Painful Flexible Flatfoot

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KEYWORDS

• Flexible flatfoot • Pes planovalgus • Pes equinovalgus • Treatment • Pain

KEY POINTS

- Flexible flatfoot (FFF) has 2 subtypes: pes planovalgus and pes equinovalgus.
- Most FFF patients are asymptomatic and only those that become symptomatic require treatment.
- Conservative treatment remains the mainstay in FFF and it is usually in the form of arch support orthotics and exercises.
- Surgical intervention, using arthrodesis or nonarthrodesis procedures, is warranted when conservative treatment fails.
- Nonarthrodesis procedures are preferred and arthrodesis procedures are the last resort when all other treatments fail.

BACKGROUND

No study in the literature adequately defines flatfoot in terms of measurable radiographic or clinical values.[1] The absence of the medial arch, the hindfoot valgus, and the relative forefoot to midfoot supination define this entity. A flatfoot is called "flexible" when forefoot supination and dorsiflexion of the hallux in a weight-bearing position restores the arch, a positive Jack's test (Fig. 1).[2] It is the most common form of flatfoot. We distinguish 2 subtypes of flexible flatfoot (FFF): pes planovalgus and pes equinovalgus. The hallmark between the subtypes is the tightness of the heel cord. As the name implies, the heel cord is tight in the equinovalgus form. Clinically, bringing the hindfoot into neutral allows the differentiation between the two. Harris and Beath[3] were the first to describe pes equinovalgus using the term "hypermobile flatfoot" in a cohort of Canadian soldiers. Characteristics of the hypermobile flatfoot are persistent since childhood, corrects when unloaded from weight bearing, associated with a short tendoachilles, and has abnormal relationships of the tarsal bones. The incidence of symptoms is higher in this group of patients.[3]

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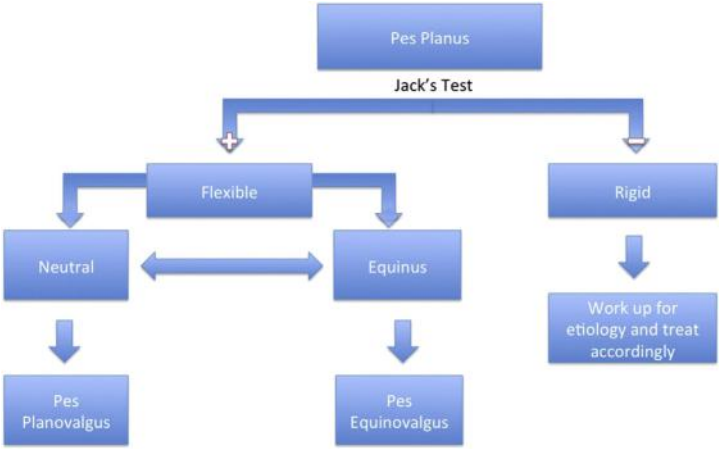

Fig. 1. Diagnosis algorithm for flatfoot.

DEVELOPMENT AND RISK FACTORS

Reports regarding the true incidence of FFF vary. Harris and Beath had the largest cohort of FFF looking into the incidence in 3619 Canadian soldiers.[1,3–5] In their study, these authors reported a 20% incidence of FFF. The many factors associated with flatfoot include age, gender, ethnicity, and shoe wearing. Early in life, flatfoot is a normal stage of development. The medial arch develops through the normal process of growing.[6–9] Vanderwilde and colleagues[8] studied a population of normal children in Columbia in the first 5 years of life. They concluded that young children are flatfooted and the arch develops as they grow beyond 5 years of age. Another study conducted in Austria showed similar results and exhibited a reduction of flatfoot in more than 50% of the children between the ages of 3 and 6 years.[10] Other authors looked into the effect of shoe wearing and found that FFF was more prevalent in the shod versus the unshod children.[11,12] Flatfoot occurs more frequently among obese school children.[13–17] Ethnicity can also play a role, with a higher incidence of flatfoot in African-Americans compared with Caucasians.[18–20]

The several theories defining the etiology of FFF depend on the anatomy of the foot and the surrounding musculature. The earliest theories focused on muscle imbalance and weakness around the foot as the primary causes of flatfootedness.[21] Later, the bony anatomy and the ligamentous laxity of the midfoot joints were proposed as the main factor.[22–24] Harris and Beath[3] distinguished between the passive and the active support of the foot. The passive support is the bony and the ligamentous structures of the foot. The active support is the muscular envelope that includes muscles belonging to the foot alone and others that insert in the foot but originate in the leg. The passive support is the primary arch support and the active support comes into play when the passive support fails. Basmajian and Stecko[24] studied the muscle electrophysiology while applying different loads to the foot. They concluded that the bony and ligamentous structures are the primary restraints of the arch and that the muscles come into play with excessive loads.[25] These muscles play a principal, active role in the stabilization of the foot during propulsion.[25]

PATHOPHYSIOLOGY

To understand the pathophysiology of the flatfoot and the principles of treatment, one must be aware of the importance of the subtalar and the midtarsal anatomy.[26] The subtalar joint is composed of the anterior and the posterior talocalcaneal articulation. The anterior articulation is between the biconcave facet of the calcaneus and the anterior convex surface of the talar head and posterior convex surface of the navicular. The posterior articulation is between the posterior convex facet of the calcaneus and the concave talar facet. The calcaneus supports the talar head and neck, which in turn supports the navicular. The interosseous talocalcaneal ligament supports the subtalar joint. This ligament blends with the talocalcaneonavicular joint anteriorly and the subtalar joint capsule posteriorly. The motion that results around the axis of rotation of the subtalar joint is "out and up" or "in and down" (**Fig. 2**).

The midtarsal joints are the talonavicular and the calcaneocuboid joints. The former is a ball-and-socket and the latter is a trochlear joint. These joints allow for minimal motion: dorsiflexion, plantar flexion, and forefoot rotation on the hindfoot. Knowledge of these relationships allows a better understanding of the effect of the various interventions available for managing flatfeet.

The subtalar and the midtarsal joints act as the mechanical connection between the foot and the tibia.[26] Loads from the body and the lower limb are transmitted through these joints to the foot. Motion through these joints orchestrates the ongoing transformation of the foot from a supple configuration to accommodate the ground during weight bearing to a rigid one to assist in push-off toward the end of stance. The foot deformity in FFF has 3 components: forefoot hyperabduction, forefoot supination, and hindfoot valgus. This deformity renders the foot supple at all times thus loosing its contribution to push-off.[27,28] It is not only a static malalignment of the foot and ankle, but also a functional change of the lower limb dynamics.[29]

Flatfoot has been reported as a risk of overuse injuries in people with high demand, including athletes and soldiers.[30] Kaufman and colleagues[31] found that the presence of flatfoot is a risk factor for overuse injuries particularly stress fractures. These findings contradicted those of Cowan and Giladi that pes planus was protective against the aforementioned injuries.[30,32]

PRESENTATION AND PHYSICAL EXAMINATION

Most patients with flatfoot who come for medical attention do so regarding cosmesis and shoe wear, but most often do not complain of pain. The symptomatic patients primarily seek treatment owing to pain and at times, a decrease in function. Flatfoot pain is usually induced by strenuous activity and relieved by rest. This pattern applies to both the flexible as well as the rigid types. Pain may be located over the medial aspect of the heel, the sinus tarsi, the distal fibula, and the medial aspect of the midfoot. Other diagnoses should be sought if this pain occurs during the night and awakens the patient from sleep.

Fig. 2. Axis of rotation (*arrow*) of the subtalar joint.

The physical examination of the child or adolescent with a FFF starts with barefoot gait observation. Depending on the severity of the flatfoot, the gait demonstrates varying degrees of forefoot abduction. Forefoot abduction is also the reason behind the too-many-toes sign noted by the examiner when inspecting the child's feet from behind (**Fig. 3**). The absence of the medial arch is also noted (**Fig. 4**) and is usually restored when the child is asked to stand on tiptoe (**Fig. 5**) or when the hallux is brought into dorsiflexion in the weight-bearing foot, a positive Jack's test (**Fig. 6**). Shoes are examined for signs of medial wear. The rest of the examination is carried out with the patient seated. The medial aspect of the foot is inspected for hypertrophied skin and callosities. The hindfoot is locked in neutral and dorsiflexion is performed looking for a tight Achilles tendon, thus differentiating between the equinovalgus and the planovalgus subtypes of FFF (**Fig. 7**). Examining the child for any signs of joint laxity and hypermobility should be a part of the evaluation.

Evaluation of rotational deformity is essential because, when present, it can mask or exacerbate the appearance of the flatfoot deformity. This examination includes assessing the femoral version and the tibial torsion. The femoral version is assessed clinically by examining hip rotation and performing the trochanteric prominence angle test. The thigh–foot angle reflects the direction and amount of tibial torsion.[33–35] This test is best performed with the patient lying in the prone position. Imaging version studies are warranted when signs of rotational malalignment are found.

Fig. 3. Posterior inspection of the flatfoot reveals hindfoot valgus and the too-many-toes sign secondary to forefoot hyperabduction.

Fig. 4. Anterior and side views of the weight-bearing flatfoot demonstrate the absence of the medial arch and the forefoot hyperabduction.

Radiographs are usually reserved for symptomatic patients with flatfoot. The radiographic evaluation consists of a dorsoplantar and a lateral projection of the foot. A Harris view and sometimes a computed tomography or MRI or both are added to the evaluation in the case of rigid flatfoot to look for a tarsal coalition, but this evaluation is not within the scope of this review. On the lateral view, the plantar sag of the talonavicular joint is appreciated. The angles that are usually measured are the talus–first metatarsal angle, talocalcaneal angle, and the calcaneal pitch (**Fig. 8**).[36] These angles are used to follow the amount of correction achieved by an intervention, whether operative or nonoperative. On the dorsoplantar view, the talus–first metatarsal angle, the talonavicular coverage angle, and the talonavicular percent uncoverage are appreciated (**Fig. 9**).[36,37]

MANAGEMENT

The management of flatfoot depends on the presence or absence of symptoms and the duration of these symptoms. The management of the symptomatic patient usually starts with conservative intervention, which includes the use of orthotics and physical

Fig. 5. Tiptoeing puts the hallux in dorsiflexion and the hindfoot in neutral, restoring the medial arch in a flexible flatfoot.

therapy. Physical therapy may include exercises to strengthen the arch as well as to teach a program for Achilles stretching. The literature contains conflicting reports on the efficacy of using orthoses for the treatment of flatfoot.[38–43] Customized and modified foot orthoses may normalize muscle activity in the flatfoot.[41] The Helfet heel seat shoe orthoses was introduced in 1956 for the treatment of the FFF[44] followed by the University of California Biomechanical Laboratory shoe insert in 1976.[45] The aim of using foot orthoses is to put the foot in a biomechanically better position to function.[39] Their mode of action is believed to rely on limiting subtalar motion, decreasing hindfoot eversion, and fixing the hindfoot in neutral, thus restoring the medial arch. Banwell and colleagues[38] performed a systematic review of the use of foot orthoses in FFF.

Fig. 6. Dorsiflexion of the hallux restores the medial arch in a flexible flatfoot (Jack's test).

Fig. 7. Holding the hindfoot in neutral and applying dorsiflexion to the foot distinguish pes planovalgus from pes equinovalgus.

Despite the moderate evidence that the use of foot orthoses may improve physical function, the evidence supporting their effectiveness in reducing pain and decreasing hindfoot eversion remains low.[38] Hard foot orthoses should be avoided in rigid flatfoot or the pes equinovalgus form in which exacerbation rather than relief of symptoms occurs. Soft gel pads should be used instead. Concomitantly, a heel cord stretching protocol should be initiated for an associated tight Achilles tendon. Patients who do not respond to conservative treatment are indicated for a surgical intervention. There is no defined cutoff for the duration of conservative treatment. The decision to transition to a surgical intervention should rely on the persistence and the lack of improvement in symptoms rather than cosmesis of the foot, which is usually the primary concern of the child's parents or caregivers. Inability to wear shoes comfortably may be another reason to move forward with surgical intervention.

PROCEDURES

The many procedures that have been described for the treatment of flatfoot can be divided into 2 categories: arthrodesis and nonarthrodesis procedures. Nonarthrodesis procedures have become the mainstay of surgical intervention. These techniques include reconstructive foot surgery and arthroereisis.

Fig. 8. Lateral radiograph showing the different radiographic measurements: the lateral talus–first metatarsal angle *a* (*red line* and *green line*), the talocalcaneal angle *b* (*red line* and *black line*), and the calcaneal pitch angle *c* (*black line* and *white line*).

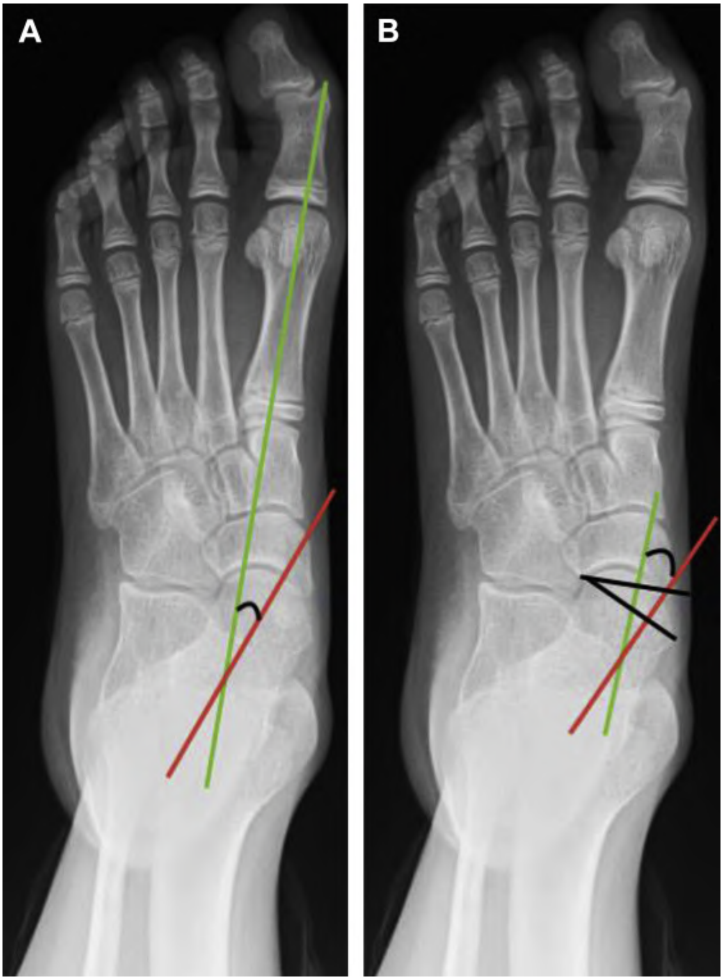

Fig. 9. Dorsoplantar radiograph showing (*A*) the talus–first MT angle and (*B*) the talonavicular coverage angle.

Reconstructive surgery includes soft tissue procedures used in conjunction with the realignment osteotomies. Soft tissue procedures alone, such as peroneus brevis with achilles lengthening, are ineffective and rarely indicated. The ultimate goal is to realign the hindfoot and correct the forefoot hyperabduction to restore a normal relationship of the foot to the weight-bearing line. The soft tissue procedures include lengthening of the peroneus brevis, talonavicular capsulorraphy, and posterior tibial advancement.[46–49] An Achilles tendon lengthening procedure is added depending on the status of the heel cord. Various bony procedures have been described. The difference is the number, location, and type of the osteotomies used. Anderson and Fowler[49] described an anterior calcaneal osteotomy for the treatment of FFF. These authors performed the osteotomy 4 mm proximal to the calcaneocuboid joint. The most popular and cited procedure in the literature is the lateral column lengthening osteotomy described by Evans[50] and later modified by Mosca.[46] Both osteotomies are done 1.5 cm proximal to the calcaneocuboid joint. Mosca's modifications of the Evan's procedure include a cosmetically more acceptable incision, an oblique osteotomy directed from proximal–lateral to distal–medial when compared with the classic straight osteotomy, the use of internal fixation, and the addition of the release of the abductor digiti minimi aponeurosis and the lateral plantar fascia, as well as the lengthening of the peronei as needed based on the intraoperative findings.[46,50] Rathjen and Mubarak[47] described an alternative technique that involved osteotomies of the calcaneus, cuboid and cuneiform. This was later referred to as the triple C osteotomy by Bouchard and Mosca.[48] A posterior translational osteotomy of the os calcis is another option if heel valgus needs to be addressed alone.[47,48,51]

Arthroereisis involves inserting a peg in the sinus tarsi to limit hindfoot eversion. The principle behind this procedure is blocking the lineal displacement of the talus during gait, which in turn stops the other components of pronation, namely calcaneal eversion, talar adduction, and plantar flexion.[52] Indications and contraindications for this procedure have not been delineated clearly. Persistent pain, overcorrection, and undercorrection have been reported.[53]

Arthrodesing procedures vary from selective mid-tarsal to triple arthrodesis. The most cited midtarsal procedure is the naviculocuneiform fusion.[54–56] Hoke described the navicular to medial and middle cuneiforms arthrodeses in 1931.[54,56,57] This procedure was a purely bony procedure and he relied on a plaster cast to achieve and maintain his correction.[54] Miller's procedure, on the other hand, fuses 2 joints: the navicular–medial cuneiform and cuneiform–first metatarsal joints. The advancement of the calcaneonavicular ligament and the posterior tibialis tendon is included in the procedure.[55,58] Duncan and Lovell[56] described a modified Hoke–Miller procedure that involves the fusion of the naviculo-medial cuneiform joint and the advancement of a subperiosteal flap to the plantar fascia to tension the latter to hold the corrected arch. Selective fusions have demonstrated good short-term results.[54,58,59] They all share the lack of long-term detailed follow-up.[56] Later, triple arthrodesis was used in the treatment of FFF. Long-term follow-up studies revealed good to excellent results in two-thirds of patients.[26] Arthrodesis procedures lead to arthritis in adjacent joints, although this finding was asymptomatic in some reports.[26,60] Procedures that combine reconstruction to realign the foot with triple arthrodesis are also described to treat FFF. Frost and colleagues[61] reported good results combining triple arthrodesis with lateral column lengthening of the calcaneus. Arthrodesis procedures should be kept as a last resort when other reconstructive options fail or when arthritis of the joints is symptomatic.

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