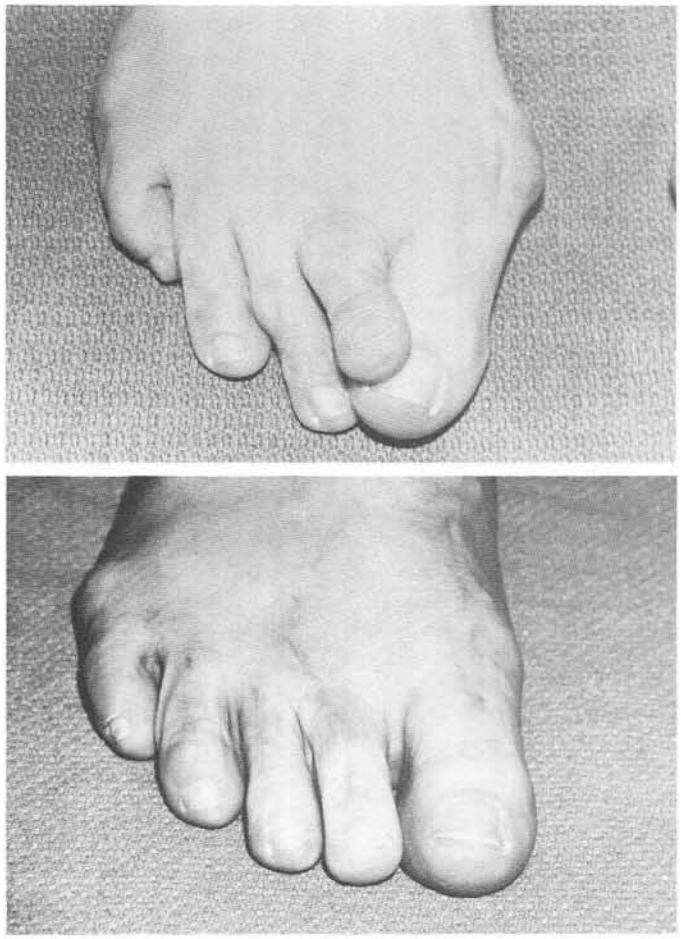

Fig. 8. A. Preoperative and B. Postoperative clinical presentation demonstrating Swanson total implant for correction of floating toe following proximal phalangeal base resection.

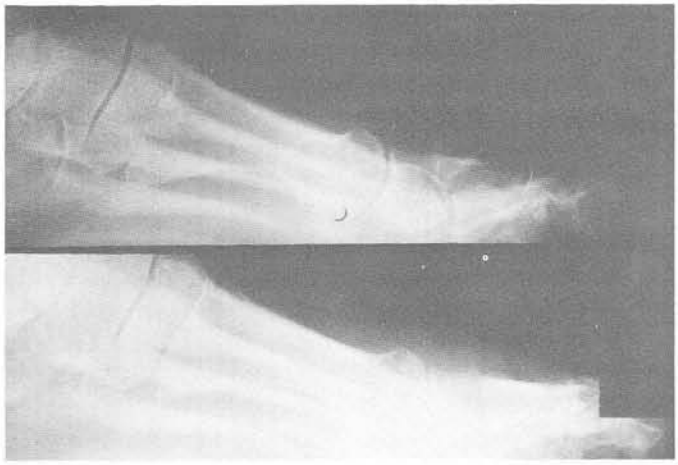

Fig. 9. Plantarflexory power to proximal phalanx of second digit effected by arthrodesis of proximal interphalangeal joint.

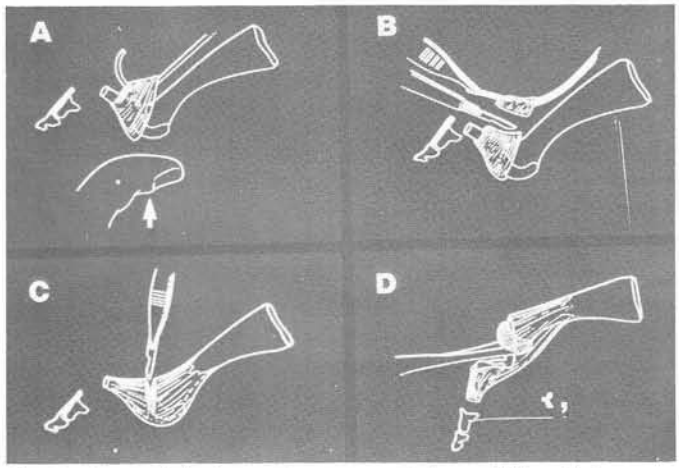

Fig. 10. Sequential release of metatarsophalangeal joint. A. Extensor tendon. B. Extensor hood. C. Joint capsule. D. Flexor cap.

operative repair has occurred. Arthrodesis provides the surgeon with the ability to create a stable two phalangeal system along with the transfer of flexor power to the metatarsophalangeal joint to assist in digital purchase.

Adequate flexor power for toe purchase can only be achieved after adequate metatarsophalangeal joint release has been established. If adequate metatarsophalangeal joint release and stability has not been created, as following arthroplasty, recurrence of the digital deformity may present. If adequate release has not been affected and arthrodesis has been performed, a nonpurchasing digit with mallet toe deformity is predictable. Inadequate release of the metatarsophalangeal joint should not be underestimated. The power of this deforming force following operative repair, or before the initial surgery is significant (Fig. 10).

SUMMARY

Iatrogenic foot deformities provide a challenging situation for operative repair. A thorough understanding of the original disease process and the effects of surgical procedures is of importance. Accurate assessment of the deformity to provide for surgical correction requires careful use of analytical evaluation techniques.

Simple goals for re-establishing forefoot function have been presented. The goals, if attained, generally will result in a satisfactory result. Understanding the basics of forefoot function helps to provide the patient with a satisfactory result that meets the requirements of pain free ambulation. Repair of iatrogenic deformities may require one or two stages to complete. The patient should be well aware and informed that some procedures may only be effectively performed following assessment of the results of others. This is a challenging area of podiatric surgery and can be extremely exciting and rewarding.

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