29 Hallux rigidus

29.1 Introduction

Hallux rigidus or degenerative arthritis of the first metatarsophalangeal (MTP) joint is the second most common condition affecting the big toe after hallux valgus. It is also the most common arthritic condition in the foot, and females are more commonly affected in all age groups.

29.2 Anatomy

The first MTP joint consists of the articulation between the metatarsal head and the proximal phalanx, as well as the articulation between the plantar aspect of the metatarsal head and the sesamoids. The range of motion of the first MTP joint is greatest in the sagittal plane and consists of approximately 15 degrees of plantar flexion to 75 degrees of dorsiflexion from standing position.

29.3 Biomechanics

Stability of the first MTP joint in turn leads to stability of the medial column of the foot. Approximately 40% to 60% of body weight passes through the first MTP joint and great toe during normal gait. During athletic activities like jogging and running, these forces can approach two to three times body weight.

29.4 Clinical Presentation
Pain and stiffness are common at the 1st MTP joint, especially pain at the dorsal aspect of the joint in the early course of the disease. As the disease progresses, patients may complain of a dorsal prominence at the 1st MTP joint, which may be aggravated by rubbing against their footwear. Symptoms are aggravated by increased loading onto the 1st MTP joint, such as during heel-off or toe-off, as well as running.

Sometimes patients may present with pain at the lateral border of the foot resulting from an attempt to offload the hallux and medial column.

### 29.5 Pathogenesis

Hallux rigidus was first described in 1887 by Davies-Colley. Cotterill coined the term to reflect the painful limitation of motion at the first MTP joint. The pathogenesis of hallux rigidus as described by Shereff consisted of loss of motion in the sagittal and transverse plane for hallux rigidus. In hallux rigidus, there is a decreased total arc of motion with near normal plantar flexion and markedly decreased dorsiflexion secondary to a dorsal mechanical block by osteophytes (dorsal impingement) and scarring of plantar structures. Small degree of transverse motion also exists in medial and lateral plane in the sagittal range of motion. This motion is less than 2 mm in normal toes but has 50% reduction in hallux rigidus, and is thought to be due to contracture of the collateral ligaments and joint capsule.

Hallux rigidus is caused by wear and tear of the first MTP joint leading to degenerative changes in the joint. Several etiologies have been proposed, such as an abnormally long first metatarsal, abnormally elevated first metatarsal, post traumatic causes and positive family history. However the true etiology of hallux rigidus is not known.

### 29.6 Classification (Staging)

Hattrup and Johnson described the following radiographic classification system (unvalidated) in 1988:

- Grade 1 - Mild changes with a maintained joint space and minimal spurring
- Grade 2 - Moderate changes, joint space narrowing, bony proliferation of the MT head, and phalanx and subchondral sclerosis or cysts
- Grade 3 - Severe changes with moderate to severe joint space narrowing, extensive bony proliferation, and loose bodies or a dorsal ossicle

![Figure 1](image-url). Grade 1 changes with preserved 1st MTP joint space and minimal osteophytes
Figures 2a-b. Grade 3 changes showing severe joint space narrowing, bony proliferation and dorsal osteophytes.

In 1999, Coughlin and Shurnas\(^6\) proposed a more elaborate classification system based on a combination of of range of motion (ROM), radiographic and clinical examination as follows:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
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<tbody>
<tr>
<td>0</td>
<td>DF of 40-60 degrees (20% loss of normal motion), normal radiographic results, and no pain</td>
</tr>
<tr>
<td>1</td>
<td>DF of 30-40 degrees, dorsal osteophytes, and minimal to no other joint changes</td>
</tr>
<tr>
<td>2</td>
<td>DF of 10-30 degrees, mild flattening of the MTP joint, mild to moderate joint space narrowing or sclerosis, and osteophytes</td>
</tr>
<tr>
<td>3</td>
<td>DF of less than 10 degrees, often less than 10 degrees PF, severe radiographic changes with hypertrophied cysts or erosions or with irregular sesamoids, constant moderate to severe pain, and pain at the extremes of ROM</td>
</tr>
<tr>
<td>4</td>
<td>Stiff joint, radiographs showing loose bodies or osteochondral defects, and pain throughout entire ROM</td>
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29.7 Physical Examination
Patients typically present with pain and stiffness at the 1st MTP joint. In the early stages of hallux rigidus, there is pain at terminal range of dorsiflexion and plantarflexion. In the late stages, there is loss of motion especially dorsiflexion, sometimes with crepitus at mid-arc of motion. Patient may complain of a dorsal prominence from osteophytes or synovitis.

29.8 Imaging

Standing radiographs of both feet in AP, Lateral and oblique radiographs may show joint space narrowing, subcondral cyst and sclerosis, and loose bodies (Hattrup & Johnson’s radiographic changes). The lateral view often reveals a dorsal osteophyte at metatarsal head. Sesamoid views may be ordered if sesamoid pathology is suspected.

29.9 Conservative Treatment

Most patients benefit from shoe wear with adequate toe box and a custom orthotic sole with a Morton’s extension orthosis to restrict motion of the 1st MTP during gait. An alternative treatment is a rocker bottom shoe with the rocker just proximal to the first MP joint. NSAIDS are helpful in the acute exacerbation episodes of pain.

Injection with corticosteroids or hyaluronic acid may result in temporary relief of symptoms for pain and function in early Grade 1-2 hallux rigidus (Level II evidence). The use of foot orthoses, shoe-wear modification, and injection with corticosteroids or hyaluronic acid constitute fair evidence (Grade B recommendation) to support a trial of conservative therapy before surgical treatment in patients with symptomatic hallux rigidus.

Figure 3. A Morton’s extension orthosis

29.10 Operative Treatment

29.10.1 Cheilectomy
First described by DuVries\textsuperscript{11} in 1959, cheilectomy consists of the resection of dorsal osteophytes and degenerative articular surface in on the dorsal one third of the metatarsal head. The procedure involves synovectomy, removal of loose bodies, release of medial and lateral collateral ligaments, as well as dorsal osteophytes.

The advantages of cheilectomy are that it is a joint-sparing procedure, preserves range of motion, maintains joint stability, and does not “burn bridges” for any secondary procedures in the future.

\textbf{Figures 4a-b.} Cheilectomy involves resection of dorsal osteophytes as well as degenerative cartilage on dorsal third of articular surface

\section*{29.10.2 Keller’s Excision Arthroplasty}

Keller’s resection arthroplasty\textsuperscript{12} has been performed since 1904 and involves a resection of the proximal phalanx base. It decompresses the first MTP and is indicated in older individuals or patients with low functional demand. Complications from this procedure are common and include cock-up deformity of the big toe, transfer lateral metatarsalgia, hallux weakness, and floppiness. Motion of the first MTP joint is preserved at the expense of stability.\textsuperscript{13,14,15}

There is fair evidence (Grade B recommendation) from Level II and Level IV studies to support the use of Keller’s arthroplasty in older and lower-demand patients.\textsuperscript{10} However, patient selection is important, and the possibility of cock-up deformity and transfer metatarsalgia must be considered. Thus, the Keller’s procedure is not recommended for active patients and patients with a prominent second metatarsal.

\section*{29.10.3 Interpositional Arthroplasty}

Since Keller’s procedure, there have been several modifications of the technique to improve stability and function. It combines cheilectomy and resection arthroplasty with the use of a biological tissue or spacer into the MTP joint with the aim to avoid the problems associated with an isolated Keller’s arthroplasty.
Common soft tissue interposition includes the extensor hallucis brevis tendon, capsule, gracilis, or plantaris tendon.\textsuperscript{16-19} Complications of this procedure are similar to that of Keller’s resection arthroplasty.

The current literature does not recommend interpositional arthroplasty to be used as a routine procedure for the surgical treatment of hallux rigidus (Grade I recommendation, insufficient evidence).\textsuperscript{10}

\section*{29.10.4 1st MTP Arthrodesis}

Although it is a “joint-sacrificing” procedure, arthrodesis provides a reliable, reproducible, and predictable long term favorable outcome for treatment of advanced-stage symptomatic hallux rigidus and for salvage of other failed surgical procedures. It involves resection of the degenerative articular surfaces of the metatarsal head and proximal phalanx base to achieve a stable fusion.

The position of fusion has been described in 10-15 degrees of valgus and 15-30 degrees of dorsiflexion (or metatarsophalangeal angle). There are various methods of achieving a stable fusion using joint preparation and joint fixation.

Joint preparation methods include conical reaming, ball and socket reaming, peg and cone preparation, and flat planar cuts of the metatarsal head and phalangeal base. Another technique involves denuding the joint surface of cartilage until there is a healthy bleeding subcondral surface and then inserting drill holes into the subchondral bone.

Joint fixation methods involve use of lag screws, dorsal plating, bone staples, Kirshner wires, cerclage wire loops, and a combination of lag screw and dorsal plating. With the varying techniques of fusion available, fusion rates of 90-100\% have been achieved.\textsuperscript{20-22}

Various studies have demonstrated that a dorsal plate with an oblique compression lag screw gives the strongest biomechanical stability after the bone ends are prepared by conical reaming, followed by conical reaming with either dorsal plating or inter-fragmentary screws alone, while memory staples or Kirschner wires give weaker biomechanical stability.\textsuperscript{22,23} Complications of arthrodesis include first ray shortening, non-union, malunion, transfer metatarsalgia, infection, and prominent implants.
Arthrodesis using two 4-mm crossed screws

29.10.5 Osteotomy

Osteotomies of the proximal phalanx and distal 1st metatarsal osteotomies have been performed as joint preserving procedure to maintain motion in the MTP joint. These procedures can be combined with a cheilectomy. In the case of the proximal phalanx osteotomy, the principle works by a dorsal closing wedge osteotomy which shifts the limited MTP arc of motion dorsally and placing the hallux in a more dorsiflexed position to allow for improvement of function.24

The various 1st metatarsal osteotomies have been designed to decompress the joint by shortening the metatarsal, or realigning the more healthy plantar articular cartilage dorsally, or to realign the articular surface to bring the arc of motion into a more functional range.24,25 These are usually performed for Grade 1-2 hallux rigidus. Complications include malunion, delayed union, transfer metatarsalgia, interphalangeal joint arthritis, and avacular necrosis of metatarsal head.

The limited and conflicting nature of evidence at present justifies a Grade I to a Grade C (insufficient to weak evidence) recommendation for osteotomy as a standard treatment for hallux rigidus.

29.10.6 Implant arthroplasty

Replacement arthroplasty has been developed as an alternative to retain functional range of motion and stability of the first MTP joint for advanced stage hallux rigidus.

Historically, silicone or Silastic implants for the great toe of the Swanson design has been used since 1967, albeit with high failure rates and poor resultant bone stock for salvage procedures.26 There were initial satisfactory to excellent results, however, radiographic signs of loosening and fragmentation coupled with silicone granulomatous disease began to surface on long-term outcomes.
Related complications of silicone implant arthroplasty include implant fracture with fragmentation, loosening, implant subsidence, silicone particle synovitis, osteolysis, silicone granuloma, and wear, as well as lymphadenitis.

The newer implants consist of mainly metallic or metal-on-polyethylene components and can be broadly classified into hemiarthroplasty or total joint replacement of the first metatarso-phalangeal joint.

**Hemiarthroplasty**

Hemiarthroplasty involves resurfacing the articular surface of either the proximal phalanx base or metatarsal head. The majority of the implants involve resurfacing of the proximal phalanx base, although some involve resurfacing of the metatarsal head.

For resurfacing of the proximal phalanx base, some form of debridement, cheilectomy of the dorsal osteophytes on the metatarsals, and soft tissue release and balancing is required. The newer implants allow less resection of bone on the phalanx side.

The Biopro hemiarthroplasty resurfacing (Biopro Inc., Port Huron, Michigan) has the longest and largest data and publication to date for its clinical use and follow-up (more than 33 years). A survivor analysis of a hemiarthroplasty population using Biopro resurfacing of the proximal phalanx has an implant failure rate of 23.8% at 18 months post-operatively. Hemiarthroplasty or resurfacing of the proximal phalanx is only supported by weak evidence (Grade C recommendation).

Early loosening, implant cut-out, recurrent osteophytes with impingement, and metatarsalgia are reported complications with the hemiarthroplasties.

**Total Joint Replacement**

Total joint replacement involves a two- or three-component, metal-on-polyethylene implant. The procedure is usually indicated in older, low-functional-demand patients with end-stage hallux rigidus where preservation of joint motion is a concern. The implants used in total joint replacement can be divided into non-constrained or semi-constrained, but most are non-constrained. The components include cobalt chrome or titanium metal and ultra-high molecular weight polyethylene.

Metallic arthroplasty is currently an alternative option for the surgeon and patient who desire a joint preservation procedure. However, most published studies report mid-term (3-5 years) results with small sample sizes; longer-term results are needed to determine the efficacy and survivorship of these implants. There is currently insufficient evidence (Grade I recommendation) to support total joint arthroplasty as a standard treatment for advanced stage hallux rigidus.

Many of the total toe implants suffer from loosening and early failure requiring revision in short- to medium-term results, with complications such as implant subluxation, subsidence, infection, post-operative stiffness, peri-prosthetic fracture, and transfer metatarsalgia.

**29.11 Controversy**

There is still debate on the effects of arthrodesis versus joint preserving arthroplasty for the advanced stage of hallux rigidus in older and physically lower-demand patients. Should motion of the joint be sacrificed for stability of the hallux, and for consistent, predictable, and reliable outcome of the procedure?
Arthrodesis stabilizes the medial column of the foot but may predispose the foot to degenerative changes in the interphalangeal joint (10-15%). These changes, however, are usually asymptomatic. There are no validated functional studies comparing the limitation of function and activities after arthrodesis and arthroplasty.

29.12 References