Hallux Rigidus: Etiology, Biomechanics, and Nonoperative Treatment

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KEYWORDS

• Osteoarthritis • Rigidus • Hallux • Limitus
• Inherited • Bilateral

ETIOLOGY AND BIOMECHANICS

The term "hallux rigidus" describes a painful malady of the great toe metatarsophalangeal (MTP) joint characterized primarily by loss of dorsiflexion and progressive osteophyte formation about the MTP joint. Initially the condition was reported in 1887 by Davies-Colley,[1] who described a plantar-flexed position of the proximal phalanx relative to the metatarsal head and proposed "hallux flexus." Cotterill[2] reported on the same condition a few months later, however, and suggested the diagnosis of hallux rigidus. The commonly used terms "hallux rigidus" and "hallux limitus" are used to describe degrees of the same problem. DuVries[3] and Moberg[4] noted that other than hallux valgus, hallux rigidus is the most common problem of the first MTP joint.

The literature shows a higher incidence of female involvement.[5–10] Coughlin[7] reported that approximately 80% of patients with bilateral hallux rigidus had a history in their family of great toe arthritis or "bunions." Long-term follow-up of the same patients with hallux rigidus showed that more than 80% developed bilateral disease. Although numerous contributory factors have been hypothesized, there has been no proven association or correlation with first ray mobility, metatarsal length, Achilles or gastrocnemius contracture, planovalgus or cavus foot posture, hallux valgus, adolescent onset, type of shoe wear, occupation, or metatarsus primus elevatus.[7,11]

Trauma is the most common cause reported in the literature and may occur as a single, isolated injury (eg, fracture) or possibly the result of chronic repetitive microtrauma.[12] A traumatic episode is the most likely cause of unilateral hallux rigidus.[7] An injury that results in forced hyperextension[12] or plantar flexion (PF)[13]

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may create compressive and shear forces that result in chondral or osteochondral injury. The resultant joint damage leads to progressive arthritic changes over time. A severe sprain or ''turf toe'' injury also may develop into arthritis. Younger, active patients with hallux rigidus may present after a sprain or jamming episode with an osteochondral defect of the MTP joint, but the diagnosis can be difficult, and oblique radiographs and MRI may be helpful.[14–18]

Other factors associated with hallux rigidus in the literature include a flat or chevron-shaped joint, metatarsus adductus, hallux valgus interphalangeus, bilaterality in persons with a positive family history, trauma in unilateral cases, and female gender.[6,7,19] The notion that instability of the first ray may predispose to hallux valgus is the corollary to the notion that a flat or chevron-shaped joint can lead to hallux rigidus. Such a constrained joint (congenital or acquired) may result more easily in jamming episodes and the resultant degenerative changes. Metatarsus adductus may be another underlying factor that creates abnormal stress on the MTP joint, but more research is needed regarding these potential causes to determine the mechanism.

Metatarsus primus elevatus (**Fig. 1**) is classically described as a fixed dorsal elevation of the first metatarsal in relation to the lesser metatarsals. For example, fixed elevation may occur iatrogenically after a first metatarsal osteotomy or may be caused by fracture malunion. Flexible elevation has been associated with posterior tibial

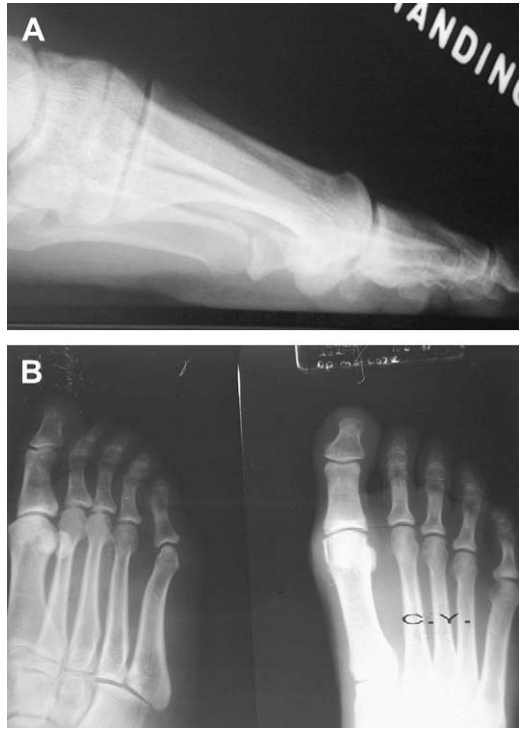

Fig. 1. Grade 1 hallux rigidus. (*A*) The lateral radiograph shows elevation of the first ray (elevatus) and often is the key finding in early grades to suggest hallux rigidus. (*B*) The metatarsal head is enlarged and the dorsal surface is prominent. Loose bodies and sesamoid irregularity are not obvious but may occur with any grade.

tendon deficiency, peroneal weakness, spastic conditions, and even paralysis. Recent studies evaluated metatarsus primus elevatus in patients with hallux rigidus.[7,11,19] Based on these studies, metatarsus primus elevatus was a secondary condition that correlated well with arthritic progression, severity of arthritis, and loss of MTP joint range of motion. Metatarsus primus elevatus was nearly eliminated after hallux rigidus repair, interposition arthroplasty, and arthrodesis. Meyer and colleagues[20] found no statistical correlation between hallux rigidus and first metatarsal elevation. They reported that up to 5 mm of elevation was considered normal. Horton and Myerson[21] confirmed Meyer's study and documented no association with hallux rigidus. The author believes that metatarsus primus elevatus is more useful as a diagnostic aid to help diagnose early or subtle cases of hallux rigidus and has noted decreased elevation after selective MTP joint injections and improvement of first ray weight bearing on dynamic gait studies. More profound first ray elevation is usually noted with advancing hallux rigidus.

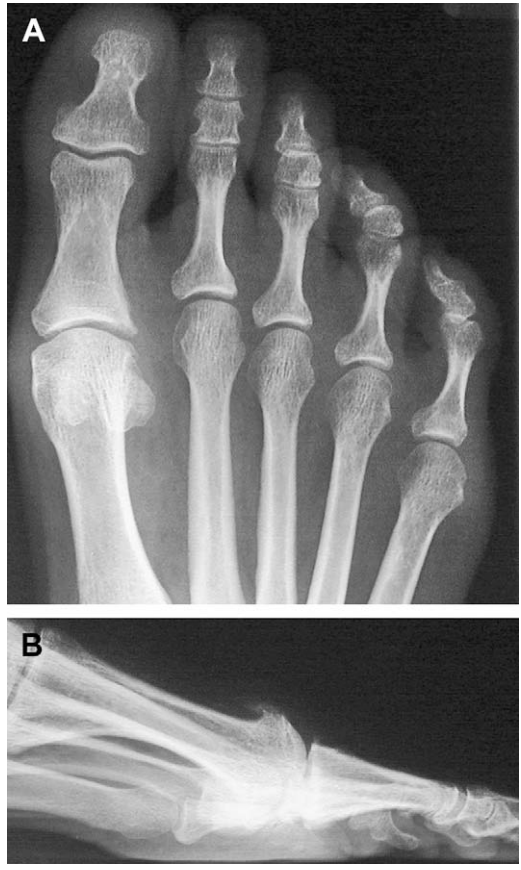

Fig. 2. Grade 2 hallux rigidus. (*A*) The metatarsal head is more flattened, marginal osteophytes are notable, and increased elevatus is obvious on the lateral radiograph. (*B*) The dorsal osteophyte is often the key finding on the lateral radiograph and classically appears like dripping candle wax. The joint space is fairly well preserved, but increased subchondral radiodensity is noted.

Clinical Findings

Early hallux rigidus is characterized by synovial thickening, MTP joint inflammation, and mild restriction in MTP joint motion. Patients may have flares of swelling and pain, but over time the flare-ups become more frequent, the joint begins to enlarge, and symptoms become more pronounced. Wearing shoes becomes difficult and most patients seek medical attention out of concern that they may have gout or a broken toe. The primary pathologic process of hallux rigidus is degenerative arthritis.[16] The common location of cartilage depletion is on the dorsal portion of the metatarsal head.[4,22] As the degeneration progresses, dorsal and dorsolateral osteophytes on the metatarsal head become pronounced and the bony ridge may impinge against the proximal phalanx (**Figs. 2–4**).

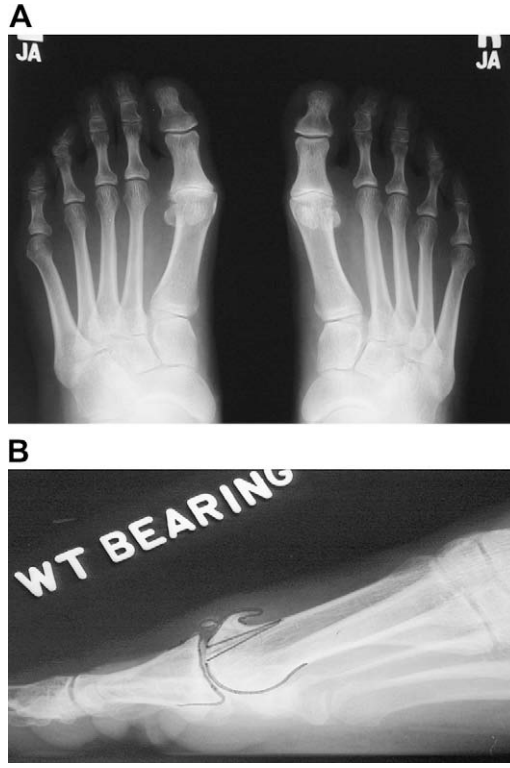

Fig. 3. Grade 3 hallux rigidus. (*A*) The first MTP joint has a definite flat appearance with proliferating marginal osteophytes, loss of cartilage space, and loose body formation. Clinically, patients have a stiff toe (10° of dorsiflexion typically) but no pain at the mid-range of the joint. Primarily they have pain at the extremes of motion caused by impingement of the dorsal osteophyte. The elevatus is markedly increased and the radiodensity around the joint is increased compared with grade 2. Elevatus is associated with worsening MTP joint function. Hallux interphalangeus (angular deformity of the proximal phalanx) is clearly notable and is associated with advanced hallux rigidus—often grades 2, 3, and 4. (*B*) The lateral radiograph demonstrates some plantar cartilage space remaining.

Fig. 4. Grade 4 hallux rigidus. (*A*) Grade 4 changes are often the same as grade 3; the key distinguishing factor is clinical. Grade 4 patients have pain at the mid-range of MTP joint motion with gentle loading, which indicates complete loss of cartilage. (*B*) Radiographs usually demonstrate complete cartilage space loss, especially on the lateral view.

Physical examination demonstrates a tender, painful, swollen MTP joint that exhibits limited motion. Grinding, catching, or clicking may be present, and with joint motion, pain may be elicited in dorsiflexion, plantarflexion, or both. Pain that clearly occurs at the mid-range of motion with gentle loading indicates profound MTP joint cartilage loss. Osteophyte growth around the margin of the affected joint may cause a superficial bursitis, neuritis, or skin ulceration. Interphalangeal joint hyperextension may be noted as compensation for restricted MTP joint dorsiflexion.[23,24]

Radiographic findings

Radiographs usually show asymmetric loss of cartilage space or chondrolysis, subchondral cysts evident in advancing cases, increased sclerosis and bony proliferation at the joint margins, and loose bodies around the joint. Standing anteroposterior, oblique, and lateral radiographs of the foot are sufficient in most cases. The anteroposterior view often shows the asymmetric joint narrowing and a flattened widening of the metatarsal head. In more advanced stages, cystic changes in the metatarsal, increased radiodensity, osteophyte formation on the base of the proximal phalanx, and sesamoid enlargement usually develop. The lateral radiograph may demonstrate a dorsal metatarsal osteophyte classic for ''dripping candle wax'' as the osteophyte courses proximally along the dorsal metatarsal surface. A radiographic and clinical classification system helps to define the magnitude of the arthritic process and may help select specific nonoperative or operative treatment (**Box 1**).[19]

Box 1
Clinical and radiographic classification of hallux rigidus

Grade 0

ROM: Dorsiflexion 40°–60° and/or 10%–20% loss compared with normal side

Radiograph: normal or minimal findings

Clinical: no subjective pain, only stiffness, loss of passive motion on examination

Grade 1

ROM: Dorsiflexion 30°–40° and/or 20%–50% loss compared with normal side

Radiograph: dorsal spur is main finding, minimal joint narrowing, minimal periarticular sclerosis, minimal flattening of metatarsal head

Clinical: mild or occasional subjective pain and stiffness, pain at extremes of dorsiflexion and/or plantarflexion on examination

Grade 2

ROM: Dorsiflexion 10°–30° and/or 50%–75% loss compared with normal side

Radiograph: dorsal, lateral and possibly medial osteophytes give flattened appearance to metatarsal head, no more than one fourth of dorsal joint space involvement on lateral radiograph, mild to moderate joint narrowing and sclerosis, sesamoids not usually involved but may be irregular in appearance

Clinical: moderate to severe subjective pain and stiffness that may be constant, pain just before maximal dorsiflexion and/or plantarflexion on examination

Grade 3

ROM: Dorsiflexion of 10° or less and/or 75%–100% loss compared with normal side and notable loss of plantarflexion (often $\leq$ 10° PF).

Radiograph: as in Grade 2 but with substantial narrowing, possibly periarticular cystic changes, more than one fourth dorsal joint may be involved on lateral, sesmoids (enlarged and/or cystic and/or irregular)

Clinical: nearly constant subjective pain and substantial stiffness, pain throughout ROM on examination (but not at mid-range)

Grade 4

Same criteria and findings as Grade 3, but definite pain at mid-ROM on examination is elicited

Abbreviation: ROM, Range of motion.
Data from Coughlin MJ, Shurnas PS. Hallux rigidus: grading and long-term results of operative treatment. J Bone Joint Surg Am 2003;85A:2072–88.

NONSURGICAL TREATMENT

Nonoperative treatment of symptomatic hallux rigidus must be tailored to each patient depending on the extent of arthritis and symptoms. The proper diagnosis must be obtained and inflammatory conditions be ruled out when necessary with appropriate blood work or joint aspiration. Early disease (grades 0–2) is often treatable with anti-inflammatory medications, shoe stretching, and strapping of the toe with figure of eight tape or Coban wrap. If symptoms continue or worsen, the use of a stiff insole (Morton's extension) to reduce excursion of the MTP joint may be useful. Orthoses

have been shown to yield better long-term pain relief than nonsteroidal anti-inflammatory drugs alone.[25] The inserts can be moved from shoe to shoe. Unfortunately, with later disease (advanced grade 2 and grades 3–4) some orthotics reduce room in the toe box and may create pressure on the dorsal prominence. Consequently, shoes with a deeper toe box are recommended. Orthotics with a supportive arch decrease pronation, which potentially alleviates pressure on the MTP joint. A carbon-fiber reinforcement under the first ray acts like a Morton's extension to minimize MTP joint excursion.

Solan and colleagues[26] noted 6 months of clinical improvement with intra-articular steroid injection and gentle MTP joint manipulation for mild to moderate grades of hallux rigidus. The same authors found limited benefit in more advanced grades, however. Smith and colleagues[27] reported on the long-term follow-up of 22 patients (24 feet) treated nonsurgically for hallux rigidus with a mean follow-up of 14 years. The authors reported that 75% of patients continued to choose nonoperative treatment, although the intensity of pain remained the same in 22 feet, worsened in 1 foot, and improved in 1 foot. Most patients were able to tolerate their pain by wearing a roomy, stiff-soled shoe. Others reported 60% successful nonoperative results with 1 to 7 years of follow-up using shoe wear modifications, orthoses, injections, and taping.[28]

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