Functional Hallux Rigidus and the Achilles-Calcaneus-Plantar System

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KEYWORDS

- Functional hallux rigidus • Metatarsophalangeal joint
- Achilles-calcaneus-plantar system

KEY POINTS

- Functional hallux rigidus is a clinical condition in which the mobility of the first metatarsophalangeal (MP) joint is normal under non-weight-bearing conditions, but its dorsiflexion is blocked when first metatarsal is made to support weight.
- In mechanical terms, functional hallux rigidus implies a pattern of interfacial contact through rolling, while in a normal joint contact by gliding is established.
- The windlass mechanism is essential to maintain the plantar vault and is based on the correct functioning of an arch formed by several bony elements, which work through compression, and foot braces, which work through tension, among which the best prepared for its moment arm is the plantar aponeurosis.
- Both the elevation of the head of first metatarsal and the increase in tension in the aponeurosis may alter the joint dynamics in the first MP joint, producing contact by rolling instead of physiologic interfacial contact through gliding.
- Limitation of the dorsiflexion in the ankle or the MP joint blocks the forward movement of the tibia during the stance phase on the sagittal plane, which is compensated through diverse mechanisms that entail abnormal movements on other planes and in other body segments.
- Patients with functional hallux rigidus should only be operated on if the pain or disability makes it necessary. Gastrocnemius release is a beneficial procedure in most patients.

INTRODUCTION

Functional hallux rigidus is a clinical condition in which the first metatarsophalangeal (MP) joint motion is impaired on weight-bearing conditions but not when unloaded.

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Weight-bearing motion at the first MP joint depends on structures that are not located at the joint itself, but more proximally. Among these structures, the Achilles-calcaneal-plantar system and the medial column of the foot are mainly responsible for optimally setting the first MP joint to provide for anteromedial support of the foot during the third rocker or propulsive phase of gait; this requires adequate passive dorsiflexion of the joint while the hallux is purchasing the ground and the verticalized first metatarsal is axially loading the hallux-sesamoid complex. Failure to achieve first metatarsal plantarflexion, or an increase on tensile stress at the plantar fascia, will limit passive first MP joint dorsiflexion in the transition from the second rocker (plantigrade support) to the third one (forefoot support). These can impede the ideal gliding contact pattern at the first MP joint, producing rolling contact on the dorsal margin of the joint. Because propulsion takes place in closed kinetic chain conditions, limited passive dorsiflexion of the first MP joint blocks motion in the sagittal plane, which is necessary for the forward progression of the body during gait. Compensatory mechanisms must develop to cope with the lack of motion at the first MP joint. They may or may not lead to the onset of symptoms.

During the second rocker, the tibia must glide forward on the ankle to allow the body's center of mass to progress from an initial position posterior to the supporting foot to a final position anterior to it. A restriction to ankle passive dorsiflexion during the second rocker will increase dorsiflexing moments at the forefoot, thus increasing tensile stress at the plantar soft tissues due to the truss and beam mechanism of the plantar vault support. Contracture of the elastic component of the gastrocnemius muscles will be particularly harmful to ankle kinetics, because the knee must be extended during the second rocker to provide for functional lengthening of the supporting limb while the opposite is swinging. Tension at the soleus muscle is not modified by knee position.

This article focuses on the functional hallux rigidus of biomechanical origin from a clinical and mechanical point of view. Some of the pathologic mechanisms described in this text have not been proven, but are nonetheless very useful to understand the concept of functional hallux rigidus. The role of the Achilles-calcaneal-plantar system is described to provide a wide range of treatments when planning surgical management.

Hallux rigidus of biomechanical origin is the final stage of functional hallux rigidus; both of them are the same disease. When passive dorsiflexion is present in non-weight-bearing conditions, it should be possible to improve motion in weight-bearing conditions, and these cases will respond to joint-preserving surgical procedures. If there is no passive motion at the first MP joint in non-weight-bearing conditions, arthrodesis is the author's preferred procedure regardless of the radiological appearance of the joint. Hallux rigidus of nonmechanical origin, which is not discussed in this article, includes traumatic, metabolic, neuromuscular, rheumatic disease, congenital anomalies, and iatrogenic disorders.

FUNCTIONAL HALLUX RIGIDUS OF BIOMECHANICAL ORIGIN: THE INFLUENCE OF EQUINUS CONTRACTURE

Functional hallux rigidus is a clinical condition in which the first MP joint allows sufficient passive dorsiflexion when the first metatarsal is not bearing weight, but not when it has to support a person's body weight.[1,2] It moves in an open kinetic chain, but not in a closed chain. In a more advanced case of hallux rigidus, complete passive dorsiflexion even when not bearing any weight is not possible; this is referred to as a structural hallux rigidus. In hallux rigidus, the capacity for passive dorsiflexion of the first MP joint is practically canceled. Examination of the mobility of the first MP joint