소아 편평족의 감별진단과 치료

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Abstract

The Pediatric Flatfoot:
Its Differential Diagnosis and Management

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편평족은 내측 세로공이 소실되어 족저부가 편평하게 되는 변형의 총칭으로, 소아에서 흔하 고 보호자의 관심이 많은 질환이다. 이학적 검사상 후측부의 외반과 전측부의 외전소견을 보이며, 감별진단을 위해 정확한 이학적 검사와 방사선학적 검사를 필요하다. 원인으로는 유연성 편평족, 종골 외반, 신천성 수직 거꿀, 부추상골, 족근골 결합등이 있으며 정상적 유아의 경우 시간동과에 따라 저절로 호전되는 유연성 편평족이 대부분이다. 따라서 병적 편평족 이 아닌 경우 편평족의 원인과 양호한 자연결과를 보호자에게 설명하는 것이 중요하다. 본 논 문에서는 소아 편평족의 감별진단을 위한 각 질환에 있어서의 이학적 소견과 검사소견 그리 고 이들의 치료에 대해 살펴 보고자 한다.

Key Words : 소아 편평족, 감별진단, 치료

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Introduction

The flatfoot (pes planus) is a term describing any condition of the foot in which the medial longitudinal arch is lowered or lost. It can be flexible or rigid, and the flexible flatfoot should be differentiated from rigid one with pathologic conditions for the loss of the arch that may require operative treatment. The configuration of the longitudinal arch is determined by age and genetic factors and the development of an arch is a natural consequence of growth and development and not related to shoes. Staeheli et al. documented that flatfeet are standard in infants, common in children, and within normal range of the observations made in adult feet: ninety percent of normal children younger than 2 years have varying degrees of pes planus due to normal joint hypermobility and the normal infant fat pad along the medial aspect of the foot in this age group; between 3 and 5 year of age, the normal longitudinal arch develops in most patients and it is estimated that only 4% of the population have persistent pes planus by age 10 years. Most flatfeet are variations of normal and are considered physiologic or flexible. Pathological forms include the flexible type that falls outside the normal range (such as hypermobile flatfoot with short Achilles tendon), as well as the flatfoot that is due to a structural abnormality often causing stiffness and disability (such as congenital vertical /oblique talus, calcaneal valgus, tarsal coalition, accessory navicular bone and valgus hindfoot deformity in cerebral palsy).

Flexible Flatfoot

Flexible flatfoot (hypermobile flatfoot, physiologic pes planus) is characterized by varying degrees of loss of the longitudinal arch of the foot on weight bearing. An arch exists when sitting but disappears with weight bearing. The foot assumes an apparent pronated posture with abduction of the forefoot. The calcaneus is in valgus and the talar head loses some of its support and assumes a more vertically oriented position, with resultant subluxation between talus and navicular. The etiology of persistent physiologic pes planus is unknown. Many patients have a positive family history of a similar condition or evidence of generalized ligamentous laxity such as Marfan and Ehlers-Danlos syndromes. Physiologic pes planus is occasionally seen as a residual of the calcaneal valgus foot deformity. Most children with physiologic pes planus are asymptomatic and there is no evidence that flexible flatfeet of any degree produce disability. In their review of 3600 recruits, Harris and Death concluded that flexible flatfoot produced disability only if it occurred in combination with contracture of triceps surae. They described low arches as "the normal contour of a string and stable foot, rather than the result of weakness in foot structure or weakness of the muscles, which motivate the foot". Most children are brought in by their parents because of the assumption that flatfeet are abnormal and harmful to their child if not treated.

Occasionally, some children may complain of symptoms that are referable to foot strain after prolonged activity and generally relieved by rest. Associated leg aches are not uncommon in patients who present with symptomatic pes planus, but because these are present in a large portion of normal people, a cause-and-effect relation is difficult to establish. The foot should be examined for abnormal callosities or pressure points. In weight bearing, varying degrees of loss of the longitudinal medial arch are noted. The heel is in valgus and the forefoot in abduction. With loss of the longitudinal arch on weight bearing, the center of gravity is shifted medially to the second or even first metatarsal. The patient may have a toe-in gait in an attempt to shift the weight-bearing axis laterally. The child should be asked to walk
normally and then on the toes, heels, and lateral border of the foot. The ability to walk in all of these manners is most often associated with a normal foot. Normal subtalar and midtarsal motion should be noted and foot flexibility may be demonstrated by the tip-toe test: the patient’s feet are observed when the patient walks on tip toes, in which position the normal arch is restored, with the heel going to a neutral or slightly varus position (Fig. 1-A, B, C).

Muscle strength of the foot should be normal, and the examination should be included to look for any excessive joint laxity. It is important to rule out hypermobile flatfoot associated with a short Achilles tendon by history and physical examination. This condition, which is often familial, is evidenced by contracture of the gastrocnemius in association with the same clinical features as described previously. This condition is usually symptomatic and associated with long-term disability. These patients can usually correct the deformity by involuntary muscular effort, as demonstrated by the patient restoring the arch by standing on tiptoes. In addition, in the non-weight-bearing position, the normal arch is generally present. Contracture of the Achilles tendon is best assessed with the knee in extension and the talonavicular joint locked in inversion so that dorsiflexion is measured only at the ankle joint. These patients may also show evidence of hypermobility at the midtarsal joints, which allows the heel to touch the floor despite a contracted Achilles tendon. Without treatment, this condition may cause severe disabling pain.

Radiographs are generally not indicated in the asymptomatic child with a physiologic pes planus. In severe cases, standing anteroposterior (AP) and lateral radiographs should be obtained. On the normal standing AP radiograph, the talocalcaneal angle should be between 15 and 35 degrees. Diversion of the talocalcaneal angle to greater than 35 degrees is evidence of heel valgus. The midtalar line passing medial to the first metatarsal with the navicular displaced laterally is evidence of forefoot
abduction. On the standing lateral radiograph, the normal lateral talocalcaneal angle is between 25 and 50 degrees. The talus–first metatarsal angle should be about 0 degrees. On the lateral view, the exact location of loss of longitudinal arch can be determined. This sag may occur at the talonavicular joint, first naviculocuneiform joint, and first metatarsocuneiform joint, or combinations thereof. The talus is more vertically oriented, with the metatarsals and the calcaneus in a more horizontal position than normal because of flattening of the arch.

Treatments offered in the past have been based on the assumption that patients will have problems in the future if the condition is not treated. In normal children, aged 1 to 3 years, reassurance and explanation of the cause and the benign natural history of pes planus are essential to the parents. The parents should be informed about the presence of the normal fat pad, the normal joint hyperlaxity of infancy, and the often familial nature of the condition. They should also be reassured that, in most children, an arch will develop by 5 years of age. Many parents are under the false assumption that so-called corrective shoes are responsible for the natural development of the longitudinal arch. The parents should be instructed that treatment modalities offered in the past were offered without any scientific basis. A recent prospective randomized study of patients with flexible flatfeet treated by corrective shoes and inserts revealed that all patients improved moderately after 3 years of treatment, and no greater improvement was seen in patients who were treated vigorously, even those treated with custom-made inserts. All treatments in the past, including exercises, varying shoe modifications, and inserts, have been proved to be ineffective.

In a child with a painful flexible flatfoot, the diagnosis must be reassessed and sources of painful flatfeet eliminated. Prophylactic treatment of any type is unwarranted.

Treatment for flexible flatfeet is only indicated if the patient presents with pain, usually in the foot or calf, or if the patients has severe excessive shoe wear. The discomfort in the foot and the associated leg aches, which occur in about 15% to 30% of normal people, should be treated symptomatically with acetaminophen, local heat, and massage. If fatigue symptoms or discomfort with increasing activity persists, shoe modifications can be considered. It is important to emphasize that these modifications are not corrective. High-top tennis shoes with a good longitudinal arch can usually be recommended. If symptoms persist, other non-corrective adaptive measures may be tried, such as a medial heel wedge, a long shoe counter, or a navicular pad. For the more severe symptomatic physiologic pes planus that fails to respond to conservative measures, a more formal shoe orthotic, such as a University of California Biomechanics Lab insert or custom-made insert, may distribute body weight more evenly across the sole of the foot and reduce the pressure off the prominent talar head.

These modalities, however, are expensive, must be changed frequently with foot growth, and have no scientific basis for their use. The use of shoe modification inserts tends to label the child as having a problem. In young patients with hypermobile flatfoot and a short tendo–Achilles, heel cord stretching exercises should be tried first. If symptoms and the contracture persist, tendo–Achilles lengthening can be considered.

The only operative indications in true physiologic pes planus are severe malalignment problems causing excessive abnormal shoe wear and pain. Surgical options for these indications are rarely indicated. In the past, these included soft tissue procedures alone; arthrodeses of the various tarsal joints; osteotomies; and combined osteotomies, arthrodeses, and soft tissue procedures, all with the
goal of restoring the normal longitudinal arch, relieving pain, and preserving as much motion as possible. However, results of these procedures have been poor.

**CALCANEAL VALGUS**

Calcaneal valgus is one of the most common foot deformities seen at birth. The entire foot is held in the dorsiflexed everted position, and in its most severe form, the foot lies adjacent to the anterior border of the tibia. It is thought to be secondary to intrauterine molding and is most common in first-born children and in children of young mothers. Clinically, the foot is held in dorsiflexion near the tibia with the forefoot in varying degrees of abduction and the heel in varying degrees of valgus (Fig. 2). The soft tissues on the dorsal and lateral aspect of the foot are contracted and restrict plantar flexion and inversion. However, there are no tarsal dislocations or subluxations.

![Image of calcaneal valgus](image)

**Fig. 2** Calcaneal valgus. the foot is held in dorsiflexion near the tibia with the foot in varying degrees of abduction and valgus.

The deformity is usually supple, and the foot can be brought into some plantar flexion and supination. The foot can generally be manipulated to neutral or just short of the neutral position. It requires counseling to convince the parents that this is not a fixed deformity. The deformity resolves without residual sequelae. In an occasional patient, a series of corrective casts can be used to hasten the recovery of a normal position.

Many authors agree that this is essentially a benign condition that can be followed clinically and does not require radiographic evaluation or active treatment.

**Congenital Vertical Talus**

(congenital convex pes planus/valgus)

Congenital vertical talus is a rare deformity of the foot, and manifests as a rigid flatfoot that requires early identification and aggressive treatment. It is characterized by rocker–bottom appearance of the foot and has four fixed components: hindfoot equinovalgus, midfoot valgus, forefoot abduction and dorsal dislocation of talonavicular joint. Its etiology is unknown and there appears to be a familial tendency. It is usually associated with other congenital abnormalities, musculoskeletal defects, or disorders of the central nervous system. There is a high incidence of congenital vertical talus in children with myelomeningocele (10% having congenital vertical talus), congenital hip dysplasia, and several trisomies (13 to 15, 18, 21). It may be bilateral, but if unilateral, it may be associated with a pathologic condition of the opposite foot, including clubfoot, metatarsus adductus, or calcaneal valgus deformity. In general, without treatment the ambulatory patient develops significant callosities or skin breakdown over the talar head, and shoeing may be a significant problem.

Clinically, the condition can be diagnosed at birth. In the newborn, the dorsal aspect of the foot may be in close approximation to the distal aspect of the tibia, similar to the foot position in the calcaneal valgus deformity. Unlike calcaneal valgus, however, this position is rigid, and the Achilles tendon is
contracted and the foot cannot be flexed in a plantar direction. The head of the talus is easily palpable on the plantar medial aspect of the foot at the apex of the foot convexity. Attempts at manipulation fail to reduce the talonavicular joint. Although, the clinical appearance may mimic a hypermobile flatfoot or calcaneal valgus deformity, normal relations, particularly the talonavicular relation, can be restored by plantar flexion. Pathoanatomic studies of a few specimens of congenital vertical talus also showed that anterior tibial tendon run straight course crossed the ankle like bowstring and peroneal tendons are subluxated anteriorly to the cuboid. All tendons to the dorsum of foot are tethered medial to the midline of ankle joint. Hypoplastic talus is noted and blunted sustentaculum tali cannot support the talar head. Os calcis is laterally rotated under the talus and the lateral column of foot is deformed into valgus position with various amounts of bony deformities.

AP and simulated standing or standing lateral radiographs should be obtained. Standing or simulated standing lateral radiographs reveal the calcaneus to be in equinus and talus to be vertically oriented. Because of the extreme plantar flexion of the talus, only the posterior aspect of dome articulates with the distal aspect of the tibia.

In children younger than 3 to 5 years of age, the navicular is not ossified, and hence the talonavicular dislocation can only be inferred by noting that the forefoot is displaced dorsally in relation to the talus. Once the navicular is ossified, the talonavicular dislocation is easily demonstrated. With time, radiographs may also demonstrate disruption of the calcaneocuboid joint with dorsolateral displacement of the cuboid as well. The diagnosis can be confirmed radiographically by a forced plantar flexion lateral view (Fig. 3-A, B, C).

The long axis of the talus is plantar to the cuboid, as opposed to dorsal, and the long axis of the metatarsals cannot be brought into co-linear alignment with the long axis of the talus.

As the treatment plans and prognoses are substantially different, the differential diagnosis should include congenital oblique talus where only a
ACCESSORY NAVICULAR BONE

This is the most common accessory bone in the foot, and occurs on the medial, plantar border of the navicular along the insertion of the posterior tibialis tendon.

Accessory navicular bones are seen in about 12% of the population and are a normal variant. Two patterns are evident. In one pattern, the accessory navicular is a sesamoid bone within the posterior tibial tendon. It is anatomically separate from the navicular and usually does not cause symptoms. In the second form, the accessory navicular is in close association with the navicular as an ossification center, causing a change in shape of the navicular. This type may be associated with pain, particularly during adolescence. However, in reality, accessory navicular is not a direct cause of hypermobile flatfoot, and there is no evidence to substantiate the opinion that the longitudinal arches of the patients with accessory navicular are different from those of normal patients. It is more likely that the accessory navicular, when present in flat foot, is an incidental finding, and its inclusion among causes of pain for painful symptomatic flatfoot in children is unwarranted.

The best radiographic view for demonstrating an accessory navicular is a standard AP or a 45-degree eversion oblique view (Fig. 4). The navicular is the last tarsal bone to appear, occurring in 1- to 3.5-year-old girls and 5.5 years-old boys, and may ossify from multiple centers. Difficulty with multiple, irregular centers may be encountered in differentiating this ossification from the intermittent stages of Koehler disease. The diagnosis of Koehler disease should not be made on the basis of a radiograph alone; it depends on clinical symptoms and findings. Instead of a true joint, there is a synchondrosis in various stages of development. In some patients, it is a separate ossicle; in others, it has more of a
cartilaginous connection to the navicular; and in the latter variety, the navicular is successfully prolonged around the medial aspect (cornuate navicular). The histological findings were consistent with healing microfractures, substantiating the opinion that the pain is related to chronic, repetitive stress reaction.12

The accessory navicular is seldom symptomatic or detected before adolescence. Most patients are asymptomatic, and can be managed conservatively without the need for operative treatment. The patient can wear softer shoes or have the shoe stretched in the area over the prominence. Surgery is indicated for failed conservative treatment.

Kidner operation has been used to remove prominence of accessory navicular. It involves excision of bone and re-insertion of tibialis posterior. However, this operation is not expected to improve a fallen arch, which probably will require lateral column lengthening. Simple excision of the prominent ossicle seems to be the surgical procedure of choice.13 Nothing is done with the tibialis posterior tendon other than place sutures in the area where the ossicle is excised. Scar may result if incision is placed over the prominence, and the patients should be forewarned that it could become painful with shoe wear.

TARSAL COALITION

Union of two or more tarsal bones is frequent cause of painful flatfoot in the older children or adolescent, and represents the most common non-neuromuscular cause of pathologic pes planus. It may be fibrous (syndesmosis), cartilaginous (synchondrosis), or osseous (synostosis). This entity is often called peroneal spastic flatfoot because of the high association with contracture of the peroneal tendons. Calcaneonaviclar coalition bar is most common, followed by coalition in the middle facet of talocalcaneal joint (between the sustentaculum tali and the talus). The incidence of tarsal coalition is estimated less than 1% to 2% of the population. Bilateralness is common and has been reported in up to 70% of calcaneonaviclar coalitions and in 20% to 50% of talocalcaneal coalitions. Rarely is there more than one coalition per foot. Tarsal coalitions are thought to be an inherited condition,14 with the most widely accepted pattern being autosomal dominant inheritance with variable penetrance. Because the true incidence of tarsal coalitions in the population is unknown and the natural history is uncertain. However, it is apparent that majority of tarsal coalitions are asymptomatic and evidence indicates that they remain so in adulthood.15

Demonstration of coalitions in fetal specimens lends support to the theory of failure of segmentation as the etiology of tarsal coalitions. This incomplete segmentation of the mesenchymal anlage of the tarsal bones gives rise to the fibrous or cartilaginous coalition, which may ossify later in life. There is a tendency to progressive ossification of bar with increasing age, and this often corresponds with the onset of symptoms; ossification occurs at 8–12 years for calcaneonaviclar bars and between 12–15 years for talocalcaneal coalitions. Ossification of the coalition restricts subtalar motion. This alteration in
subtalar mechanics leads to increased stress at adjacent joints, particularly the ankle and talonavicular joints. If a coalition remains fibrous, symptoms may never develop because of the mobility allowed through the syndesmosis. With increasing ossification of a cartilaginous coalition, decreased mobility ensues, increasing the likelihood of the patient developing clinical symptoms. The altered subtalar joint mechanics over time may lead to degenerative joint disease in adjacent joints, causing persistent pain and disability. The limited subtalar motion also causes increased laxity in adjacent joints, particularly the ankle joint, leading to increased incidence of ankle sprains and secondary joint alterations.

The typical patient with tarsal coalition presents during the second decade of life with pain or decreased subtalar motion. Occasionally, the patient complains of a limp, discomfort in the calf region, or nonspecific foot pain. The pain is often localized to the interior, medial, or lateral aspect of the subtalar joint or to the talonavicular region. The onset of pain is usually insidious or associated with a traumatic event such as a non-resolving ankle sprain. Pain is usually made worse by activities like running and jumping or prolonged standing but is usually relieved by rest. Physical examination reveals decreased hindfoot or midfoot motion, or both. Most commonly, the heel is in valgus and the forefoot abduction. The patient may walk with an antalgic gait, and if symptoms are long-standing and the pain is significant, disuse atrophy may be noted on calf measurements. In about half of cases, contracture of the peroneal muscles is present. This is evidenced by prominence of the peroneal tendons in the lateral aspect of the ankle and foot. Attempt at inversion of the deformity causes pain and discomfort along the peroneal region. The peroneal tendons are contracted secondary to prolonged positioning of the foot in valgus. True muscle spasms of the peroneal tendons are rare. Increased ankle ligamentous laxity is most commonly seen in patients with long-standing symptoms, particularly those with talocalcaneal coalitions.

There may also be varying degrees of loss of the longitudinal arch. Pathologic conditions affecting the subtalar joint, including tumors, rheumatoid arthritis, and traumatic injuries, may mimic the physical findings of tarsal coalition.

When tarsal coalitions are suspected, standing AP, lateral, and 45-degree medial oblique radiographs should be obtained (Fig. 5-A, B).

The diagnosis of a calcaneonavicular coalition can usually be made on these standard radiographs. The 45 degree medial oblique radiograph usually demonstrates this coalition. If the coalition is fibrous...
or cartilaginous, however, it may not be obvious on plain radiographs. Other findings that indicate a possible calcaneonavicular coalition include blunting of subtalar process, elongation of anterior calcaneal process, narrowing of posterior subtalar joint and talar beaking. Talocalcaneal coalitions were often difficult to diagnosis. Abnormal subtalar mechanics may be evident radiographically by secondary adaptive changes.

These include dorsal beaking at the head or neck of the talus. This is secondary to stretching of the talonavicular ligaments because of the navicular impinging on the head of the talus. The lateral aspect of the talus may appear broadened, with the undersurface of the talar neck having a concave appearance. There may be apparent narrowing of the posterior talocalcaneal joint space and inability to determine the definition of the middle talocalcaneal articulation. Radiographs of the ankle joint may demonstrate an apparent ball-and-socket ankle; this is manifest by convexity of the dome of the talus on both the AP and lateral view. In patients presenting with repeated ankle sprains and radiographic evidence of a ball-and-socket ankle, tarsal coalition should be sought. In these cases, the radiographic changes at the ankle joint are secondary to long-standing ankle instability and adaptive changes of the tibial talar articulation. CT scan is the diagnostic method of choice for demonstrating these coalitions (Fig. 6). Coronal sections should be obtained to document the coalition.

Initial management of calcaneonavicular coalitions should be non-operative because the natural history indicates that many patients have no symptoms and the literature review of various treatment programs indicates some success with nonoperative treatment. Nonoperative treatment measures are based on immobilizing the subtalar joint. Shoe orthotics, ankle-foot orthoses, nonsteroidal anti-inflammatory agents, and activity restriction may be tried as a first line of treatment. They reduce subtalar motion or stresses and medial-lateral hindfoot forces. If these fail, a period of cast immobilization with a short-leg walking cast for 3 to 6 weeks should be tried. If symptoms recur or are not alleviated by conservative measures in children before the age of 14 years, resection is usual treatment. This procedure is not appropriate if cartilaginous bar is completely ossified and degenerative changes have occurred already, or if coalition between the talus and calcaneus is also present. In patients over age of 14 who have degenerative changes, a below knee weight bearing cast, a platizate insert for the shoe, or an AFO may relieve pain. Failure to respond to these conservative measures and presence of degenerative changes indicate the need for triple arthrodesis. The treatment of talocalcaneal coalitions is somewhat more difficult.

Usual treatment should center around nonoperative measures as indicated previously for calcaneonavicular coalitions. If these nonoperative measures fail to provide lasting relief of the patient’s symptoms, resection of the coalition with interposition of fat or bone wax should be considered. Specific criteria for resectability of these coalitions are lacking. Long-term series with large numbers of patients are unavailable.
Contraindications to resection, however, are an extensive coalition and degenerative joint disease at the adjacent joints. In these circumstances, subtalar fusion or triple arthrodesis should be considered. The most common cause of failure in surgical management of tarsal coalitions is incomplete resection.

REFERENCES


