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Hallux Limitus and Hallux Rigidus

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DEFINITION

Hallux limitus can be defined as limitation of motion of proximal phalanx at the first metatarsophalangeal joint (MPJ) in the sagittal plane. The normal range of dorsiflexion for this joint is approximately 55°-65°. In hallux limitus, the range of motion is reduced to 25°-30°. With decreased dorsiflexion, symptoms may result in adolescent and early adult life with pain and inability to perform in daily and athletic activities.

With continued loss of dorsiflexion and continued jamming of the joint, degenerative changes occur within the first MPJ with severe restriction of motion, increase in pain, and immobility, which leads to the condition hallux rigidus. In symptomatic hallux rigidus, pain is noted with any attempt at dorsiflexion. The amount of dorsiflexion may be reduced to as little as 0 to 10 degrees with pain on both active and passive motion.

Hallux limitus, and its subsequent counterpart, hallux rigidus, are the most common terms used in the literature as well as the clinical setting. Other terms include hallux equinus,¹ which is described as a deficiency in sagittal plane motion wherein the proximal phalanx is in an attitude of plantar flexion with inability to dorsiflex. In older orthopedic literature, the term dorsal bunion² is used similarly to describe the same condition.

ETIOLOGY

Ever since 1887 when Davies-Colley³ first used the term hallux limitus, there have been various theories on the formation of this entity. Nilsson⁴ in 1930, described hallux rigidus as arising from a severely elongated first metatarsal with subsequent jamming of the base of the proximal phalanx. This is caused by the inability of the base of the proximal phalanx to dorsiflex adequately on the head of the first metatarsal. Lambrinudi⁵ evaluated the first metatarsal in relation to the remaining lesser metatarsals and found it to be elevated. This condition, termed metatarsus primus elevatus, decreases the available dorsiflexion present at the first MPJ with subsequent jamming. Kessel and Bonney⁶ agreed with Lambrinudi in that hyperextension was noted at the first metatarsal in hallux rigidus formation. They also found that in a small percentage of cases osteochondritis dissecans initiated the formation of degenerative changes at the first MPJ with subsequent lack of dorsiflexion.

The belief that osteochondritis dissecans at the head of the first metatarsal was the common cause in the formation of hallux rigidus was further substantiated by Goodfellow in 1966. Goodfellow⁷ found that an acute traumatic episode may damage the integrity of the first metatarsal head. This results in osteochondritis dissecans and leads to decreased range of mo-

tion as well as the subsequent changes found around the joint margins in degenerative joint disease (Fig. 23-1). McMaster⁸ in 1978 further identified the location of the lesion as being subchondral in origin. This lesion was most often found beneath the dorsal tip of the proximal phalanx.

Root et al.⁹ described hallux rigidus as being caused by a multitude of factors including hypermobility, immobilization, elongated first metatarsal, metatarsus primus elevatus, osteoarthritis, acute trauma, osteochondritis dissecans, gout, and rheumatoid arthritis. Neuromuscular disorders causing hypermobility or hyperactivity of the tibialis anterior muscle or weakness of the peroneus longus muscle may lead to hallux rigidus by causing instability of the first ray.

Hallux limitus/rigidus can result from biomechanical and dynamic imbalances in foot function.^{10,11} The peroneus longus muscle as it courses laterally around the cuboid and inserts on the base of the first metatarsal acts as a stabilizing force during gait to help maintain plantar flexion of the first ray during the mid-stance phase of gait. This allows relative dorsiflexion of the hallux on the first metatarsal head in the propulsive phase of gait (Fig. 23-2A).

When excessive pronation occurs through the subtalar joint, the peroneus longus tendon loses its fulcrum effect around the cuboid and therefore cannot stabilize the first ray. Hypermobility results in the first ray with subsequent dorsiflexion of the segment and is considered a function elevatus because it occurs during the gait cycle. In contrast, a structural elevatus, if found, is osseous in etiology and may be iatrogenic or congenital in origin. This hypermobility allows for jamming of the base of the proximal phalanx onto the dorsal aspect of the head of the first metatarsal (Fig. 23-2B). With repetitive trauma in this area, osteochondral defects occur. The body attempts to heal this lesion with the formation of new bone in the area (Fig. 23-2C). This new bone formation is seen initially as a dorsal lipping at the first metatarsal head that progresses to involve the dorsal aspect of the base of the proximal phalanx (Fig. 23-3A to C). Through repetitive jamming of the joint and possibly osteochondral fracture, a small circular osteochondral island of bone may be found between the base of the proximal phalanx and head of the first metatarsal, causing further impingement and limitation of dorsiflexion of the hallux (Fig. 23-4A and B).



Fig. 23-1. Radiographic presentation of an old osteochondral fracture of the first metatarsal head in a patient with a painful hallux limitus associated with restriction of motion, crepitation, and locking. Intraoperatively, a large cartilage tear involving both the metatarsal head and base was identified.

Despite the lack of dorsiflexion of the MPJ in hallux limitus/rigidus, both passive and active plantar flexion is preserved except in advanced cases. Hallux rigidus and limitus may also occur as a complication following surgical procedures of the first MPJ. The restriction of motion may result from fibrosis of the joint or inadvertent elevation of the first metatarsal by distal or proximal osteotomy.

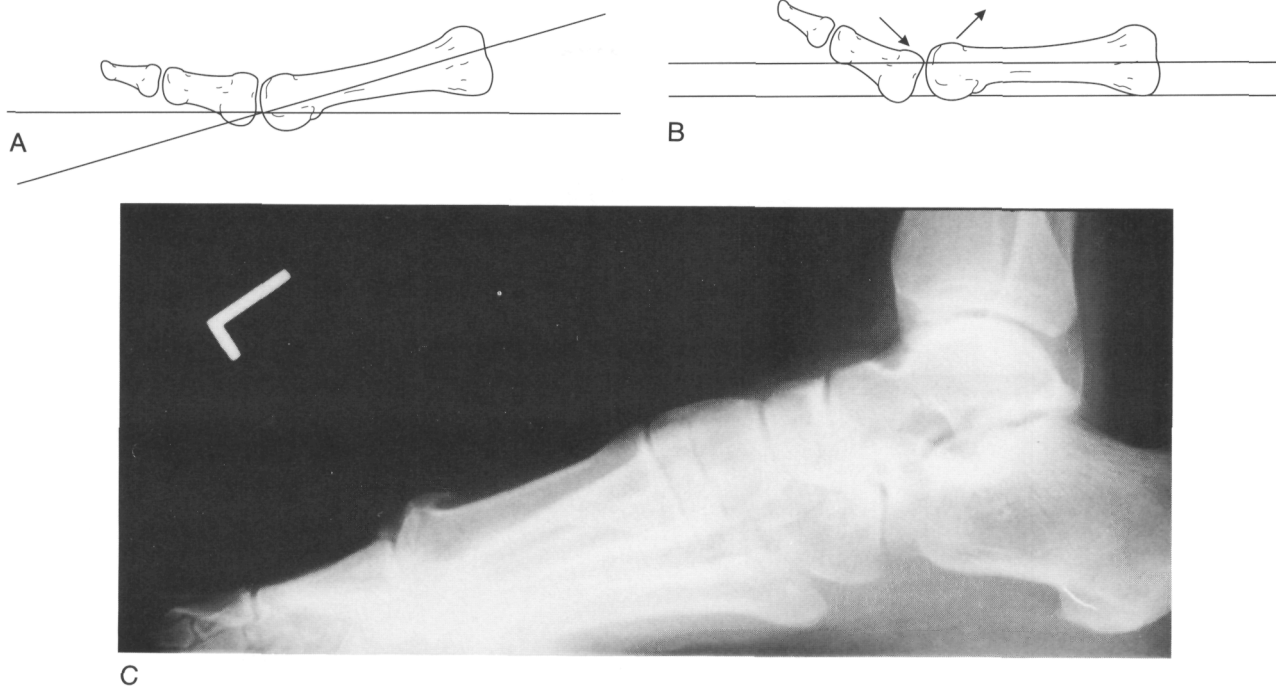


Fig. 23-2. (A) Normal plantar flexion of the first metatarsal, allowing dorsiflexion of the proximal phalanx. (B) Hypermobility resulting in dorsiflexion of the first metatarsal, causing impingement and excessive compression of the joint at the available end range of motion, and ultimately decreased motion and development of arthritic changes. (C) Radiographic presentation of hallux rigidus associated with metatarsus primus elevatus. The elevation of the first metatarsal is evident by the divergence of the first and second metatarsal shafts.

CLINICAL SYMPTOMS

The hallux limitus patient usually presents with a chief complaint of pain at the first MPJ. Pain is most often present with activity. Symptoms include edema and effusion of the first MPJ with palpable pain. There may be associated erythema around the joint, although this usually occurs after extensive or rigorous activity that causes an acute crisis.

The hallux rigidus patient is most commonly seen in early adulthood extending to middle age. Limitation of dorsiflexion is observed, both weight-bearing and non-weight-bearing (Fig. 23-5). A hypertrophy of bone that is present around the joint is evidenced clinically by palpation and by inspection. Pain is present with palpation, and edema and erythema are usually found on examination. Additional clinical symptoms include painful keratosis beneath the interphalangeal joint of

the hallux as a result of the joint compensating for the loss of dorsiflexion of the first MPJ, resulting in an extension deformity of the hallux. A painful plantar lesion, metatarsus primus elevatus, may also result beneath the second metatarsal head as a result of the hypermobility of the first ray.

Biomechanical examination of the patient with early hallux limitus usually yields a pronated foot type with demonstrated increased subtalar joint motion and compensation through the midtarsal joint, as evidenced by eversion of the calcaneus in the stance position. The midtarsal joint is usually maximally pronated, and collapse of the medial arch may be present.

Although pronation is considered a contributing factor in the formation of both hallux limitus and hallux valgus, genetics also plays an important but not fully understood part in the etiology of these conditions.

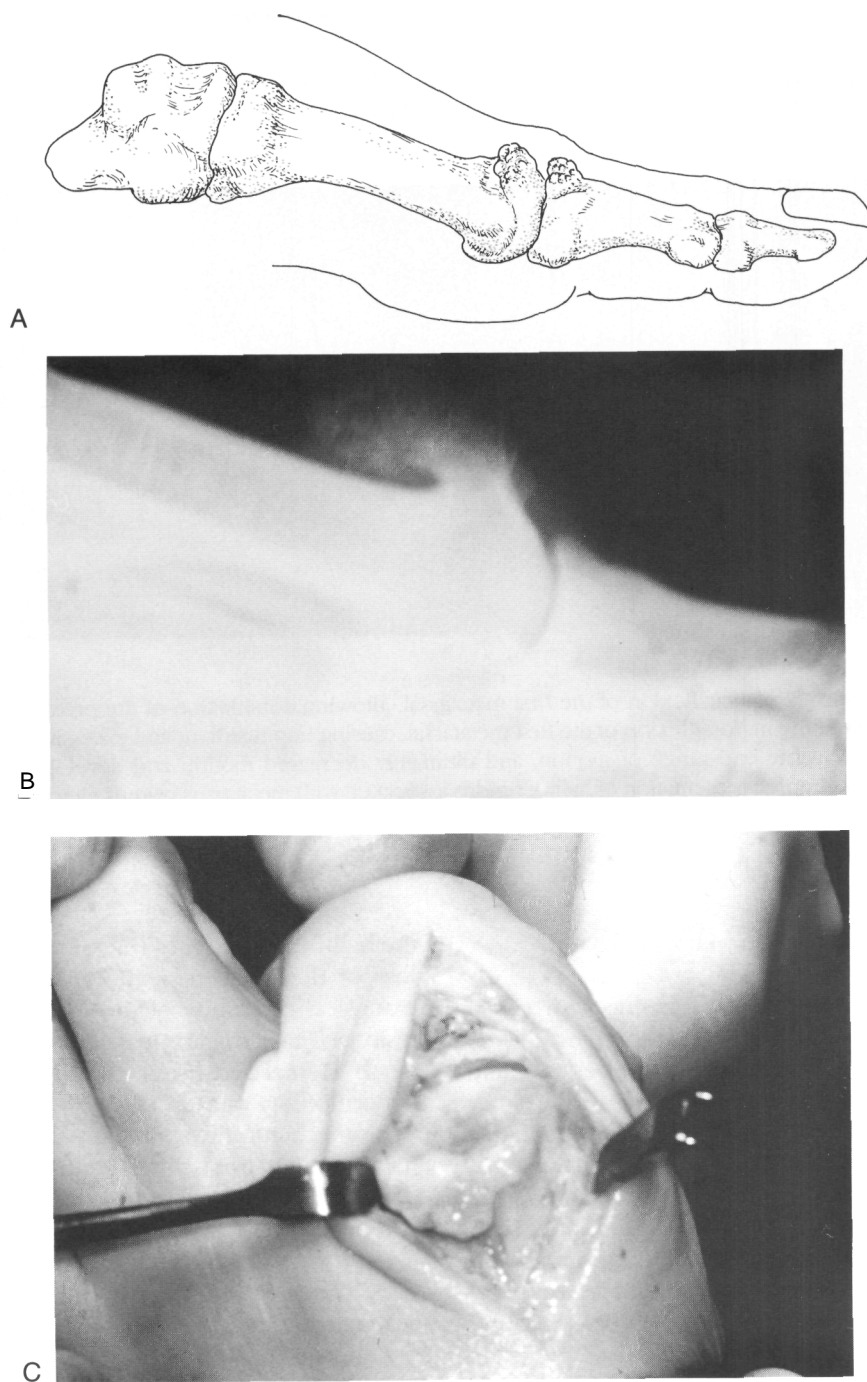


Fig. 23-3. (A) New bone formation seen as dorsal lipping on the first metatarsal head and proximal phalanx. (B) Radiographic presentation. (C) Intraoperative presentation.

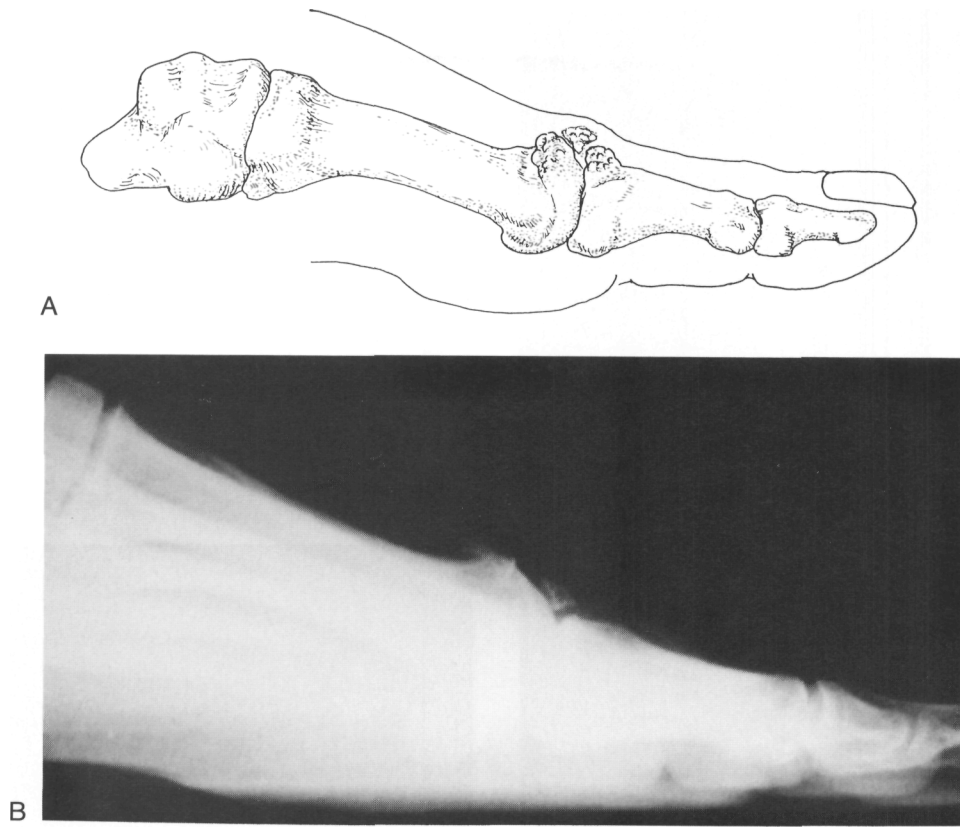


Fig. 23-4. (A) Osteochondral bone island or joint mouse formed within the joint. (B) Radiographic example.

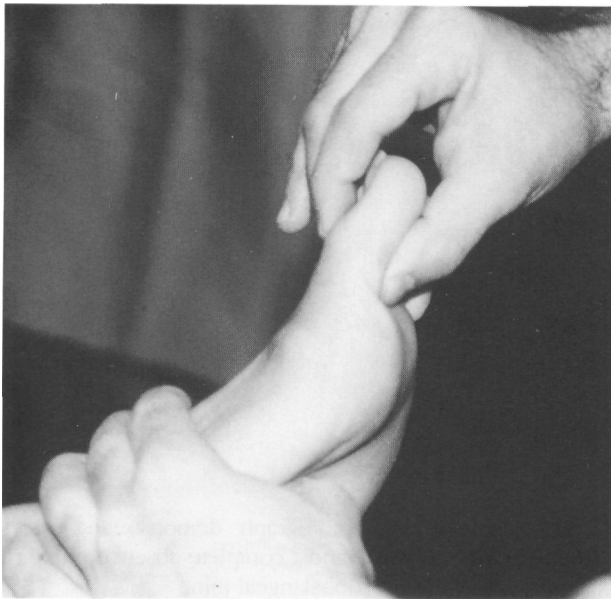


Fig. 23-5. Limitation of dorsiflexion of the first metatarso-phalangeal joint in a patient with hallux limitus.



Fig. 23-6. Dorsoplantar radiograph demonstrating decrease in joint space and hypertrophy at first metatarsophalangeal joint.

RADIOGRAPHIC INTERPRETATION FOR EVALUATION

The early stage of hallux limitus may present radiographically with very little sign of a dorsal exostosis at the first metatarsal head. Hypermobility of the first ray may be evidenced by dorsiflexion of the first ray segment as compared to the lesser metatarsals. The foot appears pronated, and on the lateral view, a decrease

in the calcaneal inclination angle and increase in the talar declination angle are evident. Joint margins may appear to be equal with little narrowing noted.

The hallux rigidus patient, radiographically, is late stage with severe dorsal flagging and an exostosis noted at the dorsal aspect of the first metatarsal; there is often a concurrent dorsal exostosis at the base of the proximal phalanx. Narrowing of the joint margins on the dorsoplantar view and the presence of an osteochondral circular island are distinguishing features (Fig. 23-6).

The shape of the first metatarsal head may be a significant factor in determining whether a hallux limi-



Fig. 23-7. Dorsoplantar radiograph demonstrating late-stage hallux rigidus with almost complete absence of joint space at the first metatarsophalangeal joint.

Table 23-1. Stages in Progressive Management of Joint Deformity

Investigator	Stage I	Stage II	Stage III	Stage IV
Rzonca et al. ¹				
Clinical	DF = 25°-45° Reducible contractures Preschool to teens	DF+ = 5°-20° Minimally reducible contractures Teenaged to geriatric years	No ROM Variable age	None
Radiographic	No osseous pathology	Osseous pathology consistent with severity	Joint fusion	None
Drago et al. ²¹				
Clinical	Pain at end ROM Minimal adaptive change	Limited ROM Structural adaptation	Painful ROM Crepitation	< 10° ROM
Radiographic	Metatarsal primus elevatus	Small dorsal exostosis	Nonuniform joint space	Loss of joint space
	Plantar subluxation proximal phalanx Pronation of rearfoot	Flattening of metatarsal head Possible osteochondral defect	Osteophytic production Large dorsal exostosis Marked flat metatarsal head	Loose bodies Inflammatory arthritis
Bonney and McNab ¹⁰				
Clinical only	DF = 35° PF = 15°	Limitation of either df or pf	Limitation of df and pf	Loss of ROM
Hattrup and Johnson ¹⁷				
Radiographic only	Mild osteophytes	Narrow joint space Moderate osteophytes Subchondral sclerosis	Loss of joint space Marked osteophytes Possible subchondral cyst	None
Regnault ¹²				
Clinical	DF = 40° Pain at end	Decrease in ROM Painful ROM	Little ROM Crepitation	None
Radiographic	Slight decrease of joint space Periarticular osteophytes Decreased metatarsal head convexity No sesamoid disease	Narrow joint space Incomplete osteophytes Flattening/broadening of joint surface Osteochondral defect Elevatus of first ray	Loss of joint space Marked osteophytes Incomplete sesamoid involvement Osteochondral defect Loose bodies Hypertrophy of joint	None

Abbreviations: DF, dorsiflexion; PF, plantar flexion; ROM, range of motion

tus/rigidus condition occurs as opposed to the hallux valgus deformity also seen in pronated foot deformities. Three shapes of first metatarsals are described. A completely rounded metatarsal head may yield to the abductory drift of the hallux and form what we commonly know as hallux abducto valgus deformity. The square metatarsal head is more stable and does not allow the abductory drift, but increases the amount of joint jamming and forms hallux limitus/rigidus. The square metatarsal head with a center ridge appears to be the most stable, which allows no transverse plane motion of the hallux, and with improper pronatory biomechanics appears to subsequently lead to the formation of hallux limitus/rigidus (Fig. 23-7).

STAGING OF HALLUX LIMITUS/RIGIDUS

Some authors have attempted to stage hallux limitus rigidus by clinical versus radiographic findings. Table 23-1 summarizes clinical and radiographic staging by various authors; they differ mainly in their interpretation of the amount and quality of the range of motion at the first MPJ.

Radiographic staging demonstrates similarities in the loss of joint space and disruption of the osteochondral defect. The differences include the disruption of the metatarsal head (i.e., flattening), osteophytic formation, and presence or absence of metatarsus primus elevatus.

CONSERVATIVE TREATMENT

Conservative treatment of the acute flare-up of the hallux limitus consists in reduction of the acute inflammatory phase. Oral nonsteroidal anti-inflammatories in combination with joint steroid injections and physical therapy are usually successful in mild to moderate cases. Also, rest helps alleviate the acute episode. Orthotic control may be beneficial in helping to prevent pronatory forces and stabilize the first ray. Concurrent first MPJ range-of-motion exercises, if successful in increasing the amount of dorsiflexion, may prevent future acute episodes. Patients who do not respond to conservative treatment, especially the hallux rigidus patient in whom there is complete absence of joint motion, inevitably require surgical intervention.

SURGERY FOR CORRECTION OF HALLUX LIMITUS/RIGIDUS

When conservative treatment has proven inadequate and symptoms are persistent, surgical intervention is indicated. Surgical procedures are tailored to certain factors, such as the patient's age, the amount of deformity, the degree of loss of motion at the first MPJ, and the amount of degenerative changes present both radiographically and intraoperatively.

When planning surgical intervention for the management of hallux limitus, two basic factors must be addressed: deformity of the joint and deformity of the first ray. If one uses Regnauld's¹² classification of hallux limitus, the severity of the symptoms and deformity progress from first degree to third degree (stage I to stage III in Table 23-1). The procedures for management of the joint deformity can be grouped in a progressive fashion, as outlined in Table 23-2, from joint preserving to joint destructive procedures. Additional consideration may be given to management of the osteochondral lesion, a long first metatarsal, and metatarsus primus elevatus. Hallux limitus secondary to a traumatic osteochondral lesion with no elevatus may be managed by arthroplasty of the first MPJ and subchondral drilling or abrasion of the defect.

Procedures such as the Bonney-Kessel phalangeal osteotomy and Watermann osteotomy are joint preservation procedures that attempt to displace the avail-

able range of motion in a more dorsal direction. Phalangeal osteotomy with resection for shortening of the hallux may be useful in those cases of hallux rigidus associated with a long hallux. The Watermann procedure redirects the articular cartilage dorsally and provides decompression of the joint. One theory is that in long-standing hallux limitus contracture of the soft tissue of the first MPJ results from the continuing inadequacy of the hallux, hallux flexus, and elevation of the first metatarsal. Decompression as a result of shortening of the first metatarsal by osteotomy also accommodates for the contracture, thereby removing a cause of joint motion limitation. Shortening of an excessively long first metatarsal can be managed by distal osteotomy. Bicorrectional osteotomies can result in shortening (decompression) and plantar flexion. Proximal osteotomies provide a direct approach to the management of metatarsus primus elevatus. Many of the osteotomies used in the management of hallux valgus have been adapted for hallux limitus. The Reverdin-Green osteotomy (distal L) osteotomy and Austin osteotomy, by resection of additional bone from the vertical or dorsal arm of the osteotomies, can provide for plantar flexion. The Z osteotomy performed in the sagittal plane can also be used for metatarsal shortening and plantar flexion.

DuVries¹³ in 1965 described the use of a cheilectomy-type procedure that was directed toward the patient with hallux limitus evidenced by the following criteria: (a) decreased range of motion at the first MPJ and dorsiflexion of no more than 20°-30°; (b) pain with range of motion; (c) narrowing of joint space as well as the beginnings of extra-articular bony changes as evidenced on radiography (dorsal flagging); and (d) early to middle-aged adult in whom arthrodesis, joint destructive procedures, or replacement procedures are contraindicated.¹⁶⁻¹⁸

Table 23-2. Staging of Procedures in the Management of Hallux Limitus

Karlén's Grades		
First degree	Limitus	Cheilectomy
		Regnauld osteocartilagenous graft
		Bonney-Kessel
Second degree	Rigidus	Watermann or decompression osteotomy
		Implant arthroplasty
		Resection arthroplasty
		Arthrodesis
Third degree		

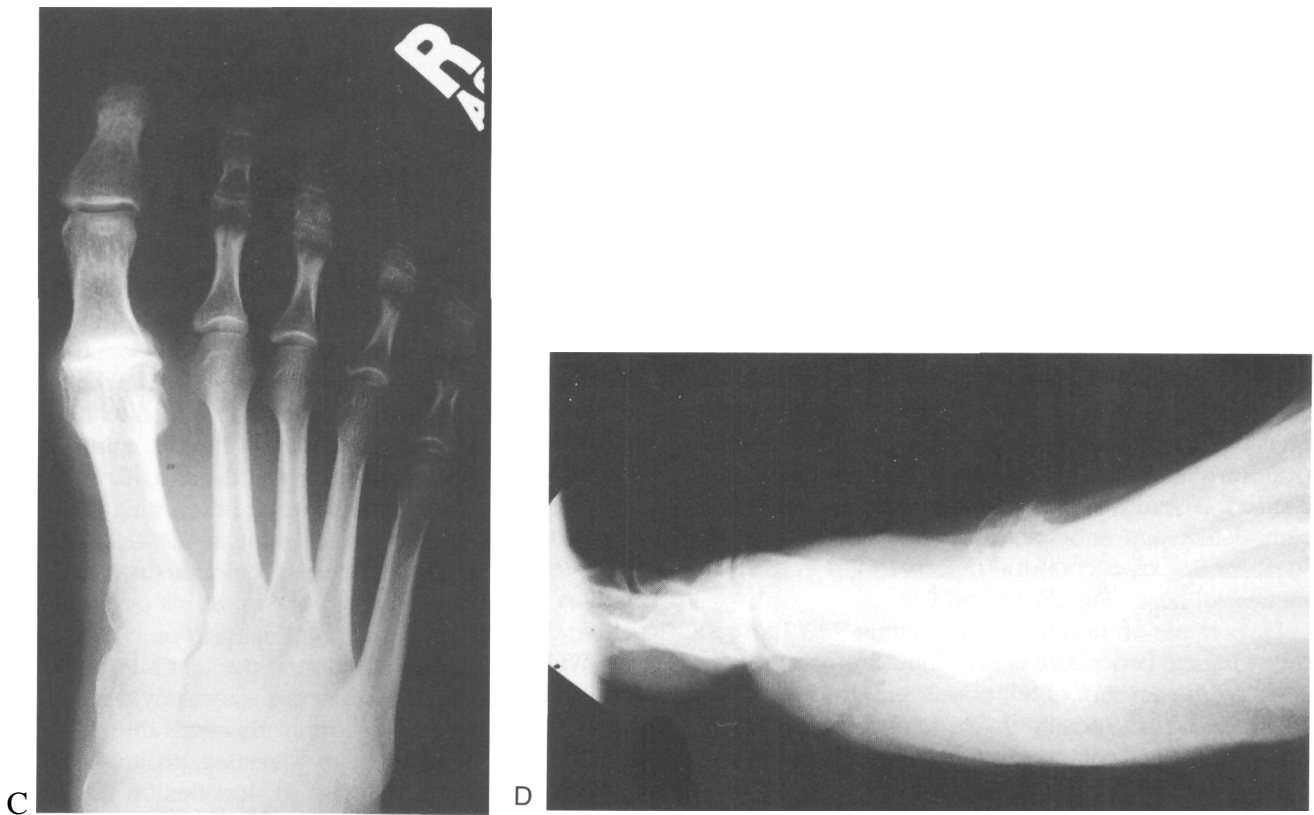
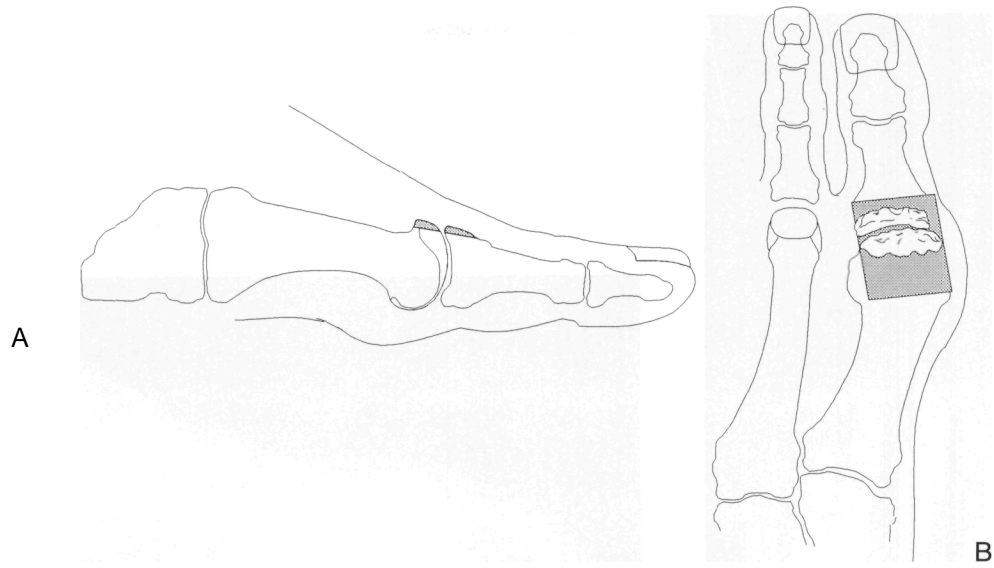


Fig. 23-8. (A & B) Diagrammatic presentation of cheilectomy surgical procedure. (C & D) Preoperative radiographs demonstrating dorsal exostosis of hallux limitus anteroposterior and lateral view. (*Figure continues.*)



Fig. 23-8 (*Continued*). (E & F) Postoperative cheilectomy anteroposterior and lateral views.

The cheilectomy procedure is sometimes termed a "clean-up arthroplasty." Remodeling of the first metatarsal head is accomplished by removal medially, laterally, and dorsally of all extra-articular bony exostoses that impede the ability of the base of the proximal phalanx to dorsiflex (Fig. 23-8A). Oftentimes a small osteocartilaginous joint mouse is present and is also excised. Dorsally, the base of the proximal phalanx is remodeled, and subchondral bone drilling may be used for any osteochondral defects found in the first metatarsal head (Fig. 23-8B and C).

Early range of motion (usually within 7 to 10 days) following the procedure is extremely important in decreasing the amount of adhesions and fibrosis, which will create a stiff postoperative joint. Early return to motion and activity is an advantage of this procedure.¹⁹ A more aggressive surgical procedure may be indicated in the future, because progressive degenerative joint disease may continue following this procedure. Pontell and Gudas²⁰ found in their 1988 study good to excellent results at 5-year follow-up occurred with

cheilectomy of the first MPJ. The range of ages of their patients was from 39 to 71 years of age.

Kessel and Bonney⁶ described in 1958 a dorsiflexory wedge osteotomy at the base of the proximal phalanx for the adolescent and early stages of hallux limitus. In these early stages of hallux limitus, minimal degenerative changes are present at the articular cartilage but pain is present as the result of jamming of the joint from the lack of dorsiflexion at the first MPJ. There should not be an associated metatarsus primus elevatus or evidence of any bony exostosis or degenerative changes around the joint margins on radiography. With limitation of motion at the first MPJ in the dorsiflexory plane of motion, the osteotomy directed at the base of the proximal phalanx aligns the hallux slightly more dorsiflexed in a resting position and achieves a "relative" increase in dorsiflexion during gait (Fig. 23-9). In this form of hallux limitus, and particularly in this age group, Kessel and Bonney reported good to excellent results utilizing their technique. A disadvantage of the procedure is that because

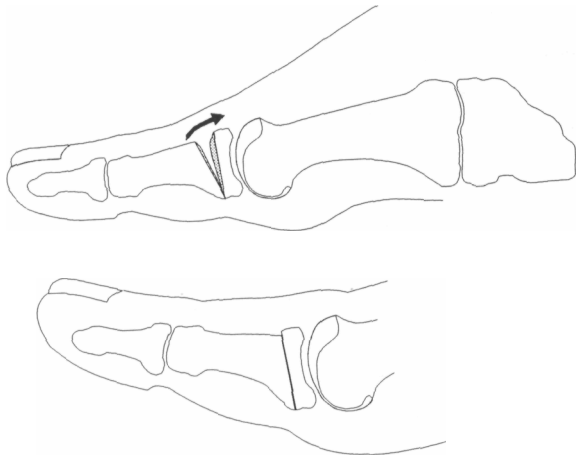


Fig. 23-9. Bonney-Kessel procedure.

an osteotomy is performed, proper bone healing, approximately 4 to 6 weeks, must take place before aggressive therapy is initiated at the first MPJ. This in itself may result in some joint stiffness after removal of the immobilization.

Another procedure indicated in the younger age group was described by Watermann (1927).¹⁹ The healthy articular cartilage of the first metatarsal bone in this condition is directed slightly plantarly. A tile-up osteotomy performed in the metaphyseal portion of the first metatarsal will direct the articular cartilage in a more dorsiflexed position, allowing for increased range of motion (Fig. 23-10). This procedure is successful when articular cartilage damage and bony degenerative changes are absent. It is contraindicated in a severe metatarsus primus elevatus deformity in that this procedure will exacerbate the elevatus and cause increased joint jamming and progression of the disorder.

A closing plantarflexory wedge osteotomy described by Lapidus (1940)²⁰ is directed at the first metatarsal cuneiform joint (Fig. 23-11). Creating increased plantar flexion of the first MPJ allows an increase in the ability of the proximal phalanx to dorsiflex on the head of the first metatarsal during the propulsive phase of gait.

An attempt to combine the advantages of a Watermann-type osteotomy at the metatarsal head and plantarflexory osteotomy at the first metatarsal base was

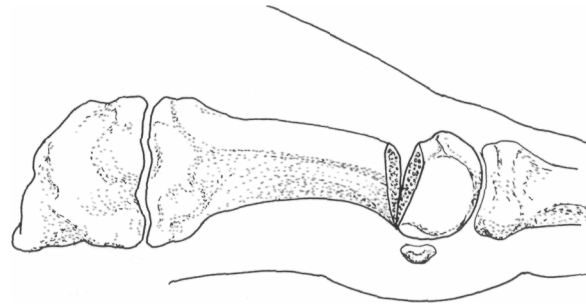


Fig. 23-10. Watermann procedure.

described by Cavolo et al.¹⁹ in 1979. A crescentic type of osteotomy is performed at the first metatarsal base with a concurrent Watermann-type osteotomy at the metatarsal head.

Further modification of this concept by Drago et al.²¹ was termed the "sagittal Logroscino." Their technique combined a Watermann-type osteotomy at the metatarsal head with an opening plantarflexory wedge osteotomy at the base of the first metatarsal bone. The procedures described provide structural correction that allow for proper functioning of the first MPJ. They are indicated in the younger, adolescent, or early adult patient in whom again no articular damage is evident as well as no periarticular joint and bone changes.

JOINT DESTRUCTIVE PROCEDURES

Joint destructive procedures are indicated in hallux rigidus where little or no dorsiflexion is present at the

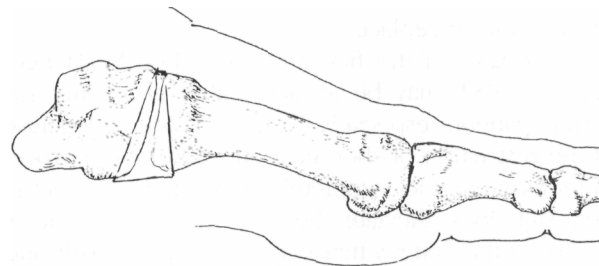


Fig. 23-11. Lapidus procedure.

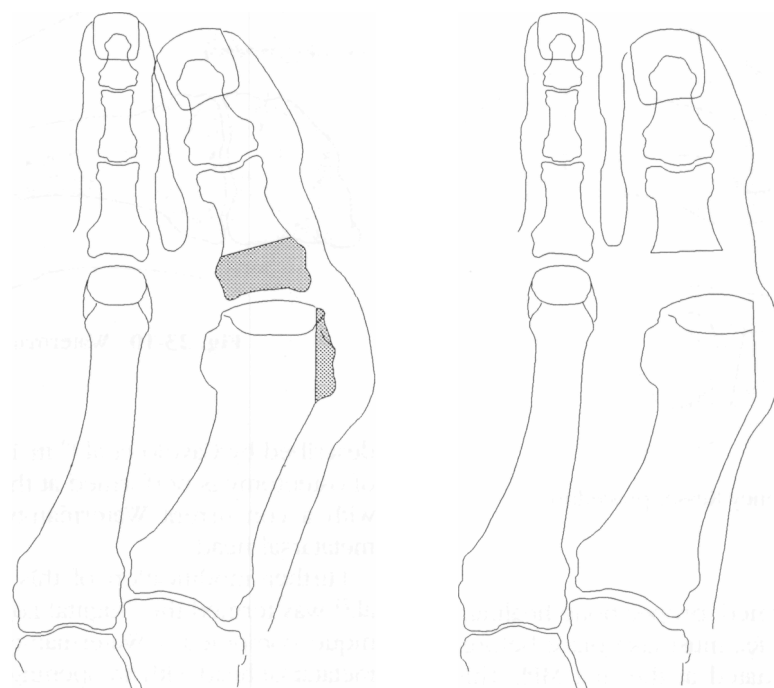


Fig. 23-12. Keller procedure.

first MPJ. These joints exhibit severe arthritic changes both radiographically and clinically.

Radiographically there is loss of joint space with squaring of the first metatarsal head and bony proliferation at the joint margins dorsally, medially, and laterally. Clinically the patient usually has such an enlargement around the first MPJ that shoe gear is extremely painful and ambulation is sometimes unbearable. With these late arthritic changes noted, there is complete absence of articular cartilage, and osteochondral defects are present. The aim of these procedures is to either arthrodesis or fuse the joint, remove a portion of the joint, or replace the joint.

Arthrodesis of the first MPJ, described by McKeever²² in 1952, may be an acceptable procedure for certain patients, especially for female patients because of the restriction of shoe gear afforded by the procedure. Its attempt to completely eliminate motion at the first MPJ does alleviate the pain, but compensatory motion at the first ray may occur more proximally and cause, over time, degenerative changes at the first metatarsal cuneiform joint or distally at the interphalangeal joint of the hallux to begin.

The joint arthroplasty described by Keller²³ in 1904 results in resection of the joint by removal of approximately one-third of the base of the proximal phalanx, resulting in an increase in the motion of the hallux relative to the lack of bony substance within the joint (Fig. 23-12). Although this is a common procedure in hallux valgus surgery, especially for the late-middle-aged to geriatric patients, complications are associated with it. These usually include loss of purchase power of the hallux and shortening of the hallux, as well as a dorsal drift of the hallux with the possibility of shoe pressure-induced lesions dorsally on the hallux. Lesser metatarsalgia is often encountered. In the middle-aged patient with severe degenerative changes and a contraindication to joint replacement arthroplasty, the Keller procedure is acceptable (see Fig. 23-12).

JOINT REPLACEMENT: IMPLANT ARTHROPLASTY

In an attempt to surgically correct severe arthritic first MPJs, Swanson et al.²⁴ in 1979 described an implant

arthroplasty utilizing a silicone-type prosthesis inserted into the proximal phalanx after removal of the base of this bone. This procedure is only indicated in patients more than 50 to 55 years of age because the life of the implant is limited and possible implant complications are associated with it.

Pontell and Gudas¹⁸ found that the use of the hinge silastic implant was a safe and efficacious procedure in patients 60 years or older with severe hallux rigidus. Their follow-up study at 5 years revealed good range of motion and return to an active lifestyle without complications.

Implant arthroplasty, joint destructive procedure, and arthrodesis of the first MPJ are discussed in greater detail in separate chapters.

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