HALLUX LIMITUS: TECHNIQUE

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INTRODUCTION

The hallux limitus deformity has recently been reviewed in Podiatry Institute publications. Because of the complexity of the deformity and the variety of treatments, the topic deserves continued attention. This chapter will review the etiology and symptomatology of the deformity, as well as the conservative and surgical treatments which the faculty at the Podiatry Institute actively employ. A case history is presented to illustrate perioperative decision making.

Hallux limitus is the restriction of motion at the first metatarsophalangeal joint (MPJ). Functional hallux limitus is the condition in which the limitation of hallux dorsiflexion is only present upon weightbearing. In a structural hallux limitus the restriction of motion is present on weightbearing and non weightbearing. The condition in which there is no range of motion at the first metatarsophalangeal joint is hallux rigidus.

ETIOLOGY

Root et al indicate that 65 to 75 degrees of dorsiflexory motion is necessary at the first metatarsophalangeal joint for normal ambulation (1). Any condition which limits this range of motion causes repetitive stress to the joint and can thus lead to hallux limitus. The joint compression associated with limitation of motion creates chronic microtrauma within the joint. This leads to circumferential osteophytic proliferation which only serves to progressively worsen the condition. The lack of motion at the joint (MPJ) will be compensated by other joints (midtarsal joint, subtalar joint, ankle joint, knee joint, hip joint, and lower back joints). The necessary postural adaptation leads to additional degenerative changes.

A number of specific etiologies of hallux limitus have been proposed (2-7). They can be categorized into four groups: acquired, iatrogenic, arthritic, and congenital.

Acquired hallux limitus can develop from abnormal subtalar joint pronation which causes hypermobility of the first ray and a metatarsus primus elevatus. Root indicates that without adequate plantarflexion of the first metatarsal during propulsion the hallux is only able to dorsiflex 25 to 35 degrees. Plantarflexion of the first metatarsal against the weight-bearing surface during propulsion is not possible without a stable first ray. When the subtalar joint is abnormally pronated, the peroneus longus tendon is unable to adequately stabilize the first ray.

Normally, the fulcrum of the peroneus longus tendon around the cuboid is plantar to the tendon's insertion into the base of the first metatarsal. When the subtalar joint is abnormally pronated (the calcaneus is everted), the fulcrum of the peroneus longus is on the same plane as its insertion into the base of the first metatarsal. The peroneus longus therefore cannot provide adequate force to plantarflex the first metatarsal. Consequently, the hallux is unable to dorsiflex more than 25 to 30 degrees, This creates a functional hallux limitus.

Chronic jamming of the joint will worsen the condition by causing osteophytic proliferation (8). In addition, the longer the hallux is burdened with functional limitus the more periarticular soft tissue adaptation occurs. The flexor plate is especially susceptible to such shortening. That which begins as a functional limitus is thus converted to a structural restriction.

Hallux limitus can develop iatrogenically after surgery at the first metatarsophalangeal joint (McBride, Reverdin, Austin). If proper range of motion exercises are not performed postoperatively, the flexor plate and joint capsule will adhere to the metatarsal head and limit dorsiflexory and plantarflexory motion. Release of the dorsal and plantar adhesions is essential in correction of iatrogenic hallux limitus.

Arthritic hallux limitus develops from a variety of arthritic conditions which affect the first MPJ. These include gout, osteoarthritis, rheumatoid arthritis, osteochondritis dissecans, and traumatic arthritis. Any condition which interferes with the smooth gliding relationship of the two joint surfaces can cause hallux limitus. Additionally, anything which causes pain in or around the joint will result in muscular splinting of the joint. The result is a functional limitus which in time becomes structural.

Congenital hallux limitus includes those cases due to an elongated first metatarsal, a short first metatarsal, a congenital metatarsus primus elevatus, and a congenital coalition between the medial cuneiform and the first metatarsal. An elongated first metatarsal bears excessive weight and causes excessive stress at the first MPJ. The chronic stress progressively erodes the cartilage and subchondral bone. Metatarsus primus elevatus and congenital short first metatarsals can lead to hallux limitus because the first metatarsal is unable to plantarflex enough to accept full loading during propulsion. A congenital coalition prevents adequate dorsiflexion of the hallux at the first metatarsophalangeal joint due to its limitation of plantarflexion of the ray (8).

SIGNS AND SYMPTOMS

The patient's chief complaint is most commonly a dull aching pain upon dorsiflexion of the hallux; although as the condition progresses the joint may be painful for hours after getting off the foot. The patient usually describes an insidious onset of symptoms which progressively worsen. Complaints of tonic spasms of the extensor hallucis longus are also common (9).

The symptomatic hallux limitus may involve an inflamed dorsal bursa. A bony exostosis can be palpated on the dorsal surface of the first metatarsal head. Depending on the severity of the condition crepitus can be elicited at first MPJ. Hypermobility of the first interphalangeal joint (IPJ) is common and is caused by compensation for lack of motion at the first MPJ. Hyperkeratotic lesions are present commonly under the hallux IPJ and under the fourth and/or fifth metatarsal heads (9). When hallux limitus is present in a patient with sensory neuropathy one may find a mal perforans ulcer beneath the hallux interphalangeal joint and often a second one beneath the fourth or fifth metatarsal head.

It is essential to evaluate the mobility of the sesamoid apparatus. The sesamoids are palpated plantarly and the hallux is dorsiflexed. If the sesamoids are immobile they are anchored to the plantar aspect of the metatarsal neck. This results in marked limitation of dorsiflexion of the MPJ. Freeing of the sesamoid apparatus is essential in correction of the condition.

Gait is greatly altered. The patient tends to compensate by internally rotating the limb, adducting the forefoot and rolling weight laterally off the fourth and fifth rays. Other patients may compensate by shortening the stride and essentially walking flatfooted. An occasional patient will compensate by severe abduction (external rotation of the hip) and with severe pronation. This latter patient rolls the weight medially off the ball of the foot and represents a rather unusual method of accommodation.

There is one further patient in whom hallux limitus represents an incidental finding and may require little or no treatment. The patient who is essentially apropulsive requires no first MPJ dorsiflexion. Such patients may begin with functional limitus and progress to full rigidus without local symptoms. They are an exception to the above group in that they require no treatment. Many such patients use a cane or a walker or may simply ambulate with a very broad base of gait.

TREATMENT

The faculty at the Podiatry Institute treat hallux limitus conditions conservatively and surgically depending on a variety of considerations. These considerations include the extent of deformity, symptomatology, activity level of the patient, patient's medical history, response to conservative care, and the condition of the patient's bone stock (osteoporosis).

Conservative Treatment

Conservative treatment may provide temporary symptomatic relief. Conservative therapies have been described in the literature with reports of relatively good results (10). Such treatment tends to be rather awkward and is often poorly received by patients.

Rocker soles have been employed by some members of the Institute faculty. The rocker sole provides a pseudo increase in dorsiflexion at the first metatarsophalangeal joint. An additional sole thickness is added to the bottom of the shoe. The addition is cut off distally at either the MPJ or at the mid sulcus beneath the proximal phalanx. At heel-off the weight is rocked over the end of the sole and no first MPJ motion is required until the sole beneath the distal phalanx contacts the ground. The thickness of the rocker sole as well as the placement of the rocker will affect how much of the hallux dorsiflexion is absorbed. Essentially, the rocker sole simply decreases the amount of MPJ dorsiflexion that is required at normal heel-off.

The specific placement of the rocker is critical in providing the maximum benefit. Placement of the rocker under the first metatarsal head will provide less dorsiflexory relief than placement under the sulcus of the first proximal phalanx. Approximately 26 degrees of decreased dorsiflexory requirement is effected with a 3/4 inch rocker under the first metatarsal head. Placement of this rocker distally under the sulcus of the proximal phalanx will provide an additional 7 to 10 degrees (depending on the length of the shoe). This is illustrated in Figure 1 A-C and Table 1.

Molded shoes or depth shoes can also be used as conservative measures. A rocker sole can be added to the shoe. In addition a 1/4 inch insole or inlay is made for the shoe. This is cut out under the hallux to allow the hallux to drop into a plantarflexed position. This will in

Fig. 1 A. Placement of 3/4 inch rocker under first MPJ.

Fig. 1 B. Placement of 3/4 inch rocker under sulcus of proximal phalanx.

Fig. 1 C. Angle of decreased dorsiflexion requirement is measured with tractograph.

turn increase the available motion in the direction of dorsiflexion of the joint during propulsion. One should be aware, however, that the joint will adapt to the new position and in time this will result in further limitation of motion.

Surgical Treatment

A variety of surgical procedures have been described for hallux limitus (11, 12). The surgical procedures most commonly performed at the Institute are the cheilectomy, Green Waterman osteotomy, plantarflexory closing base wedge osteotomy, plantarflexory opening base wedge osteotomy with pie graft, Austin osteotomy with plantar displacement of metatarsal head, and implant arthroplasty. Frequently a combination of these procedures is performed.

The surgical goals of hallux limitus repair were described in the *Reconstructive Surgery of the Foot and Leg—Update '87* as follows: 1) removal of osteophytic spurring, 2) creation of slack in the flexor apparatus, 3)

TABLE 1

Approximate angles of decreased hallux dorsiflexion required by placement of rocker at either the first MPJ or the sulcus level of the proximal phalanx.

Size of Rocker	First MPJ	Sulcus of Proximal Phalanx
1/4 inch	15 degrees	20 degrees
1/2 inch	21 degrees	26 degrees
3/4 inch	26 degrees	32 degrees

shortening of the first metatarsal if excessively long, 4) reorientation of the first metatarsal head articular surface, and 5) stabilization/plantarflexion of the first ray (11).

The cheilectomy is usually the first step of any hallux limitus repair. Osteophytic projections are resected at the dorsal and medial aspects of the first metatarsal head and the base of the first proximal phalanx and the edges smoothed. Dorsal and plantar soft tissue adhesions are released. Range of motion of the first metatarsophalangeal joint is evaluated. If there is still lack of dorsiflexion additional procedures are performed (Figs. 2 A, B).

The Green-Waterman osteotomy was described at the Podiatry Institute seminar in Atlanta in 1987 (11, 12). The procedure is most desirable since it relaxes periarticular capsular contracture by shortening the metatarsal. The head of the metatarsal is plantarly and proximally displaced to allow for additional dorsiflexory motion.

A trapezoidal wedge of bone is removed from the distal dorsal aspect of the first metatarsal. A through and through oblique osteotomy is then created from the plantar edge of the trapezoidal osteotomy to the plantar aspect of the first metatarsal neck. The capital fragment is then displaced plantarly and proximally. The distal fragment is fixated with a .062 inch threaded Kirschner wire that is cut flush with bone. (The authors have developed instruments to cut the wire flush with bone and appropriate instruments for use should removal be necessary).

As discussed previously an elevated first metatarsal will not allow for adequate dorsiflexion of the hallux. Where a structural elevatus is present a plantarflexory wedge osteotomy should be considered to correct the deformity. This can be performed by either a closing or an opening base wedge osteotomy.

A closing wedge osteotomy is performed at the proximal plantar aspect of the first metatarsal shaft. Two osteotomies are created to remove a plantarly based wedge of bone. The osteotomies are directed from distal plantar midshaft to intersect at a proximal dorsal apex at the base of the metatarsal. This procedure will further shorten the metatarsal as well as contribute to a more dorsal articulation of the phalanx on the metatarsal head by plantarflexing the metatarsal. The osteotomy is most commonly fixated with a 4.0 mm cancellous bone screw (Figs. 4 A,B).

An opening wedge osteotomy at the proximal dorsal aspect of the first metatarsal is increasingly used at the Institute. An allogenic bone graft (pie graft) is placed in a proximal dorsal oblique osteotomy. The osteotomy is directed from midshaft dorsally toward plantar proximal of the first metatarsal base. The osteotomy is opened without fracturing the apex and an appropriately sized corticocancellous allogeneic bone graft inserted. The graft is cut flush and a 2.7mm fully threaded screw inserted. The screw serves both to hold the osteotomy open as well as closed, thus avoiding compression of the graft. (Figs. 5 A, B).

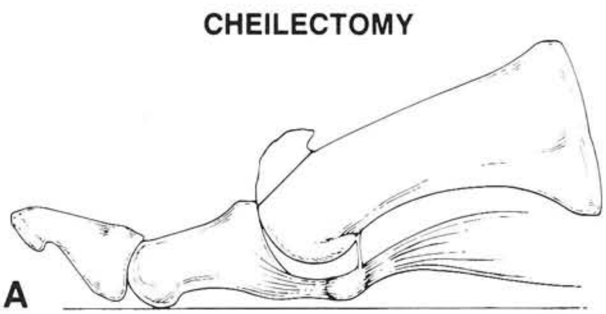

Fig. 2 A. Preoperative appearance before cheilectomy.

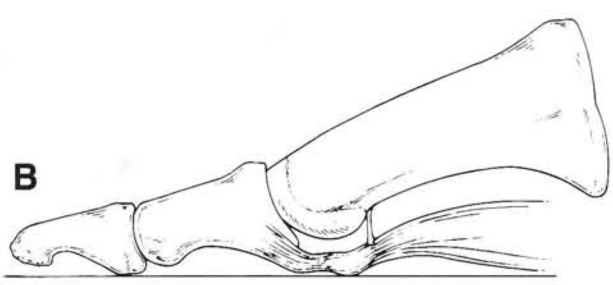

Fig. 2 B. Appearance following cheilectomy.

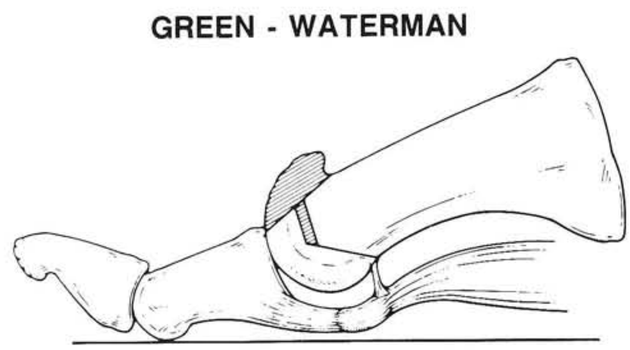

Fig. 3 A. Appearance prior to Green-Waterman osteotomy.

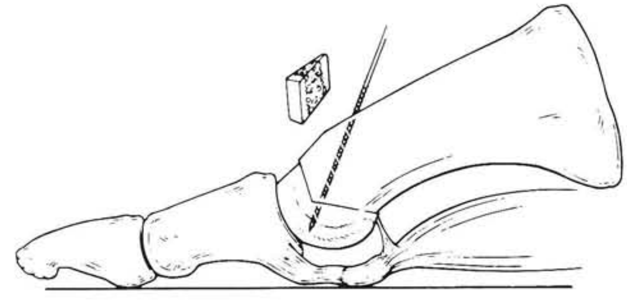

Fig. 3 B. Alignment following Green-Waterman osteotomy.

CLOSING PLANTARFLEXORY WEDGE

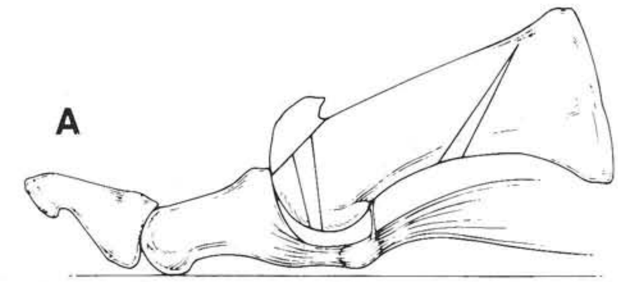

Fig. 4 A. Alignment prior to plantarflexory closing base wedge osteotomy.

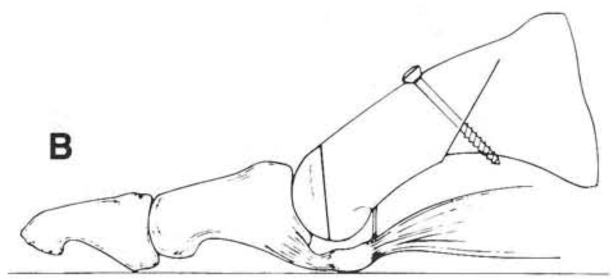

Fig. 4 B. Alignment following plantarflexory osteotomy.

OPENING PLANTARFLEXORY WEDGE

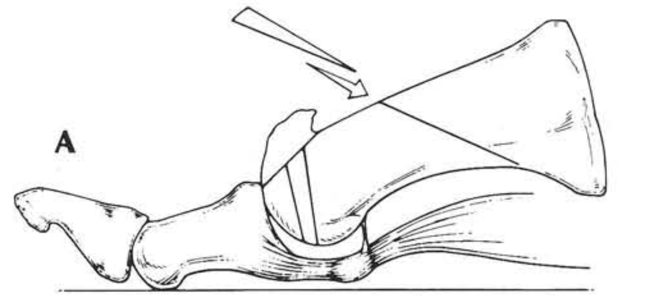

Fig. 5 A. Appearance prior to opening plantarflexory base wedge osteotomy.

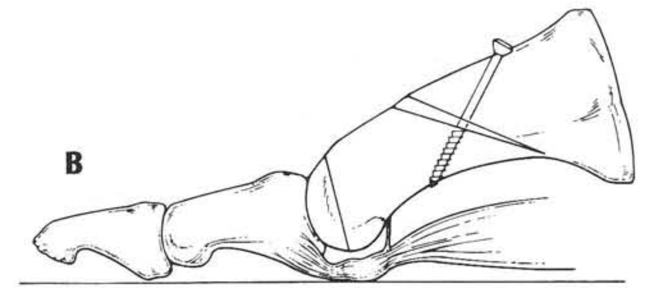

Fig. 5 B. Plantarflexory opening base wedge osteotomy with pie graft, postoperative.

Less dissection is necessary for the opening wedge osteotomy and the procedure is technically less difficult. The procedure however does lengthen the first metatarsal. If other procedures are not performed to release the peri-articular contracture, the procedure could result in tightening of plantar structures and increasing hallux limitus.

The Austin osteotomy is another procedure commonly performed for the correction of hallux limitus. It has been thoroughly discussed as treatment for hallux abducto valgus (HAV) repair in other texts (8). If the apical axis guide is directed plantarly and proximally the displacement of the capital fragment will relatively shorten and plantarflex the first metatarsal head. This will relieve tension at the peri-articular structures by shortening of the metatarsal. Reorientation of the head of the metatarsal in a plantarflexed position will increase first metatarsal weightbearing and permit greater hallux dorsiflexion (Figs. 6 A, B).

A first metatarsophalangeal joint arthroplasty with or without an implant is selected as the last resort for hallux limitus repair (Figs. 7 A, B). Excessive degeneration of the articular surfaces dictates the selection of this latter approach.

POSTOPERATIVE CARE

Appropriate postoperative care is essential for a successful result. Early passive range of motion of the joint will help prevent adhesion of dorsal and plantar ligaments. In situations where it is necessary for the limb to be in a non weight-bearing cast, the cast can be modified to allow for frequent range of motion exercises. The cast can be bivalved and removed when performing the exercises (Fig. 8). This can also be accomplished by a cut out in the cast at the hallux.

Polyurethane molds can be made to place over the first metatarsophalangeal joint after the cast has been removed (Fig. 9). This will serve to soften the scar and also resolve edema. This contributes to a rapid increase in pain free motion.

CASE STUDY

A 32 year old white female presented to the Podiatry Institute with a chief complaint of a painful great toe joint. It was particularly painful on dorsiflexion. An Austin procedure to repair a hallux abducto valgus deformity had been performed six months previously. Passive

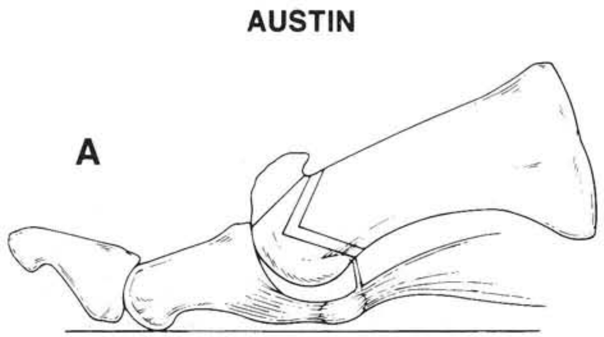

Fig. 6 A. Prior to performance of Austin procedure.

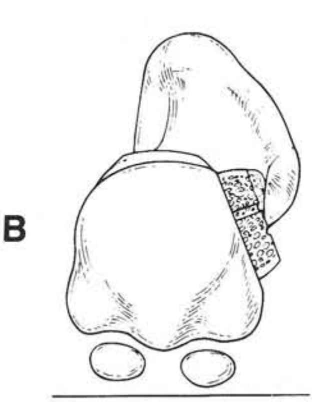

Fig. 6 B. Following Austin procedure with shortening and plantar displacement of metatarsal head.

Fig. 7 A. Failed hemi implant arthroplasty with hallux limitus.

Fig. 7 B. Total first implant arthroplasty, postoperative radiograph.

range of motion exercises had not been performed postoperatively and the joint had stiffened. Pain was now present upon ambulation and had been progressive in its course. Conservative treatment including orthoses, physical therapy, and corticosteroid injections had failed to provide relief.

Upon examination of the first metatarsophalangeal joint there was no dorsiflexion and marked limitation of plantarflexion (Fig. 10). The sesamoid apparatus was immobile. The flexor plate was adhered to the plantar aspect of the head of the metatarsal. Metatarsus primus elevatus was not present.

Surgical intervention was deemed the best alternative. Medial joint dissection was first performed which had no effect on the dorsiflexion and plantarflexion of the

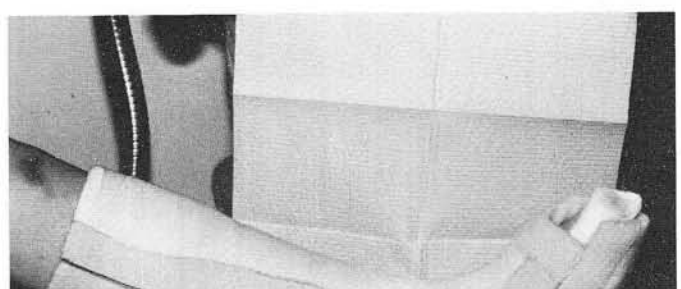

Fig. 8. Bivalved cast allows for range of motion exercises.

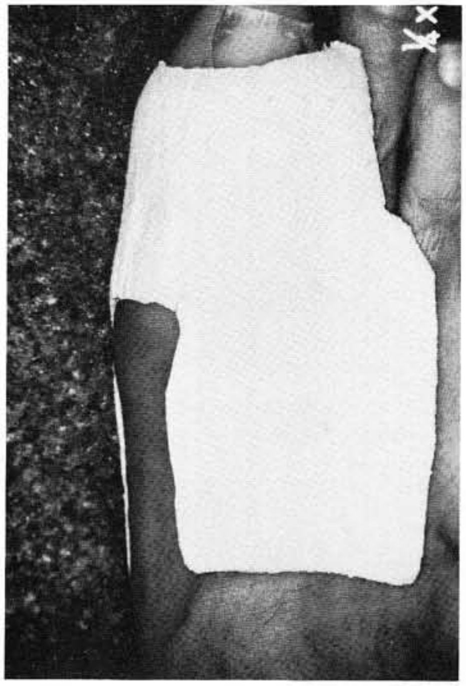

Fig. 9. Polyurethane mold placed over first MPJ softens scar and resolves remaining edema. This aids in returning full range of motion.

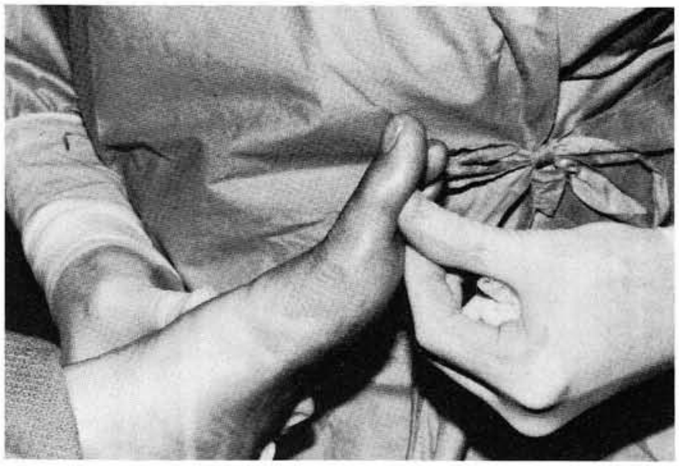

Fig. 10. Extent of preoperative dorsiflexion of hallux.

joint. The dorsal adhesions were then released which increased the passive plantarflexion by 60 degrees but did not affect dorsiflexion. The handle of a scalpel was then placed between the sesamoid apparatus and the plantar aspect of the first metatarsal to break the plantar adhesions which had bound the sesamoids (Fig. 11). This increased the dorsiflexion by 70 degrees, however the soft tissue was still tight.

In order to relax the periarticular structures, a Green-Waterman procedure was performed. The osteotomy was fixated with a threaded 0.062 inch K-wire. The procedure effectively shortened the first metatarsal and relaxed peri-articular soft tissue contracture. Dorsiflexion of the hallux was then possible without restriction (Fig. 12).

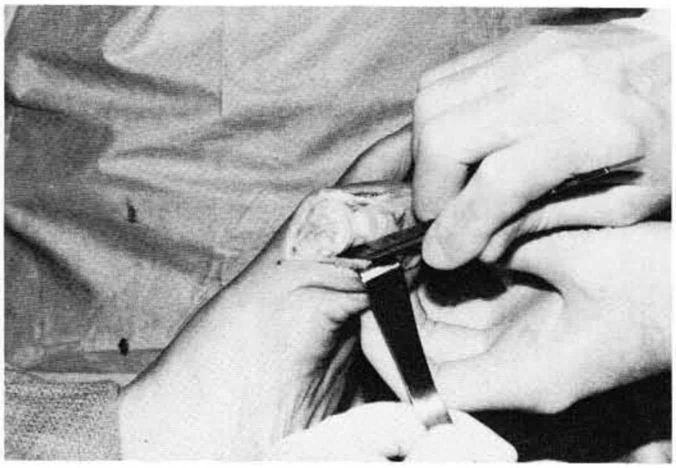

Fig. 11. Release of frozen sesamoids is performed by placing handle of scalpel between sesamoid apparatus and plantar aspect of first metatarsal and breaking adhesions.

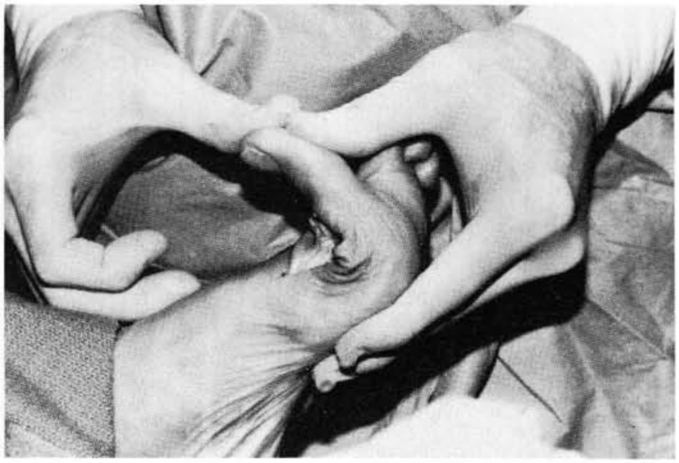

Fig. 12. Intraoperative dorsiflexion of hallux after release of arthrodesed sesamoid apparatus and Green-Waterman procedure.

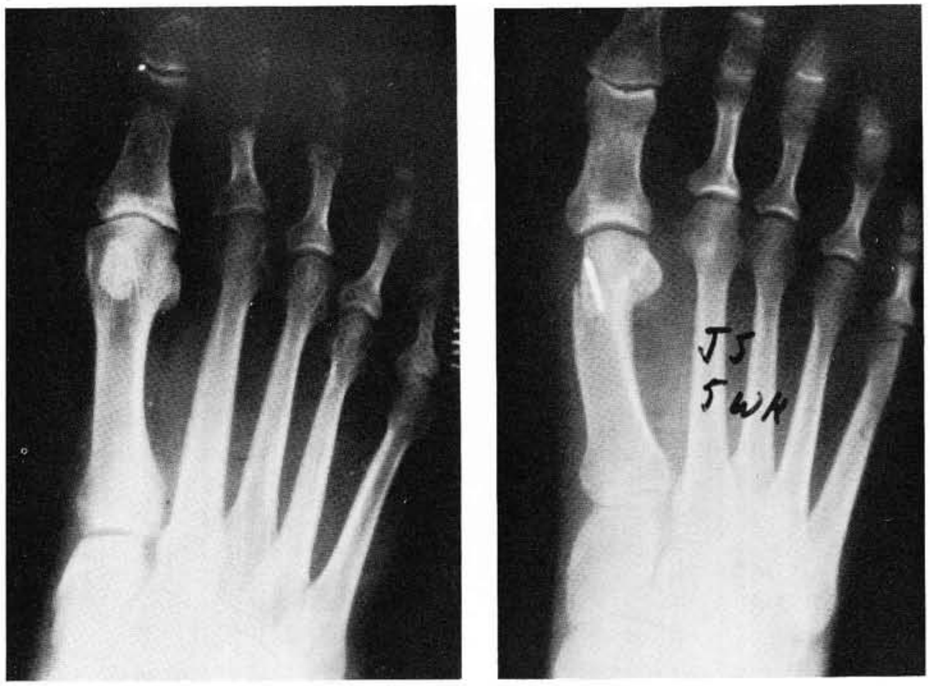

Fig. 13. Case study: preoperative and postoperative radiographs.

No further procedures appeared warranted. Adequate dorsiflexion and plantarflexion had been obtained, and the first metatarsal, though shortened, continued to assume appropriate weightbearing. The wound was closed in layers with the hallux in a rectus position. A soft dressing was applied to the foot. The patient was allowed to ambulate in a Darco surgical shoe, especially chosen because it allows motion at the metatarsophalangeal joints. Postoperatively, the importance of range of motion exercises at the first MPJ was stressed to the patient. The patient was instructed to passively dorsiflex and plantarflex the hallux ten repetitions 42 times per day.

Six months postoperatively the patient reported total relief. Seventy-five degrees of non-restrictive dorsiflexory motion was recorded (Fig. 13).

CONCLUSION

A brief review of hallux limitus has been presented. A case history illustrates intraoperative decision-making and postoperative care as presently performed at the Podiatry Institute.

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