

Adult acquired flatfoot

Overview

- The exact incidence of flatfoot in children is unknown [1].
- Flatfoot is one of the most common deformities evaluated by pediatric orthopaedists [1].
- Whether flatfoot represents a true deformity is questionable [1].
- Staheli and colleagues regarded flatfeet as usual in infants, common in children, and within the normal range in adults [1].
- Flatfoot is evaluated and treated, often prophylactically, by certain nonorthopaedic branches of medicine [1].
- Children with flatfoot are referred to pediatric orthopaedists for the treatment of pain, perceived disability, and abnormal shoe wear [1].
- In flatfoot, the heel shows excessive eversion during weight bearing [1].
- In flatfoot, the forefoot is usually abducted [1].
- In flatfoot, there is a midfoot sag with lowering of the longitudinal arch [1].
- In flatfoot, the talar head and navicular tuberosity appear to be in contact with the floor and participate excessively in weight bearing [1].
- In flatfoot, the medial column of the foot appears longer than the lateral [1].
- The entire foot in flatfoot is often described as pronated [1].
- The description of the foot as pronated is misleading because the forefoot is actually supinated in relation to the hindfoot [1].
- The relationship of the forefoot to the hindfoot in flatfoot is appreciated when the hindfoot is corrected operatively or stabilized manually during physical examination [1].
- Clinicians might be tempted to use radiography as the defining diagnostic examination for flatfoot [1].
- Flatfoot has been considered a foot with measurements greater than two standard deviations from the mean [1].
- Radiographs to document the diagnosis of flatfoot are rarely obtained because flatfeet are relatively common and generally benign [1].

- The lack of radiographic documentation perpetuates the lack of a specific definition of flatfoot [1].
- A standing lateral radiograph allows measurement of the lateral talus–first metatarsal angle, or Meary angle [1].
- The Meary angle is normally 0 degrees, appearing as a straight line [1].
- In flexible flatfoot, an apex-plantarward Meary angle will be present [1].
- The normal range of the Meary angle varies with age [1].
- Spontaneous improvement in plantar sag is seen until age 8 years [1].
- The location of the sag can be determined as either talonavicular or naviculocuneiform joint [1].
- The location of the sag may suggest the cause of an abnormal measurement [1].
- A tight heel cord can produce a plantar flexed talus and talonavicular sag [1].
- The degree of plantar flexion of the talus is measured by the angle formed by the longitudinal axis of the talus and the horizontal [1].
- The normal angle for plantar flexion of the talus is 26.5 ± 5.3 degrees [1].
- The calcaneal pitch angle is formed by the axis of the calcaneus and the horizontal [1].
- A compelling reason to obtain radiographs in cases of flatfoot is to rule out causes of the deformity other than idiopathy [1].
- The differential diagnosis for flatfoot includes tarsal coalition [1].
- The differential diagnosis for flatfoot includes congenital vertical talus (convex pes valgus) [1].
- The differential diagnosis for flatfoot includes persistent talipes calcaneovalgus [1].
- The differential diagnosis for flatfoot includes an accessory navicular [1].
- The differential diagnosis for flatfoot includes various arthritic and inflammatory conditions [1].
- Most conditions in the differential diagnosis of flatfoot are diagnosed primarily from history and physical examination findings [1].
- Radiographs should be used to confirm a suspected diagnosis in the differential diagnosis of flatfoot [1].

Anatomy & Pathophysiology

DEFINITION AND PREVALENCE

- Adult acquired flatfoot deformity (AAFD) is characterized by collapse of the medial longitudinal arch, hindfoot valgus, and midfoot abduction related to dysfunction of the posterior tibial tendon (PTT) [7].
- Flatfoot refers to loss of the normal longitudinal arch of the medial foot [3].
- The prevalence of flatfoot has been reported to be as high as 80% in children, but decreases to 10% to 20% in adults [6].
- The prevalence of flatfoot has been shown to decrease substantially from 54% of 3-year-old children to 21% of 6-year-old children [6].

- Flatfoot is associated with younger age, male sex, ligamentous laxity, and obesity [6].
- Many cases of flatfoot are inherited, and a careful family history may uncover other persons with the condition [3].

BIOMECHANICS AND PATHOPHYSIOLOGY

- The posterior tibial tendon (PTT) inverts the hindfoot, which locks the transverse tarsal joint, providing a stable platform for push-off during gait [7].
- When the PTT degenerates, the hindfoot falls into valgus, which stresses the medial static stabilizers of the ankle and foot, including the spring ligament [7].
- The navicular translates laterally because of spring ligament incompetence, resulting in medial talar head uncoverage and midfoot abduction [7].
- Progressive valgus stress through the ankle may result in deltoid ligament incompetence, talar tilt, and ankle arthritis [7].
- A gastrocnemius contracture develops as the axis of pull shifts laterally, which can further exacerbate the valgus alignment [7].
- The PTT is the primary dynamic support for the arch [13].
- The PTT fires after the foot is flat to generate heel rise and lock the transverse tarsal joint for a rigid, stable foot during push-off (toe-off) [13].
- The tibia rotates externally and the transverse tarsal locks as the PTT fires during push-off [13].
- The spring (calcaneonavicular) ligament is the primary static stabilizer of the talonavicular (TN) joint [13].
- Incompetence of the spring ligament is associated with increased flatfoot deformity [13].
- The most common site of spring ligament incompetence is the superomedial band, which originates off of the anterior-medial sustentaculum [13].
- Isolated acute rupture of the spring ligament has been reported to cause an acute deformity without PTTD [13].
- Biomechanical data has shown that the tibiospring (medial malleolus to navicular) is the most relevant ligament to decrease abduction [13].
- The gastrocnemius complex is often contracted in AAFD [13].

ETIOLOGY AND RISK FACTORS

- AAFD is most commonly seen in overweight, middle-aged females [7].
- Risk factors for AAFD include obesity, diabetes, hypertension, trauma, and history of cortisone injections [7].
- Subtalar joint orientation may predispose some patients to developing AAFD [7].
- The etiology of PTTD is multifactorial and includes a zone of hypovascularity 2 to 6 cm proximal to the PTT insertion on the navicular [13].
- Overload of the arch due to activity or obesity is a factor in the etiology of PTTD [13].

- Inflammatory disorders such as rheumatoid arthritis (RA) are a factor in the etiology of PTTD [13].

CLINICAL PRESENTATION AND EXAMINATION

- Patients with AAJD present with medial ankle pain and gait dysfunction related to deformity [7].
- With progressive disease, lateral ankle pain may develop because of subfibular impingement [7].
- On examination, there is tenderness over the PTT [7].
- Standing evaluation from behind the patient demonstrates valgus alignment [7].
- If the patient is able to perform a single-limb heel rise and the hindfoot inverts as the heel elevates, the PTT remains functional and the deformity is considered flexible [7].
- If the hindfoot does not invert during a single-limb heel rise, the deformity is considered rigid [7].
- The presence of a gastrocnemius contracture is assessed with the Silfverskiöld test, making sure to invert the hindfoot out of valgus during examination [7].
- Standing examination demonstrates asymmetric hindfoot valgus, depressed arch, and an abducted forefoot [9].
- The “too-many-toes sign” is observed when the foot is viewed posteriorly and it appears to have more than five toes [9].
- Pain or inability to perform single-limb heel rise indicates insufficient PTT [9].
- Lateral impaction syndrome or subfibular impingement with significant valgus of the heel, such that it abuts the fibula, may be present [9].
- Abutment of the lateral process of the talus and the calcaneus can occur in AAJD [9].
- In flexible flatfoot, the talar head may be palpable medially because of its plantarflexed position [6].
- Uncovering of the navicular and associated calluses may be present in flexible flatfoot [6].
- The hindfoot shows full passive motion with inversion and eversion in flexible flatfoot [6].
- With toe rise, the arch is restored, and the hindfoot rolls into varus to lock the transverse tarsal joints in flexible flatfoot [6].
- Many patients with flexible flatfoot are asymptomatic and undergo an orthopaedic evaluation because of parental concerns about the appearance of the foot [6].
- Patients who are symptomatic may report medial arch pain, calf pain caused by contracture, and/or lateral sinus tarsi pain caused by calcaneofibular abutment [6].

RADIOGRAPHIC FINDINGS

- Weight-bearing radiographs of the foot and ankle are evaluated for degree of deformity and degenerative changes [7].
- Arch collapse is quantified by measuring Meary’s angle on the lateral view [7].
- Percentage uncoverage of the talar head on the AP foot radiograph is measured to assess deformity [7].
- A hindfoot alignment radiograph may be useful to measure hindfoot moment arm, which can predict the amount of intraoperative deformity correction required [7].

- Ankle radiographs should always be performed to assess for valgus talar tilt [7].
- MRI may demonstrate degeneration in the PTT and spring ligament injury [7].
- Pes planus is indicated by a negative lateral talar–first metatarsal angle (Meary angle) [9].
- Forefoot abduction is indicated by TN uncoverage on radiographs [9].
- Standing radiographs disclose loss of the normal medial longitudinal arch and may show mild lateral subluxation of the talonavicular joint [3].
- In severe chronic cases, degenerative talonavicular spurring may be present on standing radiographs [3].
- On the AP view, the talar head may appear uncovered, and the amount of talonavicular coverage has been shown to be related to the onset of symptoms [6].
- On lateral radiographs, the talar declination angle is increased, as is the Meary angle (the angle between the first metatarsal and the axis of the talus) [6].
- Decreased calcaneal pitch may be observed in patients with contracture of the Achilles tendon [6].
- A talar–first metatarsal angle greater than 4 degrees signifies pes planus [11].
- The normal calcaneal pitch angle is between 17 and 32 degrees [11].
- Arch height loss is documented by a decrease in the calcaneal pitch angle [11].
- A loss of medial cuneiform–floor height is also indicative of loss of arch height [11].

CLASSIFICATION

- The most common classification system for AAFD is based on the degree of deformity [7].
- Stage I is tendinopathy of the posterior tibial tendon in the absence of significant deformity [7].
- Stage II is characterized by a flexible deformity with talar head uncoverage seen on the weight-bearing AP foot radiograph [7].
- Talar head uncoverage of greater than 30% differentiates between a stage IIa and IIb deformity [7].
- Stage III is a rigid deformity due to arthritis in the hindfoot [7].
- Stage IV indicates ankle joint involvement [7].
- Stage IIA is defined by hindfoot valgus without significant forefoot abduction (<40% uncovering of the talus) [11].
- Stage IIB is defined by forefoot abduction (>40% uncovering of the talus) in addition to hindfoot valgus [11].
- Stage IIC is defined by fixed forefoot supination/varus (first ray is elevated after correction of the hindfoot to neutral) in addition to hindfoot valgus [11].
- Stage III is defined by a fixed/rigid pes planovalgus deformity [11].
- Stage IV is defined by incompetence of the deltoid ligament; standing AP ankle radiograph demonstrates lateral talar tilt (valgus) or ankle arthritis [11].

Classification

- Stage I AAFD is defined as posterior tibial tendinopathy in the absence of significant deformity [7].
- Stage II AAFD is characterized by a flexible deformity with talar head uncoverage seen on the weight-bearing AP foot radiograph [7].
- Stage IIa AAFD is defined as a flexible deformity with less than 30% talonavicular (TN) uncoverage on weight-bearing AP foot radiograph [7].
- Stage IIb AAFD is defined as a flexible deformity with greater than 30% talonavicular (TN) uncoverage on weight-bearing AP foot radiograph [7].
- Stage III AAFD is characterized by a rigid deformity due to arthritis in the hindfoot [7].
- Stage III AAFD is defined by the absence of hindfoot inversion with single-limb heel rise and a deformity that is not passively correctable [7].
- Stage IV AAFD indicates ankle joint involvement [7].
- Stage IV AAFD is defined by talar tilt and/or valgus ankle arthritis due to long-standing foot deformity [7].
- If the patient can perform a single-limb heel rise and the hindfoot inverts as the heel elevates, the PTT remains functional and the deformity is considered flexible [7].

Clinical Presentation

GENERAL CHARACTERISTICS AND EPIDEMIOLOGY

PATIENT SYMPTOMS

- Patients complain of medial ankle/foot pain early, progressive loss of arch, and lateral ankle pain late due to subfibular impingement [9].

PHYSICAL EXAMINATION

- Standing evaluation from behind the patient demonstrates valgus alignment in AAFD [7].
- On examination, there is tenderness over the posterior tibial tendon (PTT) in AAFD [7].
- The “too-many-toes sign” is observed when the foot is viewed posteriorly and appears to have more than five toes [9].
- Pain or inability to perform a single-limb heel rise indicates insufficient posterior tibial tendon (PTT) function [9].
- Whether the deformity is flexible (passively correctable to a plantigrade foot) or fixed (rigid deformity that is not passively correctable) must be determined [9].
- The presence of a gastrocnemius contracture is assessed with the Silfverskiöld test, making sure to invert the hindfoot out of valgus during examination [7].

IMAGING

- Weight-bearing radiographs of the foot and ankle are evaluated for degree of deformity and degenerative changes in AAFD [7].
- Percentage uncoverage of the talar head on the AP foot radiograph is measured to evaluate deformity [7].
- MRI may demonstrate degeneration in the PTT and spring ligament injury, but it is not a requisite preoperative study in the presence of significant deformity [7].
- Pes planus is indicated by a negative lateral talar–first metatarsal angle (Meary angle) on radiographs [9].
- Forefoot abduction is indicated by talonavicular (TN) uncoverage on radiographs [9].

CLASSIFICATION

- Stage I AAFD is defined as posterior tibial tendinopathy with minimal underlying deformity [7].
- Stage III AAFD is a rigid deformity due to arthritis in the hindfoot [7].

Investigations

CLINICAL EXAMINATION

- The single-limb heel rise test assesses posterior tibial tendon (PTT) function; if the hindfoot inverts as the heel elevates, the deformity is considered flexible [7].
- The Silfverskiöld test is used to assess for gastrocnemius contracture, requiring the hindfoot to be inverted out of valgus during examination [7].
- Physical determination of flatfoot flexibility involves observing if a normal arch and varus heel appear by muscle action when the patient stands on tiptoe [3].
- In flexible flatfoot, the longitudinal arch reconstitutes when the patient walks on toes or when the foot is in a non-weight-bearing position [2].
- Stiffness or peroneal muscle spasm during passive inversion and eversion of the subtalar joint suggests the presence of tarsal coalition or inflammatory arthritis [2].
- If the hindfoot stays in valgus during examination, tarsal coalition may be present [2].

RADIOGRAPHIC IMAGING

- Weight-bearing radiographs of the foot and ankle are evaluated to determine the degree of deformity and degenerative changes in adult acquired flatfoot deformity (AAFD) [7].
- Arch collapse is quantified by measuring Meary's angle on the lateral weight-bearing radiograph [7].
- The percentage of talar head uncoverage is measured on the anteroposterior (AP) weight-bearing foot radiograph [7].
- A hindfoot alignment radiograph may be used to measure the hindfoot moment arm, which can predict the amount of intraoperative deformity correction required [7].

- Ankle radiographs should be performed to assess for valgus talar tilt [7].
- An abnormal Meary's angle is defined as 17° in the context of AAJD, whereas the normal range is zero to 10° [7].
- Normal talar head uncoverage is defined as zero to 30% [7].
- Loss of medial cuneiform–floor height is indicative of loss of arch height [11].
- Standing radiographs may show mild lateral subluxation of the talonavicular joint in flatfoot [3].
- In severe chronic cases of flatfoot, degenerative talonavicular spurring may be present on standing radiographs [3].
- The location of the sag (talonavicular or naviculocuneiform joint) can be determined on radiographs and may suggest the cause of the abnormal measurement [1].
- The degree of plantar flexion of the talus is measured as the angle formed by the longitudinal axis of the talus and the horizontal, with a normal value of 26.5 ± 5.3 degrees [1].
- Radiographs are used to rule out causes of flatfoot other than idiopathy, including tarsal coalition, congenital vertical talus, persistent talipes calcaneovalgus, accessory navicular, and arthritic or inflammatory conditions [1].

ADVANCED IMAGING

- MRI is not a requisite preoperative study in the presence of significant deformity [7].
- Computed tomography (CT) scans are used for diagnostics in tarsal coalition [14].
- A C-sign or dorsal talar beaking on x-ray may indicate middle facet coalition [14].
- An elongated anterior process of the calcaneus on the lateral radiograph may indicate calcaneonavicular coalition [14].

Treatment

NON-OPERATIVE

- Symptomatic treatment with shoe modifications, arch supports, and plantar inserts is appropriate for flatfoot [3].
- No long-term nonsurgical treatment can alter the anatomic features of flatfoot [3].
- Nonsurgical measures are the initial treatment choice for flexible flatfoot [6].
- A study of 580 preschool-aged children with flexible flatfoot demonstrated complete resolution in 38% after 1 year [6].
- No high-level studies support the treatment of patients with asymptomatic flexible flatfoot [6].
- A navicular pad, medial arch support, or a University of California Biomechanics Laboratory orthotic may help with symptoms in patients with arch pain but will not correct the deformity or prevent progression in asymptomatic patients [6].

- Patients with contractures of the Achilles tendon or gastrocnemius muscle should begin a stretching program to decrease associated calf pain [6].
- Most flexible flatfeet in children resolve spontaneously with no residual adverse effects as the child ages [2].
- Surgery is rarely indicated to treat flexible flatfoot deformity of childhood [2].

OPERATIVE

- Posterior tibial advancement, subtalar joint elevation or fusion, and elongation osteotomy of the lateral calcaneal neck are surgical options for flatfoot [3].
- Surgical options for flatfoot may not provide reproducible, predictable resolution of the problem [3].
- In patients with flexible flatfoot in whom prolonged nonsurgical measures fail, consideration can be given to lateral column lengthening through a calcaneal lengthening osteotomy or a combined calcaneal-cuboid-cuneiform osteotomy [6].
- Gastrocnemius recession may be simultaneously considered to manage the associated equinus deformity in patients undergoing surgical intervention for flexible flatfoot [6].
- Any surgical intervention for flexible flatfoot needs to be carefully planned to correct all aspects of the deformity [6].

Complications

- The differential diagnosis for flatfoot includes bony abnormalities such as tarsal coalition, congenital vertical talus (convex pes valgus), persistent talipes calcaneovalgus, and accessory navicular [1].
- In adolescents or preadolescents, nonspecific foot, ankle, or lower leg pain may be caused by tarsal coalition [2].
- Pain that is not related to exercise in a child with flatfoot may be caused by inflammatory arthritis, infection, or rarely a bone lesion [2].
- Tarsal joints are a common location for juvenile arthritis [2].
- A tight heel cord can lead to flatfoot because of compensatory midfoot breakdown [2].
- Causes of a tight heel cord include static encephalopathy, tethered cord or other intrathecal anomaly, and idiopathic factors [2].
- Congenital vertical talus is characterized by a fixed flattening of the longitudinal arch, tight heel cord, variable degree of pain, and usually a palpable dorsolateral dislocation of the navicular on the talus [2].
- Classic symptomatic tarsal coalition is characterized by fixed flattening of the longitudinal arch, fixed hindfoot valgus, and nonspecific or exercise-induced pain [2].
- During rapid passive inversion of the subtalar joint in a patient with tarsal coalition, the patient may experience peroneal muscle spasm [2].
- Patients with tarsal coalition typically present between the ages of 8 years and adolescence [2].
- During gait, patients with tarsal coalition have an externally rotated, inflexible foot [2].

Recovery

NATURAL HISTORY AND PROGNOSIS

- In a 2013 study of 580 preschool-aged children with flexible flatfoot, complete resolution occurred in 38% after 1 year [6].
- The prevalence of flatfoot decreases from 54% in 3-year-old children to 21% in 6-year-old children [6].
- Spontaneous improvement in plantar sag is observed until age 8 years [1].
- No long-term treatment can alter the anatomic features of the disorder [3].
- Arch supports, medial arch support, or orthotics will not correct the deformity or prevent progression in patients who are asymptomatic [6].

POST-OPERATIVE OUTCOMES AND COMPLICATIONS

- Surgical options including posterior tibial advancement, subtalar joint elevation or fusion, and elongation osteotomy of the lateral calcaneal neck may not provide reproducible, predictable resolution of the problem [3].
- Gait abnormalities have been documented following resection of talocalcaneal coalition [4].
- Arthrofibrosis involving the middle facet of the talocalcaneal joint has been reported in children and adolescents [4].
- Talonavicular coalition has been reported following avascular necrosis of the tarsal navicular [4].

References

- [1] Tachdjian S Pediatric Orthopaedics From The Texas Scottish Rite Hospital For Children E Book. Plate 15.3 Kramer/Barmada Osteotomy of the Base of the Femoral Neck for Slipped Capital Femoral Epiphysis > Flexible Flatfoot (Pes Planovalgus) > Definition.
- [2] Tachdjian S Pediatric Orthopaedics From The Texas Scottish Rite Hospital For Children E Book. The Focused Examination > Flatfoot.
- [3] A Lange Medical Book Current Diagnosis Treatment In Orthopedics Fifth Edition. **10Pediatric Orthopedic Surgery > 5. Pes Planus (Flatfoot).**
- [4] Campbell S Operative Orthopaedics 4 Volume Set. MULTIPLE Z-PLASTY RELEASE OF A CONGENITAL RING > TARSAL COALITION/SPASTIC FLATFOOT.
- [6] Orthopaedic Knowledge Update. Congenital Disorders of the Foot* > Flexible Flatfoot.
- [7] Orthopaedic Knowledge Update 13 Ebook Without Multimedia. Foot and Ankle Reconstruction > Adult Acquired Flatfoot Deformity.
- [9] Miller S Review Of Orthopaedics. SECTION 16 PATELLAR TRACKING IN TOTAL KNEE ARTHROPLASTY > PES PLANUS (FLATFOOT DEFORMITY) > 10. Diagnosis.

[11] Miller S Review Of Orthopaedics. SECTION 16 PATELLAR TRACKING IN TOTAL KNEE ARTHROPLASTY > PES PLANUS (FLATFOOT DEFORMITY) > 11. Treatment—based on stage of the deformity.

[13] Miller S Review Of Orthopaedics. SECTION 16 PATELLAR TRACKING IN TOTAL KNEE ARTHROPLASTY > PES PLANUS (FLATFOOT DEFORMITY).

[14] Miller S Review Of Orthopaedics. PES PLANUS (FLATFOOT DEFORMITY).