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CURRENT OPINIONS AND BIOMECHANICAL CONCEPTS IN THE TREATMENT OF FLEXIBLE FLAT FOOT

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ABSTRACT

The flat foot is a distinct medical condition within the deformities of foot and it has a prevalence of about 27% in adults. In children, the prevalence is variable depending on the age. Although the condition is predominantly idiopathic, in children it may be related to neuromuscular disease(s) and other disorders, including tarsal coalition and accessory navicular syndrome. Basically, similar principles of correction apply to both the treatment of flexible flat feet in children and to the treatment of flat feet in adults, except for the case that, in children, there is no rupture of the posterior tibial tendon, where rigid deformities are less common.The flat foot is a postural condition also known as a pes planus or fallen arches. It is a consequence of the collapse of the medial arch of foot. The major function of the longitudinal arch is to help propelling the foot and to attenuate the shock while being in orthostatic posture and while walking. A detrimental effect of the flat foot is that it decreases the capacity to absorb the shock due to the collapse of the longitudinal arch.Flat foot is a consequence of the laxity of the soft parts that support the longitudinal arch, the posterior tibia and intrinsic muscles, the plantar and tarsal fascia, as well as the deltoid and calcaneonavicular ligaments.Among these, the posterior tibia is considered the main dynamic structural support of the arch. When other supporting tissues are loosened, an even greater load is placed on the posterior tibia to maintain the arch. Muscle fatigue and dysfunction is a common cause of flat foot and it may lead to other problems, such as stress fractures and plantar fasciitis.This deformity may occur early as a congenital deformity, but it may occur as you grow older, gain weight, and decrease in the strength of the soft tissues that support the arch.The flat foot may not always lead to other pelvic limb deformities. Many people have flat foot and claim no symptoms.

Key words: Flat foot, updates and latest developments in the field, Classification, Flat foot with no evolutive potential, Mosca Procedure, Burnei Procedure.

Introduction

Flat foot is a condition where the longitudinal arch of the foot is lost. It also involves mesotarsal abduction and valgus deformity of the posterior foot. The quality of life as well as leg function [1] are diminished in flat-footed patients except for those with no evolutionary potential[2].

In flexible flat foot, the arch is visible when the patient is resting as the foot is not loaded with body weight but it is lost in orthostatism; however, in rigid flat foot, the arch is absent in both positions, *i.e*. while walking and while resting. Flexible flat foot is common in young children and it may often be cured with no treatment, whatsoever. The height of the plantar arch is variable; however, the exact incidence of flexible flat foot in children is not known as it is often misdiagnosed. This disorder may be congenital or developed.

History:

For many years, flat foot has been seen as a disability implying a limited physical capacity only in relation to intense physical efforts.

The wide range of synonyms for flat feet includes: pes planus [3], calcaneovalgus [4], pes valgus [5], flexible (with) flat feet [6], platfus flexible [7], plano valgus [8], posterior postural valvus [9], flat hyperboot [10], acute foot [11].

Although flat foot has been addressed by many papers, an accurate definition still remains elusive. According to Burnei et al. it is a change in the medial protarsus and mesotarsus that results in the collapse of the medial radius [2].

Clinically, it has been noticed that people with flat feet usually claim pain. The medial arch is lowered and the heel is everted. The dimensions of the eversion give the valgus of the protarsus and induce painful deformities, and, the larger the valgus, the more severe the pain is.

Some of these people were physically limited by their flat feet and they were considered "weaker", being less able to walk, to travel distances or to work efficiently. From the perspective of strengthening the "weak" flat feet, various arch supports have been developed and their basic principles are still incorporated in orthotic therapy. Nevertheless, an exact definition of what exactly stands for a flat foot remains debatable and the same happens with the premise that flat feet are problematic. There is no doubt that some flat feet are associated with pain and disability and that orthotic therapy may be beneficial [12]. However, there are many doubts and disputes that children's flat feet are considered a problem and there are even more disagreements about the use of orthoses in children, especially in asymptomatic children [13]. The notion of prevention has addressed the children with flat feet who had been treated with orthoses in an effort to save them from future disability. Unfortunately, this notion [14-18] is not yet documented and clinicians continue to have differing views in relation to the management of children with flat feet.

The various techniques used to assess flat feet had no contributions to defining this condition. The height of the medial longitudinal arch, the heel angle and various footprints were used to measure the "flatness" of the foot. Another subject of numerous debates among clinicians and researchers was represented by clinical measures of feet. Over the last 20 years, we noticed efforts in terms of the investigation of clinical measures of feet by assessing the basic principles of reliability and validity [19]. Basically, the reliability of these measures is poor and their validity is questionable [20]. A very few studies addressed the use of these measures in children's feet.

Aetiology and pathogenesis:

The phrase "flat foot" describes a foot deprived of the normal longitudinal arch

and whose ankle stands in the valgus position. It may be classified as rigid or flexible. A rigid flat foot is often related to a tarsal coalition or to a vertical talus, and a flexible flat foot is considered a normal option. Flat foot is normal in children aged 6 to 7 years. A rigid flat foot is always flat, compared to a flexible foot which appears to be normal when it does not support body weight and which becomes flat when the patient is standing. Where a flexible flat foot is asymptomatic, no treatment is guaranteed, but when it becomes symptomatic, the arch supports are often incorporated. Where the deformation is rigid, then the root cause must be addressed (eg, tarsal coalition, vertical talus).

Flat foot is a physiological condition in new-borns and young children. Children always pronate their feet as they learn to walk to improve their support base as well as to gain more stability. The flat foot is very common in young children and it is considered an anatomical variant of ligament laxity that does not require treatment.

The age of six is the critical age for the development of longitudinal arches. The arch has a natural tendency to continue to develop after this age; numerous studies have shown that the prevalence of flat feet is higher in 6-year-olds compared to 10-year-olds.

In an exhaustive study involving 2,300 children in rural India, Rao and Joseph [21] noted that the prevalence of flat feet was higher in the shoe-wearing feet and quite low in the barefoot feet. This suggests that closed toe shoes may impede the natural development of the longitudinal arch. Other studies have found similar patterns; a study conducted on 1846 adult subjects by Sachithanandam and Joseph [22] outlined that the prevalence of flat feet was lower in people who started wearing shoes after the age of 16. In a study conducted over 1851 Congolese children, Echarri and Forriol [23] demonstrated that the development of the foot longitudinal arch was influenced by three factors: age (younger subjects), sex (male subjects) and shoe-wearing subjects. These observations are in direct contrast to a previous statement made by Kelsey that the type of footwear played no a role in the occurrence of flat feet.

In addition, numerous studies have found a relation between obesity and the persistence of flat feet in older children.

The flexible flat foot is caused by the laxity of ligaments. The flat foot or fallen arches developed by adults, is usually thought to be caused by posterior tibial tendon failure. Obesity, neuropathy, soft tissue trauma and bone trauma are a few possible causes of tibial tendon failure.

Clinical data:

During examination, the loss of longitudinal arch of the foot which may or may not be associated with posterior valgus is often evident.

X-ray and imaging investigations:

X-ray procedures implies that the foot is able to support the body weight. X-rays should catch the lateral and anteroposterior perspectives. Magnetic resonance imaging (MRI) may also be used to determine a diagnosis for difficult cases. Computed tomography indicates bone loss or the presence of certain damages due to flat feet.

Classification:

Recently, Burnei et al. [2] came with new developments in this field: classification of the flat foot and an original treatment procedure for the flexible flat foot with evolutionary potential.

A) The evolutionary-potential flat foot

The temporary flat foot stands for the foot where the development of plantar arch and dome is still in progress. It is the normal foot which is found in different

proportions in relation to age, it has a higher incidence in children up to 10 years old and who have not been diagnosed with congenital synostosis or vertical talus.

Asymptomatic flexible flat foot (AFFF) is characterised by the presence of the plantar arch which however disappears in orthostatism and in the unilateral support stage. It is configured in the digitigrade position. Asymptomatic flexible flat foot should not be treated. These children should wear shoes properly adjusted to their age and foot configuration. Asymptomatic flexible flat foot raises a series of debates related to the prophylactic wearing of certain foot-related accessories or devices or even orthoses.

Patients in this group may develop pain or they may even develop rigid flat foot.

The aim of the treatment is to correct the flat foot and to avoid the development towards other forms that may give discomfort. Limited studies [24] [25] have shown the correction of the plantar arch with the help of devices and orthoses, although these cures may be attributed to the spontaneous evolution towards healing.

In children over 6 years of age, studies have shown that, after 2 years of treatment with rigid orthoses, there X-rays outlined the development of the medial radius [26]. Relevant studies on large groups and control groups shall undoubtedly emphasize their necessity and role. The dispute of whether or not to prescribe accessories or devices (such as orthoses) was also due to the argument that these devices cause no harm. However, the opponents of this method claim that wearing these aids for a long time leads to unnecessary expenses, dependence on orthoses or even causes psychological effects in adulthood.

On the other hand, the supporters of this treatment scheme claim that adolescents with moderate or severe flat foot document a double rate of pain in the knee or lumbar spine [27].

These controversies bring to light the need for special manufacturing plants able to manufacture children's footwear according to unique standardized rules as a number of authors point out that the existing footwear is inadequate [28]. Children's footwear must be supple, it must have a plantar support, it must allow the foot to rest on the support points and on the outer edge of the foot in order to give the possibility of developing a strong and elastic arch. This footwear may replace accessories or orthoses; furthermore, it should provide comfort for those with normal feet and maximum capacity to effort and sports performance.

Symptomatic flexible flat foot (SFFF). The pain may occur inconsistently and may be increased by effort. In case of complications (tendinitis, tenosynovitis, plantar fasciitis, etc.) the pain becomes constant.

The treatment consists of stretching and muscle strengthening exercises, orthoses and supportive soles [29].

Occasionally, patients with asymptomatic, painless flat feet who wear or who do not wear orthoses become symptomatic. To date, there is no evidence that preventive treatment with orthoses or other shoe inserts would prevent the development of symptomatic FF in the future [30]. According to their case portfolios, many practitioners had patients with AFFF treated with orthoses or who had been given the opportunity to wear special, custom shoes, which helped them recover part of the amplitude of the arch and which avoided the development towards the SFF. However, these findings are not statistically relevant.

B) Flat foot with no evolutionary potential.

This foot is usually seen between 1 and 2 years after the child starts walking and it is painless. If it occurs, it shall remain as such throughout the child's life.

There are many people over the age of 60 who had reported having painless flat feet during their childhood, and who had lived a normal life; some of them had even practiced high performance sports. Currently, the diagnosis of these flat feet requires a longer period of time involving in adolescence or even adulthood. The only diagnostic criterion is the pain-free development. There is no clear data in relation to the exact prevalence of this form of flat foot. Given this context, the definition of flat foot remains evasive [31].

Up to the moment the diagnosis is clearly determined, this condition may be added to the temporary FF group. Paraclinical investigations should determine the aetiogenic and pathogenesis diagnosis of this condition.

C) FF rigid

Basically, this is a painful condition. The plantar arch is not seen in the digitigrade position. Usually, patients with rigid FF withdraw from school sports. As children diagnosed with evolutive, flexible and painful flexible flat feet grow older, they may develop rigid feet. In adults and particularly in the elderly, this condition may worsen and plantar arches may collapse. The foot is known as the rigid foot and has no plantar arch even when the foot is raised. The rigid flat foot diminishes the quality of life [32].

The developed flat foot is usually considered to be caused by the posterior tibial tendon dysfunction [33].

Congenital rigid flat foot occurs at birth and it is caused by the vertical talus and tarsal synchondrosis. The acute development is followed by pain and changes of the foot shape which is incompatible with wearing proper footwear.

A rigid flat foot is often associated with a tarsal coalition or a vertical talus [34].

The vertical talus is treated with plastered immobilizations, physiotherapy followed by surgical interventions.

Tarsal coalitions are fibrous or cartilaginous connections between the talus and the calcaneus or between the calcaneus and the navicular and occur during the intrauterine development. Evolving synostoses also occur and cause foot stiffness. Walking becomes painful and the fibular muscles contract and refract.

Neglected rigid flat foot is a condition that has not been diagnosed or treated and which is secondary to potentially evolving, flexible or painful flexible feet. This is much rarer than congenital rigid FFs.

Neurological and myopathic RFF are found in cerebral palsy, poliomyelitis, peripheral neuropathy, Duchenne muscular dystrophy, etc. In these conditions, the deformity of the foot appears more frequently as a flat valgus foot.

The rigid neuro-muscular flat foot is characterized by the limited mobility of the subtalar joints. It is non-physiological, associated with pain and has a serious pathology. The vast majority of children with cerebral palsy have rigid flat feet.

Rigid flat foot is caused by bone abnormalities such as tarsal coalition, congenital vertical talus or arthritis. Conservative treatment for flexible flat foot may include stretching, proper shoe wearing and / or casting. Surgical treatment for flexible flat feet may include soft tissue correction, fusion and / or osteotomy.

Conservative treatment for rigid flat foot includes nonsteroidal anti-inflammatory medication, proper shoe wearing and / or casting. Surgical correction of the rigid flat foot may include the excision of either the cuneonavicular coalition or the talocalcaneal coalition, the Mosca intervention consisting of osteotomy of the calcaneus and elongation of the lateral spine, or the reconstruction of the medial radius of the foot on the calcaneus-metatarsal splint after completing the Burnei procedure.

Treatment:

The purpose of flat foot treatment is to determine an optimal support for the soft tissue as well as to provide proper bone alignment. Flexible flat foot does not always require treatment. However, if it is painful or if there is an echinus contracture, then treatment may be needed. Conservative treatment for flexible flat feet may include stretching, proper shoe wearing and / or casting. Surgical treatment for flexible flat feet may include soft tissue correction, fusion and / or osteotomy. Conservative treatment for rigid flat foot includes nonsteroidal anti-inflammatory medication, proper shoe wearing and / or casting. Surgical correction of the rigid flat foot may include excision of either the cuneonavicular coalition or the talocalcaneal coalition, surgical Mosca procedure consisting of osteotomy of the calcaneus and elongation of the lateral spine (**Fig 1**), or reconstruction of the medial radius of the foot on the calcaneus-metatarsal splint after the completion of the Burnei procedure (**Fig 2**).

Flexible flat foot

The flat foot or pes planus / pes valgus is a common condition in young athletes. Flat foot is seen as a normal position of the foot up to the age of 6 to 8 years old. Most young athletes having flat feet are asymptomatic and require no interventions whatsoever. Wenger Al. proved that orthosis intervention did not alter the natural course of asymptomatic flat feet. The cause of this congenital condition is in fact the excessive laxity of the joint capsule and ligaments, which makes the longitudinal arch collapse due to weight gain. The arch is formed when there is no body weight and is clearly outlined once with the dorsiflexion of the first finger.

A thoroughgoing investigation should be completed in young athletes with flat feet, irrespective of the fact that the athletes are or not symptomatic. Among other questions related to medical history, the clinician should determine the length of symptoms, the effect(s) of these symptoms on sports activity as well as any other systemic symptoms. Subtalar movement is a factor that may help differentiate the flat foot from tarsal coalitions. The heel must passively move from 20 to 60 degrees in the inversion and eversion movements.

When the flexibility of the Achilles tendon is measured having the knee extended and the ankle / foot held in varus, dorsiflexion of the ankle less than 10 degrees below neutral point indicates tight cords and may contribute to the occurrence of flat foot. Should the athlete claim no symptoms and the investigation suggests no secondary cause, then no additional activity is required. These young athletes should be allowed to participate in all activities without any restrictions. To date, there is no evidence that preventive treatment with orthoses or other shoe inserts would prevent the development of symptomatic flat foot in the future. Children with unilateral asymptomatic flat foot require closer monitoring as well as an assessment of the neurological causality and the spine.

Where the athlete seeks medical advice due to the discomfort, then X-rays should be made to further assess any secondary causes. These may include navicular accessories, fractures, tumours or coalitions. Painful, flexible, flat feet with no secondary causes often respond to conservative measures.

The young athlete needs to understand that this may be a chronic condition, but that extra work may also help relieve symptoms. Orthosis, stretching the aggressive heel cord and strengthening the intrinsic muscle of the foot and posterior tibialis muscle are the main elements of treatment. Time should also be given to assessing the shoes of

the young athletes. Worn shoes should be replaced with supportive footwear, especially footwear with a good support with a medial longitudinal arch.

Flat foot and Hallux Valgus

The flat foot may also lead to hallux valgus due to increased abduction of the foot, which creates a non-physiological burden onto the plantar medial aspect of the big toe during heel growth.

The association between flat foot and hallux valgus is controversial. Although some authors suggest that patients with flat foot have a greater tendency to experience the development of hallux valgus compared to patients with maintained arches, others fail to support this association.

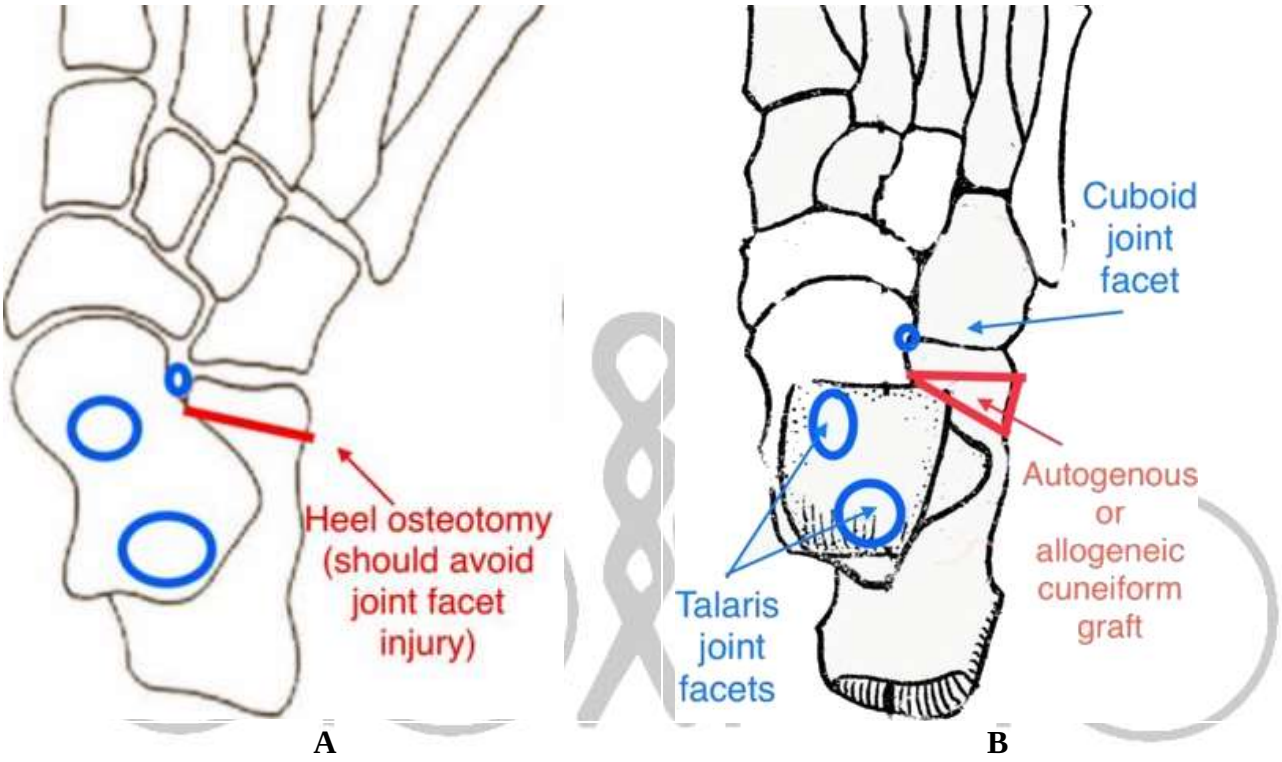
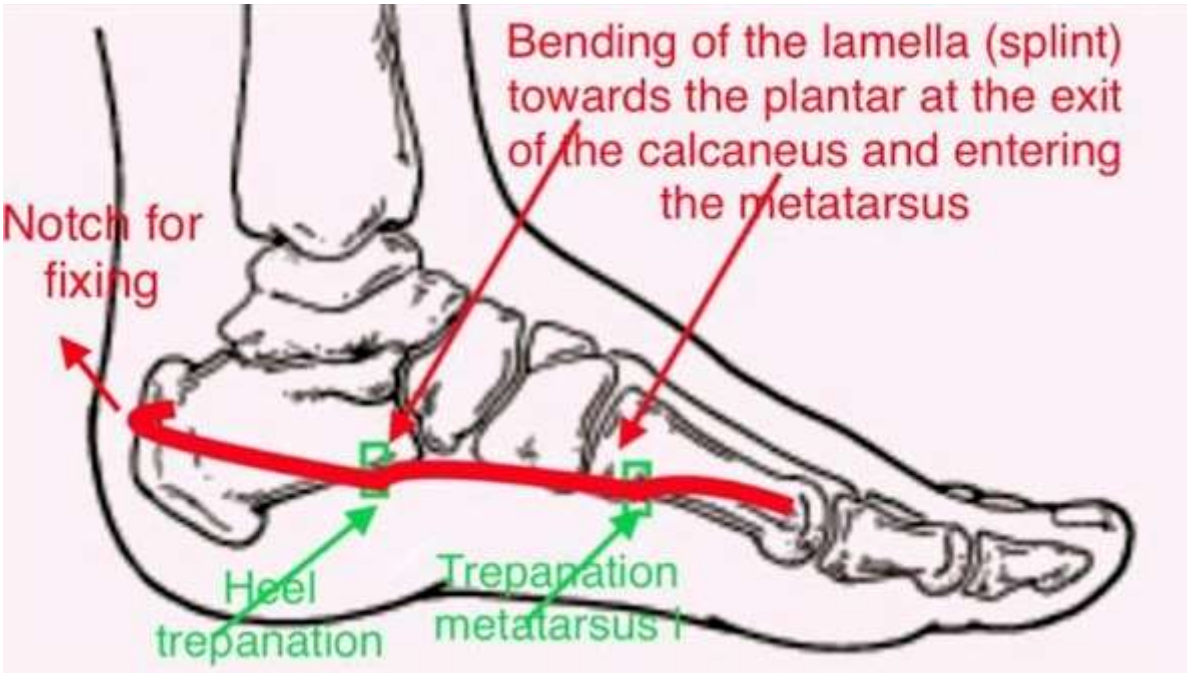


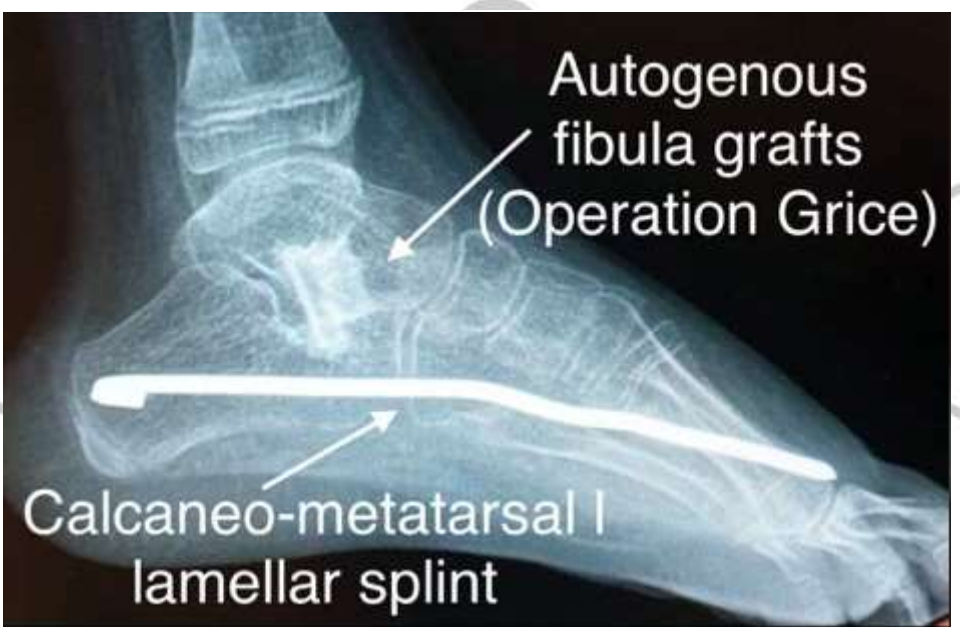
Figure 1. Correction of the flexible flat-valgus leg by the Mosca procedure. The lateral radius of the foot is elongated by heel osteotomy and the interposition of a cuneiform graft in the space between the two fragments:

a) the skeletal configuration of the flat-vague leg and the place of osteotomy
b) straightening the foot through the interfragmentary implant of a graft

A


Bending of the lamella (splint) towards the plantar at the exit of the calcaneus and entering the metatarsus
Notch for fixing
Heel trepanation
Trepanation metatarsus I

B


Autogenous fibula grafts (Operation Grice)
Calcaneo-metatarsal I lamellar splint

C

D

Figure 2. Reconstruction of the medial radius by the Burnei procedure on the calcaneo-metatarsal 1 lamellar splint

a) Flat foot with collapse of the plantar arch; talus in equin and medial radius arranged in rectitude.

b) The plantar arch is restored on the calcaneo-metatarsal 1 splint

c) Radiological profile image of a flat foot in a 10-year-old child with Spastic Tetraparesis in which the Achilles tendon elongation was performed, the Grice operation and the Burnei procedure. The complexity of the structural changes required the association of these 3 operations.

d) The semi-profile lateral radiograph shows the splint modeling to support the plantar arch.

Conclusions

The flexible flat foot is a transient form of predominantly painless deformed foot that spontaneously evolves in a proportion of 85% towards the normal reconfiguration of the plantar arch. The orthotic treatment consists in supporting the plantar arch with soles and heels with plantar supports that restore the static and dynamic plantar balance of a painful foot with potential to evolve towards a rigid and more painful foot. Pain and stiffness are treated by Burnei or Mosca surgical procedure.

Abbreviations

AFFF - Asymptomatic flexible flat foot
FF - Flat foot
SFFF - Symptomatic flexible flat foot
SFFF - Symptomatic flexible flat foot

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