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Review article

Adult flatfoot

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ABSTRACT

Adult flatfoot is defined as a flattening of the medial arch of the foot in weight-bearing and lack of a propulsive gait. The 3 lesion levels are the talonavicular, tibiotarsal and midfoot joints. The subtalar joint is damaged by the consequent rotational defects. Clinical examination determines deformity and reducibility, and assesses any posterior tibialis muscle deficit, the posterior tibialis tendon and spring ligament being frequently subject to degenerative lesions. Radiographic examination in 3 incidences in weight-bearing is essential, to determine the principal level of deformity. Tendon (posterior tibialis tendon) and ligamentous lesions (spring ligament and interosseous ligament) are analyzed on MRI or ultrasound. In fixed deformities, CT explores for arthritic evolution or specific etiologies. 3D CT reconstruction can analyze bone and joint morphology and contribute to the planning of any osteotomy. Medical management associates insoles and physiotherapy. Acute painful flatfoot requires strict cast immobilization. Surgical treatment associates numerous combinations of procedures, currently under assessment for supple flatfoot: for the hindfoot: medial slide calcaneal osteotomy, calcaneal lengthening osteotomy, or arthroereisis; for the midfoot: arthrodesis on one or several rays, or first cuneiform or first metatarsal osteotomy; for the ankle: medial collateral ligament repair with tendon transfer. Fixed deformities require arthrodesis of one or several joint-lines in the hindfoot; for the ankle, total replacement after realignment of the foot, or tibiotalocalcaneal fusion or ankle and hindfoot fusion; and, for the midfoot, cuneonavicular or cuneometatarsal fusion. Tendinous procedures are often associated. Specific etiologies may need individualized procedures. In conclusion, adult flatfoot tends to be diagnosed and managed too late, with consequent impact on the ankle, the management of which is complex and poorly codified.

1. Introduction

Flatfoot is a syndrome combining multiple static and dynamic deformities, with flattening of the medial arch. This diversity explains the difficulty of analysis and hence of treatment.

The common point in all these deformities is failure of foot-locking during gait. It is thus important to understand the factors of foot stabilization in order to know which levels treatment should target.

Clinical assessment and complementary examinations determine the deformity and its reducibility. Radiologic assessment is systematically in weight-bearing, some forms of flatfoot being completely reduced under non-weight-bearing. Other examinations complete assessment and determine the status of the posterior tibial tendon (ultrasound or MRI), the evolutive stage of secondary osteoarthritis (CT) or certain etiologies.

Indications for surgery should take on board the components of the deformity and its reducibility at 3 levels: the talonavicular, tibiotarsal and midfoot joints.

2. Pathophysiology of flatfoot

Flatfoot is a pathology of the weight-bearing foot, which may under certain conditions induce posterior tibial tendon dysfunction. Locking failure may involve different levels:

- the talocalcaneonavicular joint, or coxa pedis: it lies at the summit of the medial arch, and is subject to the pressure of the talar head in plantigrade weight-bearing, increased by the advance of the tibia. The mid-plantar tendon-ligament sling constituted by the calcaneonavicular or "spring" ligament and the posterior tibial tendon play an essential role in the elastic support of the joint complex. Bonnel [1] described a type-III morphotype in which the talus is longer than the calcaneus, thus exerting greater pressure on the tendon-ligament structures. During gait, unipedal weight bearing acceptance lateralizes the body, thus reducing

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mid-plantar tension and allowing dynamic action of the posterior tibial muscle. Progressive strain on the mid-plantar sling is the most common cause of flatfoot, causing midfoot abduction;
- the medial collateral ligament (MCL) of the tibiotarsal joint: it is subjected to stress when the heel strikes the ground, due to physiological non-alignment between the calcaneus and the tibia. MCL distension induces tibiotarsal valgus, with weight-bearing progressively displaced toward the medial edge of the foot, straining the more distal medial foot joints;
- the midfoot: raising the heel automatically induces dorsiflexion of the phalanges, leading to tension in the plantar muscles and fascia, known as the "windlass mechanism". This locks the midfoot joints; locking failure, encountered in case of first-ray hypermobility, leads to elevation of the first metatarsal during medial forefoot weight-acceptance, then to locking defect during unipodal weight-bearing and hallux toe-off.

Lesions in these three levels may be degenerative, but some may have a specific cause. Long-standing trauma such as ankle sprain, with often neglected medial involvement of the tibiotarsal or midfoot joints, should be explored for.

Flatfoot assessment should thus focus on all three levels, plus the subtalar joint, which is subject to abnormal rotational stress in flatfoot.

3. Diagnosis

3.1. Pain

Flatfoot is considered pathological only when symptomatic.

Pain is generally located in the medial part of the hindfoot [2], along the posterior tibial tendon, sometimes associated with effusion into the tendon sheath. Pain may be plantar and deep, suggesting spring ligament lesion. Even so, such pain may be caused by another pathology, such as talocalcaneal synostosis coalition or talonavicular, subtalar or mediotarsal osteoarthritis.

Pain may also be lateral, due to fibulocalcaneal impingement in severe tibiotalar valgus, calcaneocuboid impingement in severe forefoot abduction, or impingement between the lateral tubercle of the talus and dorsal angle of Gissane of the anterior apophysis of the calcaneus in case of rotation and slippage of the talus.

3.2. Clinical assessment

Clinical assessment should determine the characteristics of the deformity and whether deformities of the tibiotalar and subtalar joints and Chopart and Lisfranc joint-lines are reducible.

Range of motion is assessed, and joint stiffness is screened for as it points to synostosis coalition or osteoarthritis.

3.2.1. Hindfoot

The bipedal tiptoe test normally induces hindfoot inversion. Inversion loss or eversion points to subtalar and Chopart's joint dysfunction (stiffening or hyperlaxity) and/or posterior tibial muscle deficiency.

Abduction is analyzed with the patient standing, with the examiner behind to observe the "too-many-toes sign", or else in dorsal decubitus, to observe the plantar face of the foot with a break in the lateral edge in abduction. Hallux valgus is often associated.

The posterior tibial tendon is tested in inversion against resistance starting with the foot in eversion. Note is taken of resulting pain and loss of muscle force. Complete motor assessment of the foot muscles is performed to explore for neurologic etiology.

The unipedal tiptoe test assesses posterior tibial muscle and spring ligament function:
- if the foot moves into eversion on unipedal tiptoe weight-acceptance (or the heel fails to rise) although the bipedal tiptoe position can be achieved normally, the posterior tibial tendon is involved;
- reduced active inversion may suggest a spring ligament lesion [3];
- pain along the posterior tibial tendon on repeating the test is a sign of tendinitis.

In some cases, tendon-muscle retraction may fix the deformity under weight-bearing: valgus fixed by the sural triceps and abduction by the fibular muscles. Ankle examination in plantar flexion, which relaxes these tendons, determines whether there is associated joint stiffness.

3.2.2. Tibiotalar joint

Ankle dorsiflexion deficit, with hindfoot valgus corrected, is assessed with the knee in extension and then flexed, exploring for gastrocnemial retraction (Silfverskiold test).

Hindfoot valgus under weight-bearing may be due to medial laxity of the ankle or to forefoot supination.

Medial laxity of the ankle is not always easy to detect.

Forefoot supination is analyzed with the patient in dorsal decubitus, with hindfoot valgus corrected.

The reverse Coleman test demonstrates hindfoot valgus correction by placing a 2-cm block under the first metatarsal head.

3.2.3. Midfoot

Three elements are explored for in the midfoot: supination, first-ray hypermobility, and osteoarthritic stiffness.

3.2.3.1. Supination. It is important to determine whether supination is fixed, using the Hintermann test [4], which consists in external rotation of the limb with the foot under weight-bearing. If the first metatarsal head rises, supination is fixed and, if not, is reducible.

3.2.3.2. First-ray hypermobility. Hypermobility of the first cuneometatarsal joint [5] is explored for by moving the first ray, held between thumb and index finger, downward and upward while holding the metatarsal bones in the other hand.

There may be a plantar corn under the second metatarsal head.

Gait shows first-ray elevation on forefoot weight-acceptance.

Passive hallux dorsiflexion (Jack test) explores for possible raising of the medial arch of the foot. It may be performed with or without weight-bearing; in weight-bearing, it may require passive correction of the hindfoot valgus causing excessive tension in the flexor hallucis longus tendon. Normally, first metatarsophalangeal joint dorsiflexion induces passive tension in the sesamoid muscles and flexor hallucis longus, stabilizing and thus, lowering the medial arch. In first-ray hypermobility, the foot does not arch and first metatarsophalangeal joint shows hyperdorsiflexion in non-weight-bearing, with a soft stop indicating plantar muscle locking defect.

3.2.3.3. Osteoarthritic stiffness. Osteoarthritic stiffness is indicated by dorsal swelling due to osteophytosis and impaired Lisfranc joint motion.

3.3. Complementary imaging investigations

3.3.1. X-ray

First-line assessment comprises 3 weight-bearing radiographs: dorsoplantar for abduction, lateral for flattening, and AP view with Méary cerclage for valgus.