Current Concepts Review - Hallux Rigidus and Osteoarthrosis of the First Metatarsophalangeal Joint

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Publisher Information
The Journal of Bone and Joint Surgery
20 Pickering Street, Needham, MA 02492-3157
www.jbjs.org
Hallux rigidus is characterized by restriction of motion at the first metatarsophalangeal joint. It is a common disorder that has been reported to affect one in forty-five individuals who are more than fifty years of age. There is a generalized decrease in motion with particular limitation of dorsiflexion. Hallux rigidus is often associated with a mechanical block to dorsiflexion caused by periartricular osteophytes with an impingement exostosis of the first metatarsal head against an osteophyte at the base of the proximal phalanx. The natural course of this disorder is typical of degenerative processes, with progression of the osteoarthrotic changes leading to limitation of motion and interference with function of the metatarsophalangeal joint.

Other terms that have been used to describe this clinical entity include hallux limitus, dorsal bunion, and localized arthrosis. When there is a large dorsal osteophyte, the great toe is in a position of flexion, which has led to use of the term hallux flexus. As the position of the great toe becomes even more plantar, the metatarsal becomes elevated, which has led to use of the term metatarsus elevatus.

Pathophysiology

Hallux rigidus has been attributed to various causes, including trauma, metabolic disorders, and congenital disorders. These disease processes result in degenerative changes within the joint, including loss of articular cartilage, narrowing of the joint space, and formation of periartricular osteophytes. Most of these alterations are localized to the dorsal aspect of the joint, leading to formation of the characteristic dorsal exostosis. Intraoperative findings have revealed that this periartricular osseous excrescence actually extends medially, dorsally, and laterally to form a horseshoe-shaped collar of bone in this region. In many patients, a concomitant osteophyte forms on the medial, dorsal, and lateral surfaces of the base of the proximal phalanx. These two osseous protuberances mechanically block motion and lead to early jamming of the joint during the arc of motion. Some patients are seen initially because of an acute exacerbation of chronic pain in this region; this may be due to a fracture of a portion of the metatarsal or phalangeal osteophyte that leads to a loose fragment of bone within the joint.

Kinematic analysis of the first metatarsophalangeal joint in patients who have hallux rigidus reveals a decrease in the total arc of motion, with relatively normal plantar plantar pressures of the first ray. Motion analysis reveals instant centers of rotation that are displaced and located eccentrically about the metatarsal head.

 Patients who have symptomatic hallux rigidus have been found to have higher-than-normal dynamic plantar pressures of the first ray. Dynamic plantar pressures also have been analyzed as a function of loading of the first ray before and after operations for the treatment of this condition, including resection arthroplasty, implant arthroplasty, and cheilectomy. Decreased plantar pressures of the first ray have been reported after resection arthroplasty and implant arthroplasty.

The minimum physiological dorsiflexion of the first metatarsophalangeal joint that is necessary for a normal gait is unknown; however, the values that have been reported in the literature have ranged from 15 to approximately 90 degrees.

Etiology

Clinical evaluation of patients who have hallux rigidus has revealed multiple causative factors. The condition may be a manifestation of a generalized systemic osteoarthrosis. Traumatic events, such as stubbing injuries to the great toe, may cause damage of the articular cartilage, resulting in hallux rigidus. Juvenile hallux rigidus may be associated with osteochondritic lesions of the first metatarsophalangeal joint. Bingold and Collins reported no pathological differences between the juvenile and adult forms of hallux rigidus and suggested that the variations are only stages in the progression of the disease. Other congenital variations, such as a long first ray, an irregular ball and socket
of the metatarsophalangeal joint, a long and narrow foot, a pronated foot, and an abnormal gait, all have been implicated as causes of hallux rigidus. Poor footwear and obesity have been suggested as acquired causes of this disorder.

Inflammatory disorders such as rheumatoid and seronegative arthritis may be associated with synovitis in the first metatarsophalangeal joint. Later manifestations include degeneration of the articular surface. Metabolic disorders such as gout may mimic hallux rigidus but also may lead to typical degenerative patterns consistent with this disease. Regardless of the underlying pathological disorder, articular degeneration occurs as the disorder progresses. In its late stage, the disorder is characterized by diffuse osteoarthrotic change with loss of cartilage and narrowing of the joint space.

Clinical Manifestations

History
Patients may describe limitation of motion of the first metatarsophalangeal joint, with particular restriction of dorsiflexion. They often will note localized pain in the metatarsophalangeal joint, which is especially severe during terminal heel-rise just before toe-off. The pain increases with weight-bearing and walking and decreases with rest, and it often is associated with localized swelling and a limp. Some patients initially have symptoms related to mechanical impingement of the dorsal exostosis against the toe-box of the shoe. In this situation, localized swelling and erythema of the skin overlying the osseous prominence may be observed. Occasionally, patients report burning pain or paresthesia of the great toe caused by traction or compression of the dorsal digital nerve as it passes over the osseous prominence. Symptomatic hallux rigidus occurs in two age-groups, adolescents and the elderly, but it is more common in the latter population. The average age of onset ranges from twelve to fifty-seven years. Women and girls are affected twice as commonly as men and boys. The condition often is bilateral.

Clinical Findings

Physical examination usually reveals a prominent dorsal exostosis and erythema of the skin overlying the osseous prominence. Tenderness generally is present at the metatarsophalangeal joint line. The dorsal osseous ridge is palpable and also may be tender. The first web space at the lateral portion of the prominent exostosis may be tender as well.

Motion, particularly dorsiflexion, is limited on examination (Fig. 1). Pain may be present throughout the arc of motion, especially at the extreme of dorsiflexion. Plantar flexion may also be painful, because of traction of the extensor hallucis longus tendon over the dorsal exostosis. Occasionally, a positive Tinel sign is elicited as the dorsal digital nerve courses over the medial aspect of the exostosis.

Evaluation of gait reveals a characteristic limp. Patients tend to shift their weight laterally or to rotate externally at the hip in order to clear the foot from the floor, and often toe-off occurs on the lesser metatarsal heads.

Radiographic Findings

Anteroposterior, lateral, and oblique radiographs of the foot should be made with the patient standing. Coned-down radiographs of the region of the first metatarsophalangeal joint also may be helpful. The lateral radiographs usually are the most revealing (Fig. 2). Often, they demonstrate an osteophyte at the base of the proximal phalanx and the corresponding metatarsal head. Fracture of a portion of the exostosis may result in the appearance of a loose body in the joint. Narrowing of the joint space and osteophytic changes involving primarily the dorsal aspect of the joint also are seen. The plantar surface may be intact. Patients who have had symptoms for several years or more may have more diffuse changes as the articular degeneration extends to involve the plantar aspect of the joint.

Hattrup and Johnson classified the radiographic findings of hallux rigidus according to three grades. Grade I is characterized by mild-to-moderate formation...
of osteophytes with preservation of the joint space; grade II, by moderate formation of osteophytes, narrowing of the joint space, and subchondral sclerosis; and grade III, by marked formation of osteophytes and loss of the joint space with or without subchondral cysts. These radiographic changes have been shown to be factors in the choice of operative treatment and to be associated with patient outcome.

The anteroposterior radiographs may show diffuse narrowing of the joint space. The horseshoe-shaped collar of bone that is present medially, dorsally, and laterally may overhang the articulation, giving the impression that the joint is more diffusely damaged than it actually is (Figs. 3-A and 3-B). The oblique radiographs may help the physician to identify the site and extent of the exostosis.

Computerized tomographic scans or lateral tomosgrams of the joint may help the physician to determine whether the degenerative changes have extended to the plantar surface of the joint; however, use of these modalities is rarely necessary.

Non-Operative Treatment

Initial treatment typically includes the use of non-steroidal anti-inflammatory medications, which may alleviate the synovitis of the joint or the other inflammatory components of the disease. Modification of activities — from those producing high-impact loading of the foot, such as running, to those that are low-impact, such as bicycling and swimming — also is recommended. The use of a shoe with a high toe-box and a soft rubber sole helps to avoid irritation of the dorsal aspect of the toe and to decrease impact loading of the foot during the stance phase of gait. The addition of an extended inflexible steel or fiberglass shank between the inner and outer soles of the shoe leads to decreased motion of the joint. The addition of a rocker to the outer sole of the shoe allows the shoe to propel the body forward during push-off. A iteratively, a prefabricated or custom insole made of carbon-reinforced material and designed to serve as an extension (a Morton extension) under the medial rays may decrease the motion of the first metatarsophalangeal joint and may be moved from shoe to shoe. To our knowledge, there have been no prospective studies assessing the efficacy of these non-operative treatment options.

Operative Treatment

If non-operative measures fail to provide relief, operative intervention may be considered.

Cheilectomy

A cheilectomy may be helpful in the early stages of hallux rigidus while the pathological changes are confined to the dorsal aspect of the joint. This operative procedure is essentially a débridement of the joint. Loose bodies are removed, and a synovectomy is performed. The dorsal exostosis is excised along with the degenerated portion of the articular surface at the dorsal aspect of the joint. The concomitant osteophyte at the base of the proximal phalanx is resected, providing osseous decompression of that area.

This operation should be limited to active patients who have restriction of dorsiflexion and localized pain dorsally, primarily during the toe-off phase of gait. Physical examination of these patients reveals a prominent exostosis at the dorsal aspect of the metatarsal head as well as tenderness at the articulation. Radiographs reveal that most of the changes are localized to the dorsal aspect of the joint. Mechanical impingement of the dorsal exostosis against the toe-box of the shoe is another indication for this procedure.

Once the osteoarthrotic process has progressed to involve the joint more diffusely, an arthrodesis or a Keller resection arthroplasty may be more effective. In this situation, younger, more active patients are appropriately managed with an arthrodesis. Patients who place low demands on the foot and have a limited level of activity may be better served by a resection arthroplasty.

It should be noted that gout should be considered in the differential diagnosis of hallux rigidus. If hyperuricemia is present, non-operative treatment, appropriate medications, and modifications of shoe-wear may alleviate the problem.

The senior one of us (M. J. S.) prefers to use a dorsal longitudinal incision centered over the metatarsophalangeal joint. The exostosis is excised along with the damaged dorsal one-quarter to one-third of the metatarsal head. The concomitant osteophyte at the base of the proximal phalanx is resected. The goal of osseous decompression is to achieve 60 to 80 degrees of dorsiflexion of the joint.

After the operation, the patient uses crutches with—
out weight-bearing on the involved foot or with heel-walking if both feet were operated on. This regimen is maintained for two weeks in order to decrease swelling and promote wound-healing. The sutures then are removed, and slow, progressive range-of-motion exercises are initiated. The patient is instructed to wear a soft, flexible, rubber-sole shoe while walking. This helps to maintain the motion of the joint that was achieved operatively.

Inadequate removal of bone may prevent dorsiflexion of the joint, whereas excessive removal may lead to instability of the articulation with dorsal subluxation of the proximal phalanx. Excessive stripping of the capsule and release of the volar plate may lead to a postoperative hallux valgus deformity.

The dorsal exostosis may recur postoperatively. Additional articular degeneration may lead to recurrent symptoms. There may be loss of motion secondary to periarticular scarring especially if postoperative exercises are inadequately performed.

Review of the Literature

There is controversy concerning the effectiveness of cheilectomy for the treatment of hallux rigidus. All of the published studies, to our knowledge, have been retrospective and have lacked a control group of patients who were managed non-operatively or with another type of operation. Because of a lack of standardized procedural techniques, comparison between studies is difficult.

To our knowledge, the largest study of the results of cheilectomy included fifty-eight patients. The operative technique was the same as that described earlier in this paper. The results were determined with use of a patient-satisfaction questionnaire that was administered by telephone. Motion of the first metatarsophalangeal joint was not assessed at the time of follow-up. Forty-two patients (72 per cent) were satisfied with the result at an average of 37.7 months postoperatively. Three patients had a complication: two had subluxation of the first metatarsophalangeal joint caused by excessive resection of the head of the first metatarsal, and one had a superficial wound infection that was treated uneventfully with antibiotics.

The next-largest study, which was retrospective and included twenty-five patients, was reported by Mann and Clanton. The operative procedure, which was described in detail, included resection of 25 to 33 per cent of the articular surface of the metatarsal head (as described by others) in addition to resection of osteophytes on the metatarsal head dorsally, medially, and laterally. Dorsiflexion of the first metatarsophalangeal joint improved an average of 31.2 degrees. At an average of fifty-six months postoperatively, the subjective results were assessed on the basis of whether the patient had pain and was satisfied with the result of the operation. Twenty-two patients (88 per cent) were satisfied and had at least partial relief of pain. Seven patients had a complication: six had persistent swelling at the first metatarsophalangeal joint lasting from six weeks to one year, and one had recurrence of a dorsal osteophyte. No patient had subluxation of the joint. In an earlier report, one of the same authors and colleagues reported on twenty patients who had been managed with a cheilectomy and had been followed for a longer average dura-
tion (67.6 months). Whether this retrospective series included patients who were reported on in the subsequent paper is unclear. Seventeen patients (85 per cent) were satisfied with the result of the operation. There were two complications: a postoperative hallux valgus deformity in one patient and recurrence of a dorsal osteophyte in another.

Keogh et al. used an operative technique similar to that of Hattrup and Johnson and reported that eighteen (90 per cent) of twenty patients were satisfied with the result in terms of function and resolution of pain34. The duration of follow-up ranged from six to thirty-one months (average, eighteen months). There were no operative or postoperative complications.

Arthrodesis of the First Metatarsophalangeal Joint

For patients who have diffuse osteoarthrosis of the first metatarsophalangeal joint, arthrodesis is a reasonable alternative after non-operative measures, such as use of an inflexible rocker sole or an orthosis as well as anti-inflammatory medications, have failed. This procedure eliminates the painful motion of the joint that typically is associated with intra-articular osteoarthrosis. The osteoarthrosis may be a localized manifestation of a systemic process and may be associated with severe hallux rigidus that has progressed to involve the entire joint. Patients report limitation of motion and pain during terminal heel-rise just before toe-off. Physical examination reveals tenderness at the joint line dorsally, at the metatarsosesamoid articulation, and throughout the arc of motion.

Arthrodesis is indicated for patients who have degenerative osteoarthrosis or inflammatory arthropathy associated with diffuse involvement of the joint. Patients who have a metabolic disorder such as gout with secondary degenerative changes may be candidates for this operation. A arthrodesis is best reserved for patients who have an active lifestyle and engage in regular walking and other weight-bearing activities.

Elderly individuals who have a less active lifestyle may be better served by non-operative management or a resection arthroplasty of the joint. Patients who have a general medical condition that precludes operative intervention and those who have neurological or vascular dysfunction of the distal part of the extremity are not appropriate candidates for this procedure.

Multiple techniques have been described for arthrodesis of the first metatarsophalangeal joint. These have included use of convex and concave reamers or flat cuts of the proximal phalanx and the metatarsal head to prepare the bone surfaces. The site of the arthrodesis may be stabilized with use of threaded Steinmann pins, Kirschner wires, multiple screws, or a plate and screws (Figs. 4-A and 4-B).

The senior one of us prefers the M cKeever-type arthrodesis35. The metatarsal head is prepared with use of a concave power reamer, and the proximal phalanx is prepared with use of a convex reamer. The cut surfaces are positioned so that the great toe lies in 15 to 20 degrees of valgus and 15 to 25 degrees of dorsiflexion in relation to the shaft of the first metatarsal. The position of the arthrodesis is adjusted according to the alignment of the foot (supinated or pronated) of each patient, to allow the great toe to lie alongside the second toe without impingement. Simulated weight-bearing with use of
a flat plate intraoperatively helps the surgeon to assess the appropriate position of the arthrodesis. The site of the arthrodesis is stabilized by means of an interfragmentary compression screw inserted from the planar medial aspect of the base of the proximal phalanx into the lateral aspect of the metatarsal neck.

A sterile dressing and a below-the-knee cast are applied. The patient is instructed to use crutches without weight-bearing for six weeks or until radiographs reveal osseous union. The decision as to when to allow weight-bearing is based on the postoperative immobilization and the stability of the site of the arthrodesis as determined intraoperatively. Weight-bearing before six weeks is permitted at the surgeon’s discretion.

Excessive dorsiflexion at the site of the arthrodesis may lead to impingement of the interphalangeal joint and the distal phalanx against the toe-box of the shoe. Patients who have more than 10 degrees of medial deviation at the great toe emanating from the interphalangeal joint may need less than 15 to 20 degrees of valgus deviation to avoid mechanical impingement on the second toe. Kirschner wires may be used for supplementary fixation to ensure rotatory stability of the proximal phalanx in relation to the first metatarsal. Inadequate positioning of the great toe in valgus or dorsiflexion may lead to difficulties during the toe-off phase of gait or to osteoarthrosis of the interphalangeal joint.

Non-union or delayed union of the site of the arthrodesis may occur. Clawing of the interphalangeal joint may be associated with excessive dorsiflexion of the great toe. There is usually some restriction with regard to the type of shoes that can be worn because the patient is limited to a specific heel height depending on the extent of dorsiflexion at the site of the arthrodesis. A gentle rocker-sole shoe may improve stride length and gait postoperatively.

Review of the Literature

There have been few reports of the results after arthrodesis of the first metatarsophalangeal joint for the treatment of isolated hallux rigidus, and most of these studies have also included patients with hallux valgus. Although these reports are helpful because they provide an indication of the satisfaction of the patient, their usefulness is limited because of the multiple operative techniques that have been used, the subjectiveness of the criteria for reporting results, and the lack of statistical analyses.

Fitzgerald reported improvement after arthrodesis in forty-eight (98 per cent) of forty-nine patients who had hallux rigidus compared with forty-three (84 per cent) of forty-eight (98 per cent) of forty-nine patients who had hallux rigidus. Shin hypothesized that lateral shoe pressure at the interphalangeal joint was an important mechanism leading to hallux valgus.

Although these reports are helpful because they provide an indication of the satisfaction of the patient, their usefulness is limited because of the multiple operative techniques that have been used, the subjectiveness of the criteria for reporting results, and the lack of statistical analyses.

Fitzgerald reported improvement after arthrodesis in forty-eight (98 per cent) of forty-nine patients who had hallux rigidus compared with forty-three (84 per cent) of fifty-one who had hallux valgus; after a minimum duration of follow-up of ten years. The complications in this combined population of patients included malunion, due to technical error, in the transverse (rotational), sagittal (dorsiflexion-planter flexion), and frontal (varus-valgus) planes. Malalignment occurred in sixteen of the 100 patients; non-union, in three; and a stress fracture of the first metatarsal, in two. (The stress fracture was thought to be due to use of a sliding bone-graft technique that is no longer employed.) Pain necessitated removal of the hardware from three patients.

Moynihan reported the results of arthrodesis of the first metatarsophalangeal joint in 108 patients — ninety-four who had hallux valgus and fourteen who had hallux rigidus — at a minimum of five years postoperatively. The results were compared with those in a similar group of patients who had had a Keller resection procedure.

The overall rate of success was 86 per cent; all fourteen patients who had hallux rigidus were satisfied with the result compared with seventy of the ninety-four who had hallux valgus (sixty-eight of whom were satisfied and eleven of whom were satisfied but had reservations). The complications in this combined population included a painful fixation screw that had to be removed in sixteen patients and fibrous ankylosis in twenty-one. Only seven of the feet that had fibrous ankylosis were symptomatic, and three needed a reoperation (a Keller arthroplasty).
months). In the group that had an arthrodesis, all but one patient was completely satisfied with the result or had postoperative improvement. Twenty-two feet had a non-union, but only four were symptomatic. This high rate of non-union was thought to be due to the biomechanically inferior wire-loop technique of fixation, which is no longer used. Six feet had a repeat arthrodesis, including the four that had a painful non-union, one that had a malunion, and one that had a fracture. Metatarsalgia developed postoperatively in one foot, and five feet that had had metatarsalgia preoperatively had improvement after the arthrodesis.

Harrison and Harvey retrospectively reviewed the results after arthrodesis of the first metatarsophalangeal joint in sixty-six patients (seventy-two feet). The duration of follow-up ranged from less than one year to twelve years (the average was not given). Sixty-two feet had complete relief of pain. Of the ten feet with continued pain, four had mildly symptomatic fibrous ankylosis that did not need additional treatment, two had a second arthrodesis because of fibrous ankylosis with severe pain, two had symptomatic osteoarthrosis of the interphalangeal joint that was left untreated, and one had a modification of the shoe with use of an insert because of a malunion. The cause of the pain in the tenth foot was unknown.

The common theme throughout these studies appears to be the relief of pain and the potential for non-union, malunion, metatarsalgia, and osteoarthrosis of the interphalangeal joint after arthrodesis. However, as stated previously, the usefulness of the literature on arthrodesis of the first metatarsophalangeal joint is limited.

Keller Resection Arthroplasty

Keller resection arthroplasty is intended to correct severe hallux rigidus or hallux valgus associated with osteoarthrosis at the first metatarsophalangeal joint. In this operation, the proximal one-third of the proximal phalanx along with the prominent medial eminence of the first metatarsal head are excised through a dorsomedial longitudinal incision. The procedure generally is limited to older patients who have a less active lifestyle, because it may decrease the power of the great toe and result in transfer metatarsalgia (transfer of weight-bearing pressure to the lesser metatarsal heads). The senior one of us performs resection arthroplasty as described by Keller.

The operation is indicated for the treatment of severe hallux rigidus with diffuse involvement of the metatarsophalangeal articulation. At the time of presentation, patients usually have pain with motion, tenderness at the joint line, and radiographic evidence of diffuse degeneration of the articular surfaces.

Patients who are younger than sixty years of age or who have a lifestyle that involves rigorous walking may be better served by an arthrodesis. Patients who have metatarsalgia and intractable plantar keratoses under the metatarsal heads also are not candidates for a Keller

![Fig. 5-A](image1) ![Fig. 5-B](image2)
A contraindication to the operation. Inadequate peripheral neurologic- 
al or vascular status of the distal aspect of the extrem- 
ity is a contraindication to the operation.

A sterile compressive dressing and an adhesive-tape 
strapping are applied to hold the great toe in a neutral 
position. The patient is permitted to heel-walk while 
using a rigid-soled shoe. The dressing and the correc-
tive strapping are changed every one to two weeks for 
a total of six weeks.

The removal of excessive bone from the base of the 
proximal phalanx may lead to severe shortening of the 
great toe. Inadvertent transection of the flexor hallucis 
longus tendon may lead to a cock-up deformity of the 
toe.

Shortening of the great toe is expected. Decreased 
power of the great toe is also commonly associated 
with this procedure. Transfer metatarsalgia may occur 
because of a shift in weight-bearing from the great toe 
to the lateral side of the foot.

Review of the Literature

The etiology of the disorder appears to play an 
important role in the patient's satisfaction after the 
Keller procedure. Patients who have hallux rigidus 
have fewer postoperative complications and better re-

cults than patients who have hallux valgus. This may 
be the case because patients with hallux rigidus have 
less motion of the toe after the resection, resulting 
in better stability and allowing more weight-bearing 
and push-off power during gait. Wrighton found that 
five of fourteen patients who had had isolated hal-

lax rigidus with joint pain as the presenting symptom 
still had some pain ten years after a Keller resection ar-
throplasty; however, no patient was dissatisfied with the 
result. A thorough basic purpose of the Keller pro-
cedure is to improve motion and to decrease contact 
between and irritation of the joint surfaces. Wrighton 
noted little motion of the metatarsophalangeal joint 
at the time of the reexamination. Nine of the four-
teen patients had no plantar flexion, and eleven had 1 
1 to 14 degrees of dorsiflexion. Five patients had had 
preoperative metatarsalgia, and it persisted postopera-
tively in two of them. A n additional patient had meta-
tarsalgia postoperatively. None of these patients had 
symptoms severe enough to warrant additional treat-
ment. Zadik stated that severe hallux valgus should be 
a contraindication to the Keller procedure. Humbert 
et al. reported that metatarsus primus varus is not cor-
rected by the Keller procedure and that this operation 
should not be used to treat it.

Use of a modified Keller procedure with capsular 
interposition has been suggested by several authors. 
The instability created by the Keller procedure is due 
to the loss of bone and soft-tissue restraints for the 
great toe; these include the plantar fascial attachments to 
the base of the proximal phalanx, the loss of which results 
in impairment of the windlass mechanism. The loss of 
the stability provided by the collateral ligaments and the 
capsular attachments without the aid of the bone artic- 
ulation may allow varus or valgus deviation of the great 
toe. The extensor hallucis brevis and flexor hallucis 
brevis tendons (the intrinsic dynamic stabilizers of the 
great toe) also are weakened or released during this 
procedure, leading to muscular imbalance and poten-
tially resulting in cock-up or claw-toe deformity and in 
impaired function and shortening of the great toe.

Hamilton et al. reported the results of an interposi-
tion arthroplasty technique used to modify the Keller 
procedure and to improve the stability of the great toe 
in twenty-three patients. The extensor hallucis brevis ten-
don was tenotomized in the proximal portion of the 
wound, allowing the dorsal aspect of the metatarsopha-
langeal joint capsule to be brought into the space where 
the arthroplasty was performed. This capsular slide then 
was sutured to the stump of the flexor hallucis brevis 
tendon on the plantar surface of the first metatarsal, 
resulting in stabilization of the soft-tissue envelope 
around the first metatarsal and preventing bone irrita-
tion due to shortening and contact of the proximal pha-
lax with the first metatarsal head. At one average of 
more than one year, twenty-two of the twenty-three feet 
had a good or excellent result in terms of function and 
stability of the toe and satisfaction of the patient.

In summary, the Keller procedure is successful in 
selected patients. Factors that may adversely affect the 
outcome include a congenitally short first ray, a long 
second ray, preoperative metatarsalgia, severe hallux 
valgus, and metatarsus primus varus. The literature sug-
gests that patients with hallux rigidus have higher rates 
of satisfaction and lower rates of postoperative compli-
cations than do patients with hallux valgus. Meticulous 
attention to operative detail is necessary to avoid over-
resection of the bone. The interposition of capsular tis-
sue may improve the result. Future studies of capsular 
interposition procedures should include the use of vali-
dated statistical methods and should be based on larger 
numbers of patients.

Other Operative Procedures

A dditional procedures that have been suggested for the 
treatment of hallux rigidus include osteotomy and 
joint-replacement arthroplasty.

A dorsal closing-wedge osteotomy of the prox-
imal phalanx apparently was first described in 1952 by 
Bonney and Macnab, and the short-term results were 
reported subsequently by Kessel and Bonney. This pro-
cedure involves sacrifice of unnecessary flexion of the 
first metatarsophalangeal joint and placement of the 
toe in a functional angle of dorsiflexion. The criteria for 
the selection of patients include minimum dorsiflexion of 
the first metatarsophalangeal joint, normal plantar 
flexion, and no deterioration of the joint or osteophytes. 
Although the procedure initially was recommended for 
young patients (those eighteen years of age or less).
Moberg extended the indications to include adults\textsuperscript{47}. The longest follow-up, to our knowledge, was reported by Citron and Neil in a retrospective series of eight women (ten great toes) whose ages ranged from ten to fifty-two years\textsuperscript{5}. All eight patients had complete relief of pain initially after the procedure, and five remained pain-free at the time of the latest follow-up at an average of twenty-two years (range, eleven to twenty-nine years). Complications included (in one patient each) a malunion leading to rotation at the site of the osteotomy and painful callosities; osteoarthritis of the interphalangeal joint due to compensatory plantar flexion, necessitating arthrodesis; and a painful non-union, which was treated with an arthrodesis of the first metatarsophalangeal joint. Two other patients had mild symptoms but did not need additional operative intervention. Nine of the ten toes had radiographic evidence of progressive degenerative changes that were not considered to be clinically important.

Kessel and Bonney reported good results in a short-term follow-up study of nine patients (ten feet)\textsuperscript{48}. Moberg stated that his report of good initial results “cannot be accepted as a recommendation, only as a stimulus for further testing.”\textsuperscript{47}

The use of a similar dorsally based closing-wedge osteotomy of the distal metaphysis of the first metatarsal (a Watermann osteotomy) has been reported primarily in the podiatric literature\textsuperscript{49}. Because these studies were small and retrospective and did not include statistical analyses, additional investigations are needed to confirm the efficacy of this procedure.

In a recent study of cadavera, the range of motion, stability, and decompression of the first metatarsophalangeal joint were assessed after a cheilectomy involving removal of 25, 33, or 50 per cent of the articular surface; a Keller resection arthroplasty; or a Watermann osteotomy\textsuperscript{50}. Improved dorsiflexion was reported after all procedures. Instability of the first metatarsophalangeal joint, measured as subluxation, was absent only after the Watermann osteotomies. Decompression of the joint, measured as distraction, was present after both the Watermann osteotomies and the Keller resection arthroplasties. These findings support the use of osteotomy to increase motion, preserve function of the joint, and unload the first metatarsophalangeal joint. The osteotomy procedure as originally described involved a trapezoidal resection of bone, based dorsally\textsuperscript{51}. This procedure may be technically difficult. In addition, the exostosis is excised medially, laterally, and dorsally, causing stripping of the blood supply to the fragment of the metatarsal head. This is known to increase the risk of avascular necrosis of the capital fragment\textsuperscript{52,53}.

Replacement arthroplasty of the first metatarsophalangeal joint has continued to evolve over the past thirty years\textsuperscript{54,55,56,57,58,59,60,61,62,63,64,65,66,67}. The advantages of the procedure include preservation of motion and excellent relief of pain. The disadvantages include material failure of the implant, leading to silicone-induced synovitis and osteolysis\textsuperscript{68,69,70,71,72,73,74,75}. There also is loss of the strength and the weight-bearing function of the great toe as a result of shortening and subluxation\textsuperscript{76,77}.

The results of joint-replacement arthroplasty are quite variable because of the many factors involved, including the type of implant, the patient population, the age and functional abilities of the patient, the duration of follow-up, and the presence of associated deformities of the foot (Table I). Because of the high biomechanical demands placed on the first metatarsophalangeal joint and the complex interactions between the joints of the foot, routine use of joint-replacement arthroplasty cannot be recommended until good and excellent results have been achieved consistently over time.

### Overview

Hallux rigidus represents articular degeneration of the first metatarsophalangeal joint primarily affecting the dorsal aspect of that articulation. Once articular degeneration has progressed to involve the joint more diffusely, the options for treatment change. Non-operative treatment, including modifications of shoe-wear, use of a shoe insert, and use of anti-inflammatory medication, should be discussed in detail with the patient. If non-operative measures fail, operative intervention may be indicated. Cheilectomy, which essentially consists of a débridement arthroplasty of the joint, may be appropriate. Once more extensive involvement has occurred, arthrodesis is preferred for younger patients whereas resection arthroplasty may be more appropriate for elderly patients who have a less active lifestyle. With use of these guidelines, orthopaedic surgeons should be able to provide optimum care to patients who have these common acquired disorders of the forefoot.
References


