Overview of Treatment of Flexible Flatfoot Using Subtalar Arthroereisis

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Abstract

Flatfoot** is a condition in which the medial longitudinal arch is flat and with weightbearing the entire sole rests on the ground. **Pes planus** refers to the same condition, pes a Latin word meaning foot and planus meaning flat. Flexible flatfeet occur in both children and adults. Flatfoot deformit results of a combination of many structural factors. Flatfoot can be categorized as rigid or flexible. Flexible form has no single identifiable cause and is often asymptomatic. It may become painful and may require intervention. Treatment modalities include rest, physiotherapy, orthotics and anti-inflammatory medications. Understanding the radiographic findings is important when trying to assess the severity of a flatfoot deformity. Surgery is uncommon unless pain persists in spite of nonsurgical treatment. Surgical options include soft tissue procedures, realignment osteotomies and Subtalar arthroereisis. Subtalar arthroereisis as an adjunct procedure may hold promise for patients who have mild and more severe variants of posterior tibial tendon dysfunction (PTTD). The biomechanics of the implant function have not been fully elucidated, and questions remain about the best clinical indications. This article aimed to review flexible flatfoot and the using of Subtalar arthroereisis technique for the treatment of flexible flatfoot.

Keywords: Flexible Flatfoot ; Subtalar Arthroereisis

INTRODUCTION

Flatfoot deformity can affect either one foot (unilateral pes planus) or both feet (bilateral pes planus). It is the result of several structural factors combining collectively including increased subtalar joint eversion, the hindfoot eversion and valgus, and abduction of the forefoot is often present. The navicular bone might be subluxed to the dorsolateral direction in relation to the talus **(1)**. This talo-navicular subluxation is a contributing factor to pes planus or a biomechanical consequence of existing flatfoot of other causes**.** There is may be gastrocnemiusesoleus complex contracture (short tendo-Achilles) which may prevent normal dorsiflexion of the ankle joint and the mechanical stress shifts to the subtalar joint **(2,3)**.

Physical findings are suggestive of stage 2 posterior tibial tendon dysfunction provided that a flexible flatfoot is present and that there is no active inversion of the foot past the middle without recruiting the anterior tibial muscle-tendon unit. In a flexible flatfoot, a medial longitudinal arch is present when the foot is nonweightbearing; however, the arch collapses with walking or standing **(4,5)**.

Furthermore, during single leg standing, decreased in muscle activity (abductor hallucis, medial gastrocnemius, anterior tibialis, and vastus medialis) have been reported in flatfoot **(6)**. The abductor hallucis muscle acts as a dynamic stabilizer of the MLA, So lower activity in this muscle can lead to decrease biomechanical capability, decrease absorption of external forces and postural instability causing injuries **(3)**. Additionally, abnormal alignment of the foot leads to weakening of foot intrinsic muscles (abductor hallucis, flexor digitorum brevis, flexor hallucis brevis, and interosseous muscles) leading to musculoskeletal dysfunction and overuse injuries **(7)**. Furthermore, there is concentration of foot pressure in second and third metatarsal areas in flatfeet compared to the normal arch group during dynamic activities such as walking **(8)**.

Flatfoot can be categorized as rigid or flexible. When there is loss of arch height in both non weight bearing and weight bearing positions, it is termed as rigid flatfeet. but, when a normal MLA height is present in non-weight bearing condition and collapses with weight bearing is classified as flexible flatfeet **(1,5)**. Surgery is uncommon unless pain persists in spite of nonsurgical treatment. Surgical options include soft tissue procedures, realignment osteotomies and Subtalar arthroereisis. Fusion is not recommended in paediatric patients unless associated with a neuromuscular pathology **(9,10)**.

Diagnosis of flexible flatfoot:

1. **Clinical examination :**

Generalized ligamentous laxity ; hyperextension of the elbows or knees, touching the thumb to the volar forearm, hyperextension of the metacarpophalangeal joints to 90 degree and touching the ground with the palms while the knees extended. The child’s shoes should be examined; flatfeet may cause rapid and uneven shoe wear **(8).** Routine preoperative evaluation includes examination of strength, range of motion, and standing foot deformity and weight bearing radiographs of the foot. The patient should be observed during gait, because fatigue of the posterior tibial tendon may not be as apparent during a standing or seated examination **(11,12)**.

- ***Tiptoe test:***

In flexible flatfoot; MLA of the foot collapses in various degrees during weightbearing and forms again during raising up on tiptoe **(Fig. 1)**. In rigid flatfoot; the arch is not seen even the foot is not weight bearing **(13,14)**.

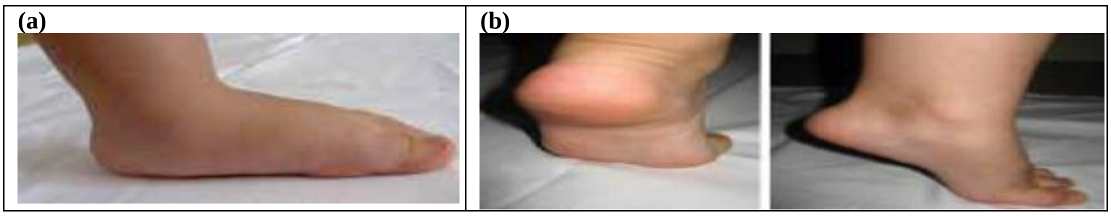

Fig. (1): (a) Collapse of the medial longitudinal arch in the weight-bearing foot, on posterior view, hindfoot valgus is observed. (b) Reconstruction of the medial longitudinal arch and hindfoot varus, while raising up on tiptoe is observed [14].

- ***Jack’s toe-raising test:***

Dorsiflexion of the hallux at the metatarsophalangeal joint the longitudinal arch can be created due to the "windlass action" of the plantar fascia in a flexible deformity, so it can differentiate flexible from rigid deformity **(14).**

Fig. (2): Jack's toe-raising test: when great toe is brought to passive dorsiflexion position, medial longitudinal arch is observed [14].

- ***The Silfverskiöld test:***

Clinically identify a contracture of the gastrocnemiusesoleus complex. In this test, the subtalar joint must be held in the neutral position to accurately assess ankle dorsiflexion **(Fig. 3)**. Dorsiflexion of <10 with the knee flexed indicates contracture of the soleus muscle, which indicates a contracture of the entire Achilles tendon. If dorsiflexion >10 is possible with the knee flexed, but <10 of dorsiflexion is possible with the knee extended, a contracture of the gastrocnemius muscle alone is present **(8,15).**

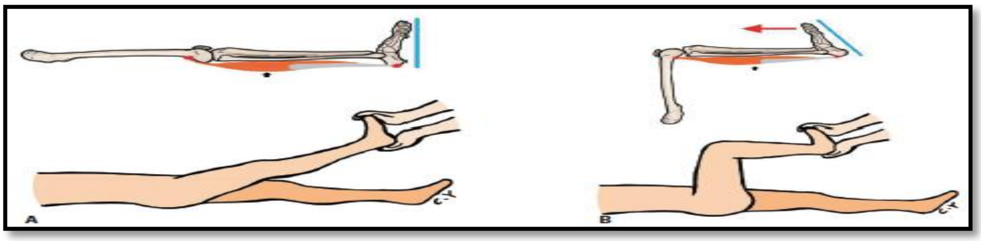

Fig. (3) The Silfverskiöld test: The participant is placed in the supine position with the knee extended. The hip and knee flexed at 90°. The angle is measured between parallel to long axis of fibula and parallel to long axis of 5th metatarsal. Arrows indicate gastrocnemius muscle [15].

Exclusion of rigid flatfoot deformity:

Neurological and myopathic disorders including muscular weakness, and contracture of the Achilles tendon, calcaneus equinus deformity together with spasticity (cerebral palsy). Painful and restricted hindfoot movements: tarsal coalition, inflammatory arthritis. Calcaneus equinus together with rocker-bottom deformity: congenital vertical talus. Pain elicited on pressing over navicular bone: accessory navicular bone or osteochondritis **(14).**

Direct inspection:

There is a straight or convex medial border of the foot. The lateral border is straight or concave (too many toes sign) **(Fig. 4)**. The midfoot sag and touches the ground. The hindfoot is in valgus alignment **(8,16).**

Fig. (4): Direct inspection of the flat foot: A) Convex medial border with midfoot sag. B) Valgus hindfoot and too many toes sign [16].

In asymptomatic cases of flatfoot, Volpe's classify flatfoot severity based only on clinical examination to mild, moderate, and severe **(Table 1) (17).**

Table (1) Volpe's treatment classification system, (RCSP: resting calcaneal stance position) (17).

	Mild	Moderate	Severe
Collapse of medial arch	Collapsed but arch is visible	Not visible	Not visible, convexity noted from talar head
RCSP	2°–5° valgus	6°–10° valgus	>10° valgus
Too many toes sign	Toes 4 & 5	Toes 3–5	Toes 2–5

- **Plain radiography**

Routine radiological imaging is not essential, but can be helpful in excluding other pathologies and for surgical planning. Radiographs should always include weight-bearing antero-posterior (AP) and lateral views of the foot and ankle. Multiple measurements can be performed on plain radiographs to quantify midfoot and forefoot abduction, the loss of the longitudinal arch and hind foot valgus **(Table 2, Fig. 5,6) (18).**

Table 2 Description of radiological measurements relevant to pes planus (18).

Measurement	Descripition	Normal range
Antroposterior:		
Talonavicular coverage angle	The angle formed between a line connecting the edges of the articular surface of the talus and the articular surface of the navicular.	0° to 7°
Anteroposterior talar 1st metatarsal angle	The angle formed from a line through the mid-axis of the talus and the long axis of the 1st metatarsal.	3° -11°
Anteroposterior talocalcaneal Angle (Kite's angle)	The angle formed by a line bisecting the head and neck of the talus and a line along the lateral surface of the calcaneus.	15° - 27°
Lateral:		
Lat. talar1st metatarsal angle (Meary's angle)	The angle formed from the bisection of the long axis of the talus and the 1st metatarsal.	2° - 10°
Calcaneal inclination	The angle formed between a line from the plantar surface of the calcaneus to the inferior distal articular surface and the transverse plan.	13° -23°
Talar declination	The angle formed between a line drawn along the long axis of the talus and the transverse plan.	18° -24°
Lateral talocalcaneal angle	The angle formed between a line bisecting the talus and a line from the plantar surface of the calcaneus to the inferior distal articular surface.	25° -45°
Moreau-Costa-Bartani angle	The angle formed between a line from the inferior posterior calcaneal tuberosity to the inferior border of the talonavicular joint and a line from the medial sesamoid to the inferior border of the talonavicular joint.	115°-125°
Antroposterior and Lateral:		
Cyma line	A line drawn along the talonavicular joint and calcaneocuboid joint.	Smooth double curve

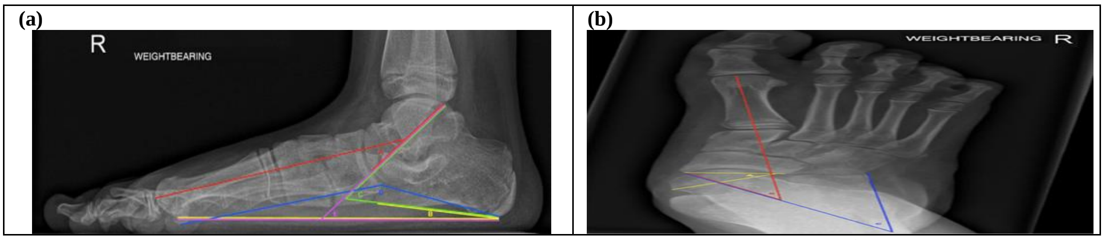

Fig. (5): (a) Radiological measurements from a weight-bearing lateral foot radiograph. Lateral talar 1st metatarsal angle: red ; Calcaneal inclination: yellow; Lateral talocalcaneal angle: green; Moreau-Costa-Bartani angle: blue; Talar declination: pink. **(b) Radiological measurements from a weight-bearing antero-posterior (AP) foot radiograph.** Talonavicular coverage angle: yellow; AP talar 1st metatarsal angle: red; AP talocalcaneal angle: blue [(18)].

Fig. (6): The cyma line: a) Normal, b) **The broken line is abnormal [(19)].**

Footprints analysis

Analysis of foot ground contact area is done using simple ink print on paper, plantar pressure analyzing plates, or with a pressure analysis system **(3).** Viladot divided flat feet according to the plantar area that on weightbearing touch the ground **(Figure 7): (a)** Grade 1: Ratio between the largest and narrowest diameter is less than 2**; (b)** Grade 2: Contact of the inner border of the foot on the ground but the arch is still present; (c) Grade 3: Disppearance of the longitudinal arch; (d) Grade 4: Ratio between midfoot /forefoot > 1. **(20).**

Fig. (7): Viladot's classification of flatfoot (on footprint) [(20)].

Subtalar Arthroereisis

Flexible flatfoot deformities also can be corrected by restricting the excessive eversion of the subtalar joint (a subtalar joint arthroereisis). Subtalar arthroereisis has been reported as a minimally-invasive, effective and low-risk procedure in the treatment of flatfoot mainly in children but also in adults **(21)**.

Arthroereisis (also arthroreisis, arthrorhisis or arthrorisis) derives from Greek, translated as to support a joint. The procedure involves correcting the excessive eversion and maintaining the subtalar joint in a more neutral position using an implant inserted into the sinus tarsi or adjacent to it **(**18).

In shortly, arthroereisis reestablish the medial foot arch and limit the movement of the subtalar joint without blocking it. The technique was first described by Chambers in 1946 **(21).** Subtalar arthroereisis may be performed as a standalone or associated with other procedure in treating painful flexible flatfoot **(22)**.

The operation is performed under regional, spinal, or general anesthesia to allow for the placement of a thigh tourniquet. This tourniquet placement helps to avoid compressing the FDL muscle belly, which is transferred in the third stage of the procedure **(23)**.

There are three techniques for subtalar arthroereisis: (Fig. 8) (21,24)

(1) Self-locking implants: Inserted directly in the sinus tarsi along its main axis, supporting the talar neck and prevent it collapsing down, thus limiting the talar adduction and plantarflexion.

(2) Impact-blocking devices: Screw insertion into the lateral side of the talus or calcaneus and its head is slightly more anterior to the posterior subtalar surface to impinge with the talar lateral process limiting its anterior gliding and to limit the internal rotation of the calcaneus (preventing eversion) **(21)**.

(3)Axis-altering prostheses: Screw insertion into the lateral side of the talus or calcaneus and its head just anteriorly to the posterior subtalar surface in contact with the lateral process of the talus, in order to modify the subtalar joint axis and to limit the internal rotation of the calcaneus.

The implants were made of metal or resorbable poly-L-lactic acid (PLLA). The most used techniques were; self-locking and an impact blocking implants ***(Caravaggi P et al, 2018*).**

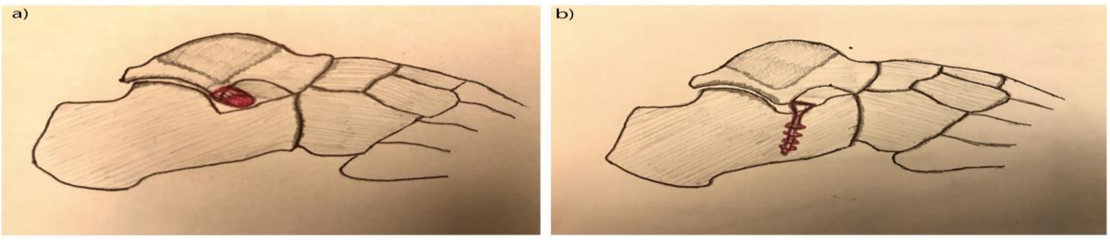

Fig. (8): Lateral view of a hindfoot show the difference in positioning between a self-locking (a) and an impact blocking (b) device (in red) [(21)].

Mechanism of action:

1-Biomechanical: Subtalar arthroereisis induces a triplanar modification of the foot limiting pronation through its three components (calcaneal eversion, talar adduction and plantar flexion) **(25).**

2-Proprioceptive action: A hypothetical proprioceptive action of these implants related to the density of receptors (mostly mechanoreptors) in and around the sinus tarsi (not proved) (**26).**

Advantages:

- Less invasiveness (mini-incision).
- Decreased post-operative edema.
- Shorter hospital stays.
- Possibility of performing associated soft-tissue and bony procedures **(21).**

Complications:

Complications may be divided into four main categories, including the consequences of:

(a) Inappropriate indications (unstable midtarsal joint, arthritis, rigid equinus).
(b) Technical error (extrusion, over- or under-correction).
(c) Adaptation/irritation (painful sinus tarsitis, peroneal spasm, soft-tissue entrapment).
(d) Biomaterial failure (wear or breakage) **(26).**

CONCLUSION:

Individuals with flat feet exhibit poor static and dynamic balance in comparison to those with normal feet, despite the fact that the increase in contact surface area can be seen as a support for postural stability.

Subtalar arthroereisis can be considered as an adjunct procedure for patients who have posterior tibial tendon deficiency.

Use of subtalar arthroereisis in surgical correction of flexible flatfoot seems beneficial with a low risk profile.

Further studies will help define the best results and outcomes. Also, the procedure does not limit future surgical options.

Conflict of interest: The authors declare no conflict of interest.
Author contribution: Authors contributed equally in the study.

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