Clinical and radiological diagnosis of flat foot deformity in children and adolescents

Mohsen Mohamed Abdo Mar'éi [1], Riad Mansour Megahed [1], Mohammed Said Mohammed Abdelhafez [1], and Reda Hussien El-kady [1]
[1] Department of orthopedic surgery, Faculty of Medicine Zagazig University, Egypt.

Corresponding Author: Mohammed Said Mohammed Abdelhafez.
Email:dr.mhmd.said@gmail.com **Telephone**: 01065319340

Abstract:

Background: The true incidence of flatfoot is unidentified, primarily because there is no consensual agreement on the strict clinical or radiographic criteria for defining a flatfoot. At the root of this dilemma is the lack of a universally known definition of a ‘‘normal,’’ in contrast to an ‘‘average height,’’ of the longitudinal arch. Traditionally, a flatfoot has been demarcated subjectively as a weight-bearing foot with an abnormally low or absent longitudinal arch. **Objective:** To Clinical and Radiological assessment of the flexible flat foot. **Conclusions:** The technique can be done safely in young children as there is no interference with the centers of ossification of the foot bones with minimal complications.

Keywords: Flexable Flat Foot, Children, Clinical, Radiological

INTRODUCTION

The true incidence of flatfoot is unidentified, primarily because there is no consensual agreement on the strict clinical or radiographic criteria for defining a flatfoot. At the root of this dilemma is the lack of a universally known definition of a ‘‘normal,’’ in contrast to an ‘‘average height,’’ of the longitudinal arch. Traditionally, a flatfoot has been demarcated subjectively as a weight-bearing foot with an abnormally low or absent longitudinal arch [(1)].

We may consider some parameters as the predisposing factors of flatfoot, such as age, sex, body composition, ligamentous laxity, family history, types of footwear and age at which shoe wearing began. Males were twice more prone to have flatfoot as females. Obese and overweight children were more likely to have flatfoot than those with proper weight[(2)].

Children with ligamentous laxity may also be prone to flatfoot due to impairment of arch development. Positive family history of flatfoot may be another important factor. Shoe wearing before the age of six may be another predisposing factor for flatfoot [(2)].

Types of flatfoot:

Pediatric flatfoot can be divided into flexible and rigid categories:

- Flexible flatfoot is characterized by a normal arch during non weight-bearing and a flattening of the arch on stance and may be asymptomatic or symptomatic [(3,4)].

ISSN: 0975-3583, 0976-2833 VOL 12, ISSUE 07, 2021

- ❖ Rigid flatfoot is characterized by a stiff, flattened arch in both weight bearing and non-weight bearing positions. Most rigid flatfeet are associated with underlying pathology that requires special considerations [3,4].

Clinical features

A-Symptoms:

Mobile flatfeet are usually asymptomatic. Cases with severe deformity present during childhood with the following complaints:

- ❖ Foot and leg pain especially during standing and walking. Pain may be pronounced as aching, throbbing or cramping including the medial longitudinal arch, lateral sinus tarsi region, heel or posterior calf.
- ❖ Difficulty in walking or running and easy fatigability with poor participation in physical activities.
- ❖ Unsightly appearance of the foot, Excessive shoe distortion and wear, Symptoms rise as age progresses [5].

B- On examination: the diagnosis of Flexable Flat Foot (FFF) is attained by:

1) **Loss of the medial longitudinal arch:** On weight-bearing position the foot downfalls with complete loss of the medial longitudinal arch, in non weight- bearing the foot appears relatively normal and with tiptoeing the arch is reestablished (Fig. 1).

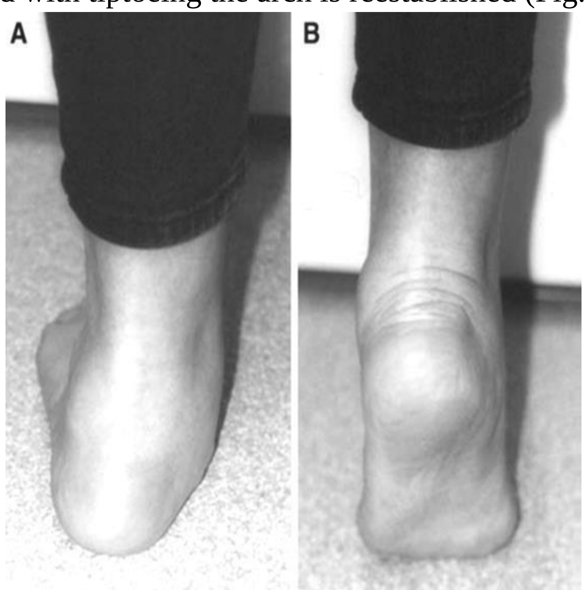


Figure 1. Left FFF. A) Weight-bearing, B) In toe-standing, heel valgus converts to varus and the longitudinal arch can be seen [6].

Flatfoot deformity is subdivided into three grades regarding the condition of the medial longitudinal arch on weight bearing position.

Grade 1 (mild), when the arch is slightly decreased, grade 2 (moderate), when the arch is absent but the medial border of the foot is straight and grade 3 (severe), when there is no arch and the medial border of the foot is convex (fig.2) [7].

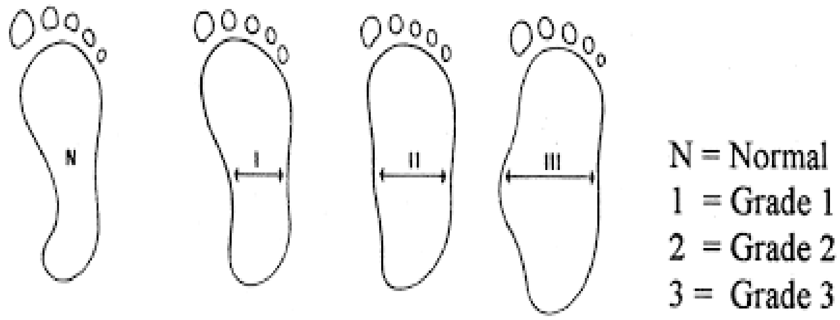


Figure 2. Showing grades of flexible flatfoot [7].

2) **Heel valgus:** Normally a plumb line ran from the middle of the popliteal space (longitudinal axis of the leg) must be parallel with the Achilles tendon; if the latter is disposed medial or lateral this means hindfoot varus or valgus respectively. The angle that the heel makes with the longitudinal axis of the leg is called posterior tibiocalcaneal angle (PTC angle) (fig.3) [7].

Heel alignment is normal with 0° to 5° of valgus .The PTC angle is used in case of significant heel valgus. The hindfoot valgus subdivided into the following grades regarding the measurement of the PTC angle, Normal 0° to 5°, Mild 5° to 10°, moderate 10° to 15°, Severe> 15°[7].

Figure 3. Left FFF with heel valgus can be seen [5]

3) **Positive toe extension test of Jack :** (Great toe extension test):

Passive dorsiflexion of the hallux leads to increase of the medial arch and inversion of the heel (Fig. 4). When this happens in a patient who on weight bearing displays collapsed medial longitudinal arch and everted heel, this means FFF.

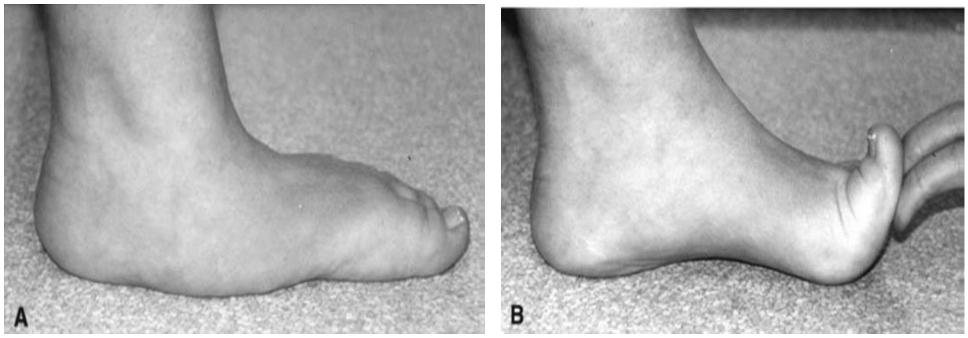


Figure 4. Showing positive Jack's toe-raising test[35].

4) Forefoot abduction:

Heel bisector expresses relationship between heel and forefoot; normally it runs between second and third toes, if it runs medial or lateral to this, this means forefoot abduction or adduction respectively. Forefoot abduction is thought to be mild when heel bisector runs through the second toe, moderate when heel bisector runs between first and second toes and severe when heel bisector runs through or medial to the big toe.

Viewing the patient from behind helps the examiner to assess forefoot abduction. The toes visible lateral to the heel are counted up. The finding of one or two toes visible lateral to the heel is normal. In cases of significant forefoot abduction, more toes are visible. This "too- many-toes" sign is a test to diagnose forefoot abduction (Fig. 5) [7].

Figure 5. Too many-toes sign. Three lateral toes are visible on viewing the foot from behind. (The front part of the foot (forefoot) is often splayed out to the side. This leads to the presence of a "too many toes" sign)[7].

5) **Prominence of the talar head on the inner part of the foot** with overlying tenderness. The sublaxed talar head is always prominent in the infero-medial aspect of the flatfoot. The prominence is thought to be severe, when callosity appears in the underlying skin and moderate, when this cutaneous change is not existing [7].

6) **The orthopedist** is urged to avoid the use of the term‘‘pronated’’ as a substitute for the term ‘‘flatfoot.’’ While it is true that pronation is a component of the hindfoot deformity in this condition, the subtalar joint is dorsiflexed and externally rotated, the midfoot is abducted, and the forefoot is supinated in relation to the hindfoot(6).
7) **Tightness of Achilles tendon** is proved by limited ankle joint dorsiflexion. With the knee extended and the foot is brought in a subtalar neutral position, passive ankle dorsiflexion is attempted Normally dorsiflexion is possible, but in cases of long-standing pes planus, dorsiflexion past neutral may be restricted because of the development of planter flexion contracture (7). Assessment of true ankle dorsiflexion and Achilles tendon excursion are important. In order to separate and evaluate the motion of the talus in the ankle joint, the knee is flexed and the ankle is dorsiflexed while upholding neutral alignment of the subtalar joint (7).

Dorsiflexion is assessed as the angle between the plantar-lateral border of the foot and the anterior tibial shaft. Less than 10^0 of dorsiflexion means contracture of the soleus muscle, which means contracture of the entire tendo-Achilles (5).

The knee is then extended while upholding neutral alignment of the subtalar joint and trying to keep dorsiflexion of the ankle joint.

Dorsiflexion is reassessed. If more than $10^0$of dorsiflexion was possible with the knee flexed, but less than 10^0 of dorsiflexion is possible with the knee extended, the gastrocnemius alone is contracted (8).

One should distinguishs contracture of the gastrocnemius from contracture of the entire triceps surae (tendo-Achilles), because both can cause pain that needs surgical management, but the surgical technique obviously differs between them by (Silfverskiöld – Test) (Fig. 6(8).

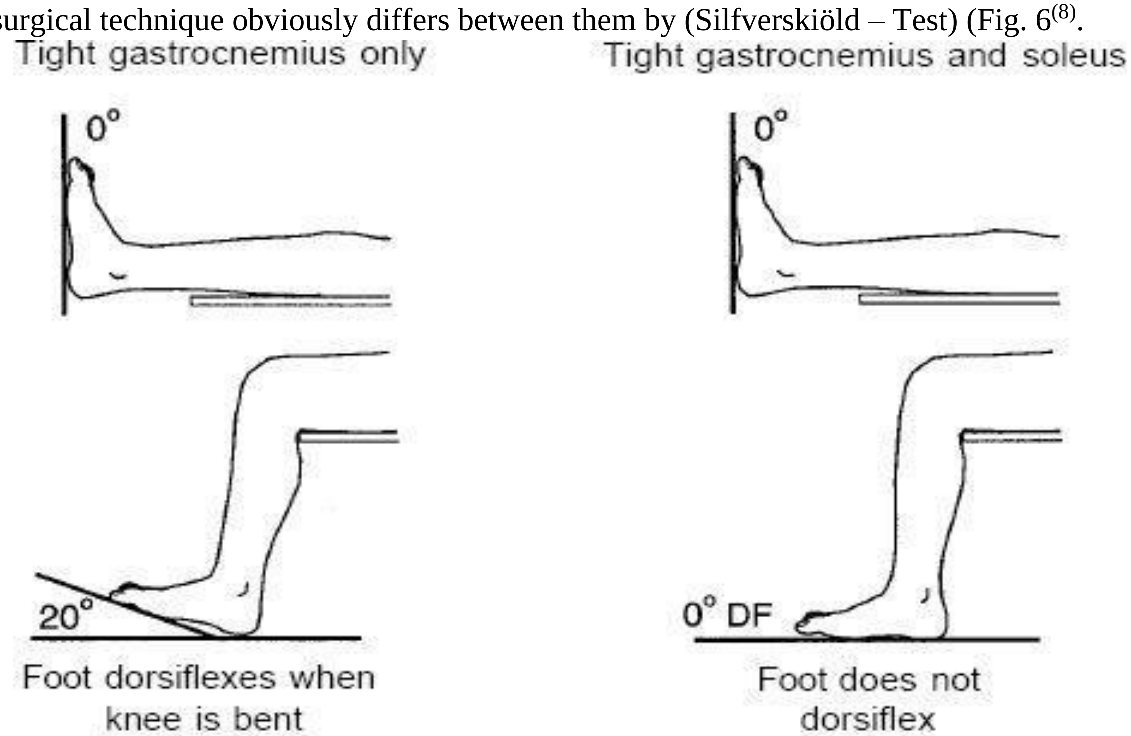


Figure 6. Determining the Contribution of the Gastrocnemius and Soleus to a "Tight Heel Cord"(8).

8) Plantar skin callosity on the medial aspect of the sole.

9) General examination for generalized ligamentous laxity which may be existent proved by excessive motion of the foot in dorsiflexion, hyperextension of the elbow, hypermobility of the thumb allowing it to touch or go beyond the arm, genu recurvatum of the knee and total hyperextension on the metacarpophalangeal joints [(7)].

It is often directing to question about familial flatfeet and to assess the feet of other family members who are present in the examination room[(8)].

General examination also held out to find other skeletal deformities e.g. tarsal coalition (fusion of tarsal bones), accessory navicular bone, generalized ligamentous laxity or any medical disease. Neurological examination was served to exclude cases of spina bifida, cerebral palsy, poliomyelitis and myelo-meningocele[(9)].

Radiological assessment of the flexible flat foot

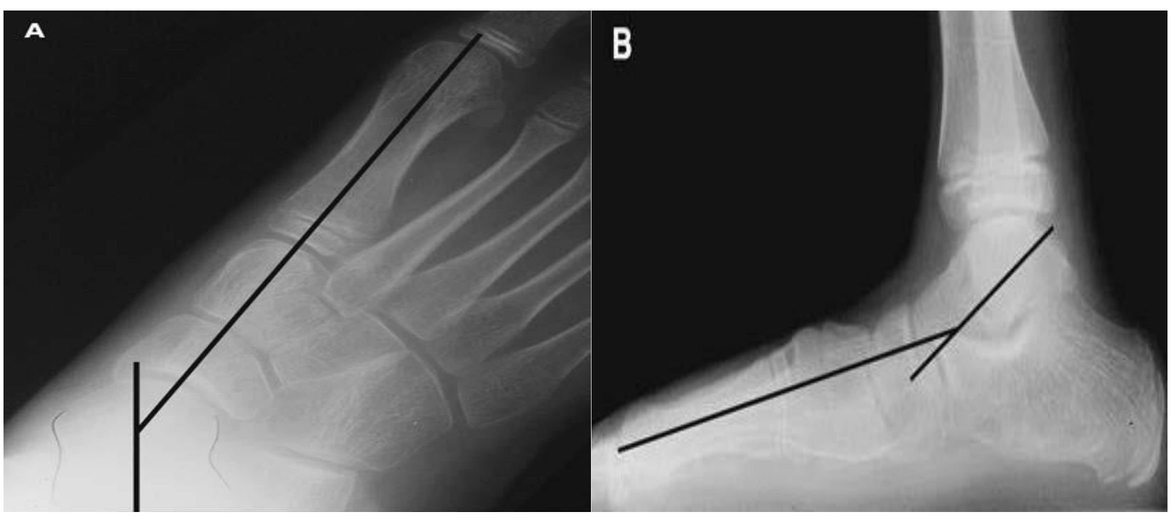
Radiographic evaluation is a critical tool in evaluation of pediatric foot abnormalities [(10)].

Weight-bearing radiographs of the flexible flatfoot which show peritalar sublaxation (the site of the midfoot sag) with uncovering of the talar articular surface are the basic radiological views, proved by rise in the lateral talo- metatarsal angle (L-TMTA) may be negative as well as a decreased calcaneal pitch angle (CPA) due to equinus position of the os-calcis [(11)].

The center of rotation of angulation (CORA) can be done to the foot in a modified version. The site of intersection of the axis of the talus and that of the first metatarsal in a flatfoot is most often be in the head of the talus or at the talo-navicular joint, which means that the midfoot sag is at the talo-navicular joint (Fig . 7) [(12)].

But the CORA can alternatively be placed at the naviculocuneiform joint, or within the body of one of the mid-tarsal bones.

In a simple flatfoot, the CORA should be in the head of the talus or at the talo-navicular joint, which means eversion of the subtalar joint that is apparent as abduction at the talonavicular joint (Fig. 7) [(13)].



ISSN: 0975-3583, 0976-2833 VOL 12, ISSUE 07, 2021

Figure 7. Standing radiographs of a flatfoot showing talus and first metatarsal axis lines crossing at the center of rotation of angulation (CORA) in the center of the head of the talus, indicating a single deformity at the talo-navicular joint. (A) Anteroposterior view, (b) Lateral view [13].

There are different radiographic views of the foot to reveal foot lesions and abnormalities. Computerized tomography especially in the coronal plane is the most informative. Magnetic resonance imaging is needed for the immature foot as well as the non- osseous forms of coalition because visualization of cartilaginous and fibrous tissue is reached[13].

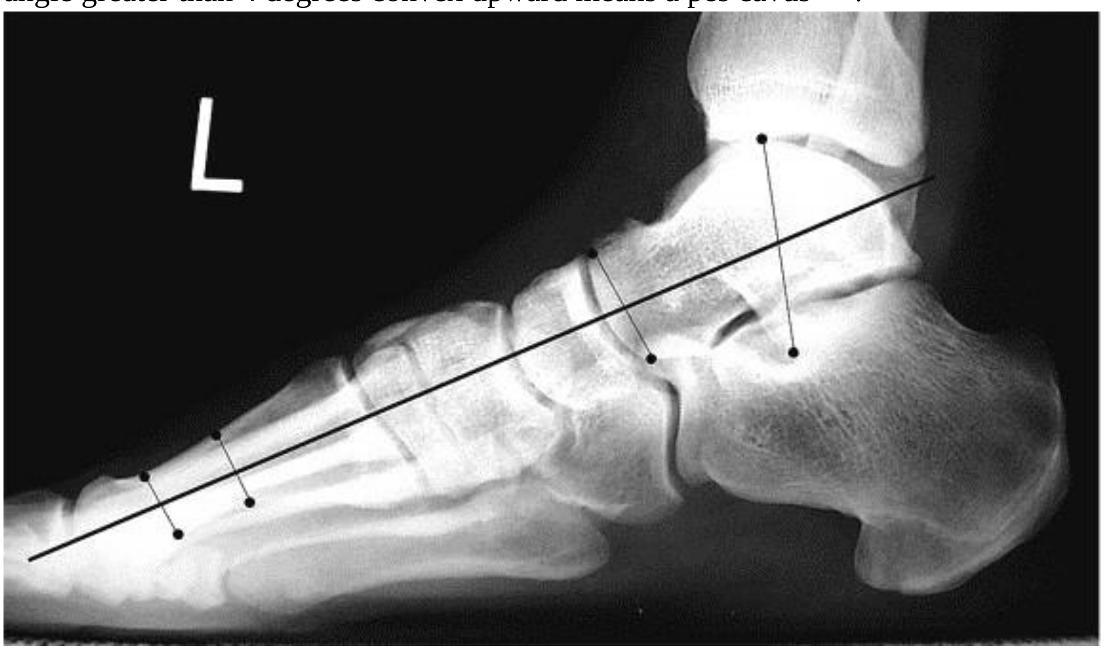
The most popular of these are the antero-posterior (AP), medial oblique and the lateral foot radiographs; accurate radiographs of the foot are those done in the standing position.

A) Weight-bearing lateral radiographs

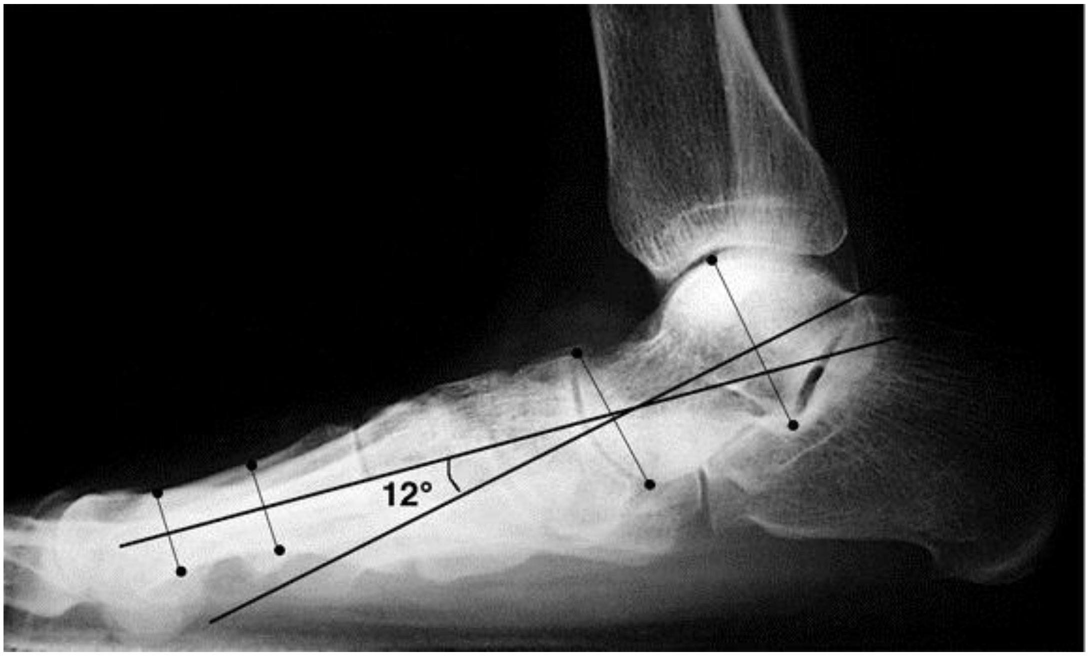
1-The Lateral talar - 1st metatarsal angle(Meary's angle)

This is the angle between the axis of the talus and the axis of the first metatarsal. This angle measures the relation between the forefoot and the hindfoot in the lateral view (Fig.19-A). This line is used as a measurement of collapse of the longitudinal arch. [13]

In the normal weight-bearing foot, the midline axis of the talus is collinear with the axis of the first metatarsal. Angles between +4° and -4° are accepted as representing a normal weight-bearing medial longitudinal arch. An angle that is greater than 4° convex downward is thought to be pes planus (Fig.8-B) with an angle of 15° - 30° is moderate, and greater than 30° severe. An angle greater than 4 degrees convex upward means a pes cavus [13].



A

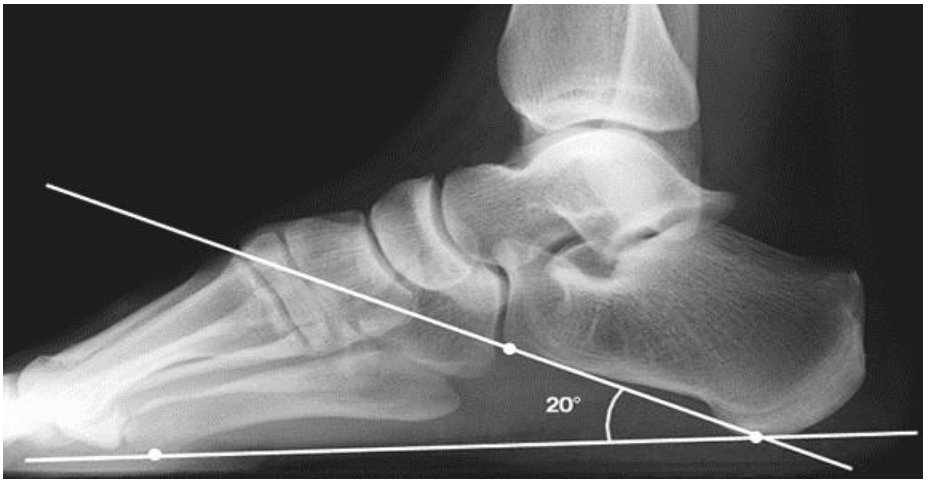


B

Figure 8: Lateral talar - 1st metatarsal angle. A)Normal Meary's angle. The long axis of the talus in line with that of the first metatarsal [14]. B) The long axis of the talus is angled plantar ward in relation to the first metatarsal, consistent with pes planus [13].

2- The Calcaneal pitch angle (CPA)

This angle evaluates the longitudinal plantar arch on the weight-bearing lateral film (Fig. 9-A). It is drawn by a line which crosses the weight-bearing tips of the calcaneus and the first metatarsal head with another line that passes across the planter limits of the calcanenus. The normal average value is 25°; the range of acceptance is 15° to 30°. In flatfoot the angle is decreased. (Fig. 9-B)[13].



A

B

Figure 9: A) Normal calcaneal pitch. B) Decreased calcaneal pitch indicating pes planus(14).

B) Weight-bearing AP radiographs

1- The Talonavicular coverage angle

A measurement that is quite useful for assessing pes planus on AP views is lateral sublaxation of the navicular on the talus, or talonavicular uncoverage. This is an indication of forefoot abduction. This measurement is taken off a weight-bearing AP. This angle denotes the degree of shift of the navicular on the talus. Two lines are drawn, one connecting the edges of the articular surface of the talus, and one connecting the edges of the articular surface of the navicular. The angle made by these two lines is the talonavicular coverage angle (fig.10-A and B). An angle of greater than 7 degrees means lateral talar sublaxation (14).

A) Normal talonavicular coverage angle. The angle between the lines on the articular

B) Talonavicular uncoverage indicating pes planus surfaces of the talus and the navicular is less than 7 degrees

Figure 10. The Talonavicular Coverage Angle [14].

2- AP Talar - 1st metatarsal angle

The alignment of the forefoot with respect to the hindfoot in the AP x-ray is identified by the Talo-metatarsal angle (TMT angle) which is made by the intersection of the axis of the talus with the axis of the first metatarsal. Normally, the axis of the talus matches with the axis of the first metatarsal .i.e. the AP TMT angle is 0^0. In flatfoot the forefoot, diverges lateral in relation to the hindfoot i.e. valgus deformity, and the axis of the first metatarsal swerves lateral to the talar axis (fig. 11) [13].

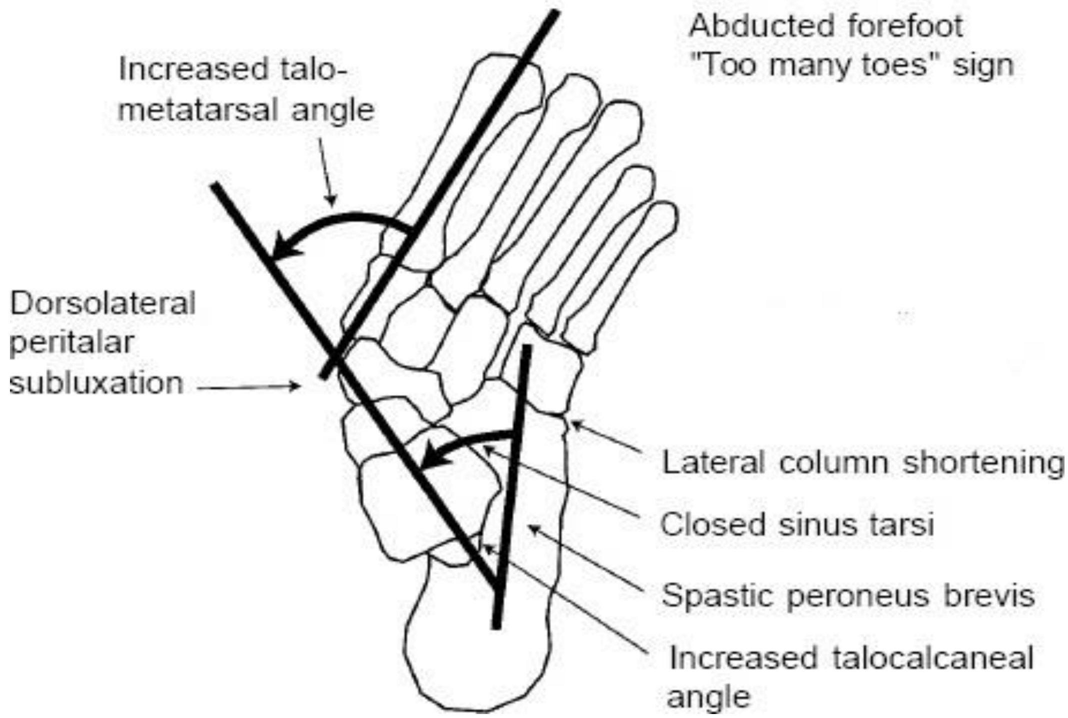


Figure 11. Weight bearing AP in flatfoot shows increased talo-metatarsal angle (forefoot abduction) and increased talo-calcaneal angle [15].

This is another method for assessing the degree of midfoot and forefoot abduction. A line drawn through the mid-axis of the talus should be in line with the first metatarsal shaft (fig. 12-A); if it is angled medial to the first metatarsal it means pes planus (fig. 12-B) [14].

A- Normal

talar1 st metatarsal angle on AP view. A line drawn trough the mid- axis of the talus passes through the base of the first metatarsal and is angled laterally in relation to the long axis of the shaft of the metatarsal.

B-Abnormal talar-1st metatarsal angle, angled medial to the first metatarsal.

Figure 12. The AP Talar - 1st metatarsal angle [14].

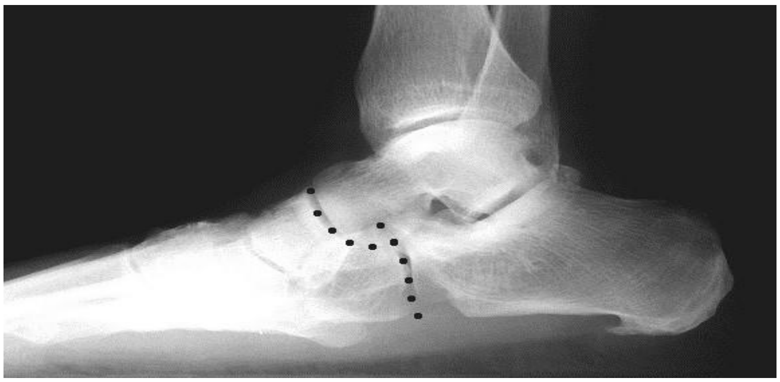
The Cyma Line

A cyma line is an architectural term labelling the union of two curve lines. A normal midtarsal joint should make a smooth cyma between the talo-navicular joint and calcaneocuboid joint on both the AP and lateral views (fig.13-A, 14-A). If the cyma line is smashed it proposes "shortening" of the calcaneus relative to the talus (fig 13-B, 14B). This is often just a radiographic shortening possibly due to rotation of the talus on calcaneus (typically seen in a patient with flatfoot including loss of the medial arch). It may, however, be due to actual shortening of the calcaneus, so it may be useful to do a lateral column lengthening in addition to medial column stabilization [13].

A. Normal AP cyma line: smooth &continuous **B.** Broken cyma line.

Figure 13. The AP CYMA Line [14].

A



B

Figure 14. The Lateral CYMA Line. A) Normal lateralCyma line (Line connecting talonavicular joint and calcaneocuboid joint is smooth and continuous) , B)Broken lateral Cyma line of pes planus. [14].

CONCLUSION:

The technique can be done safely in young children as there is no interference with the centers of ossification of the foot bones with minimal complications.

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