Continuing Medical Education

Evaluation and Surgical Management of Flexible Pediatric Flatfoot

Proper diagnosis will lead to better conservative or surgical outcomes.

Objectives

1) Be able to determine the appropriate procedure for the symptomatic pediatric flatfoot

2) Be able to identify the plane of deformity in the symptomatic pediatric flatfoot patient

3) The procedures that correspond with the different planes of deformity for the symptomatic pediatric flatfoot

4) The key surgical pearls for a successful surgical outcome for the symptomatic pediatric flatfoot deformity

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*Following this article, an answer sheet and full set of instructions are provided (p. 184).—**Editor***

By David Yeager, DPM, and Hyim Baronofsky, DPM

The pediatric flatfoot patient is a condition with which every podiatrist has great familiarity. Frequently, pediatric flatfoot can be asymptomatic or even self-correcting with development. Still, we are all aware of children who are reluctant to exercise due to pain, or adults who did not receive treatment as adolescents and are now faced with major reconstructive surgery. Most patients will present by referral from pediatricians or a concerned parent who has brought in his/her child to be evaluated. Most pediatricians consider pediatric flatfoot to be a benign process because most infants are born with a flexible flatfoot and really do not develop a normal arch until they are seven to ten years of age. Studies have shown that approximately 52-70% of children aged two to three have flatfoot, yet only 17-26% of children at six present with flatfoot[1]. This demonstrates a natural correction with aging.

A second study in *Pediatrics* reported that only 2.7% of children 4-13 are flatfooted.[2] Furthermore, the original study had data showing that greater than 90% of the patients re-

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ceiving treatment for flatfoot did not actually meet the criteria for flatfoot diagnosis.[1] The key is that if podiatrists can gain better understanding of pediatric flatfoot and its treatment, we can then better assist our colleagues in identifying and helping children who need surgical intervention. This, in turn, ultimately assists those individuals in leading a more active and normal life.

Identifying the types of pediatric flatfoot, whether it is flexible or rigid, and assessing the proper time for treatment are paramount to the clinician's success in treatment.

Clinical Exam

Physical examination is the first step in identifying a patient with flatfoot. Asking the patient, parent, or guardian simple historical questions of onset, progression, family history, and any associated neurological conditions is a solid place to start.

Common features to examine and identify are low arch, calcaneus in everted position, medial talar head uncovering, altered gait, and presence of calluses medially.[3] Frequently, when the patient is examined in a non-weight-bearing position, the foot structure may appear to be rectus when placed in neutral position. However, when the same patient is observed in weight-bearing stance and in gait, one will see the foot morph into a flatfooted appearance. Visualization of the foot, determining the plane of dominance, and how it functions dynamically in gait analysis is crucial.

Biomechanical evaluation should include ankle joint, first ray, subtalar joint and midfoot range of motion, as well as analysis of forefoot to rearfoot relationship. The Silverskoild test should be performed with knee extended and flexed to check for equinus. This test determines what type of flatfoot is present and is important for possible surgical planning at a later date. Gait evaluation should assess for normal gait patterns as well as over-pronation, calcaneal eversion, heel-to-contact position, and possible knee or hip pathologies. Neutral and relaxed calcaneal stance position should be measured as well as the 'too many toes' sign evaluated (Figure 1) . Dynamically, the patient should perform single and double heel lifts to evaluate whether proper heel inversion is achieved.[3]

Radiographic Exam

Radiographic evaluation is essential in identifying the plane(s) of deformity. Neutral weight-bearing films are very important. If neutral weight-bearing films are not performed, possible dire results could occur, such as over-correction, leaving the patient with a nice arch but a foot that has a metatarsus adductus function. On anterior-posterior (AP) film, talocalcaneal (Kite's) angle, forefoot to rear foot adduction, and talus to first metatarsal angle should be assessed. On lateral projection, calcaneal inclination, talar declination, talus to first metatarsal angle (Meary's angle), anterior break in the cyma line, and first metatarsal elevation or declination should be measured.

Patients with sagittal plane deformities will have increased talar declination and talocalcaneal angles (lateral) and decreased calcaneal inclination. Frontal plane deformities will present with decreased first metatarsal declination angle, decreased sustentaculum tali height, increased lesser

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Figure 1: This picture depicts the classic "too many toes" sign.

Figure 2: This picture indicates a complete collapse of the medial arch with talar bulging and attenuation of the posterior tibial tendon.

Figure 3: Notice the lateral fold of the foot indicative of a valgus heel.

Figure 4: The picture depicts an accommodative orthotic that is obviously too short to be of any use for this pediatric patient.

metatarsal superimposition on lateral projection, and widening on AP. Transverse plane dominance will be noted with increased talocalcaneal (AP) and calcanealcuboid angles and decreased talonavicular joint congruency (increased talar uncovering).[4]

Flexible versus Rigid Flatfoot

The difference between the flexible versus rigid flatfoot is that in the rigid flatfoot the foot is flat both in weight-bearing and non-weight-bearing, combined with a significant decrease or absence of motion. In addition, the rigid flatfoot will fail the Huebschner maneuver (dorsiflexing the hallux in a weight-bearing position with no arch recovery) (Figure 2).

Flexible Flatfoot

Flexible flatfoot can be asymptomatic or symptomatic. Etiologies of flexible flatfoot include rearfoot equinus, compensated forefoot varus, compensated rearfoot valgus, limb length discrepancy, ligamentous laxity, metatarsus adductus, internal tibial torsion, external femoral torsion, Ehlos-Danlos, and trauma, among others. Asymptomatic patients are typically patients who will improve with time and development. Their symptoms may be exaggerated due to obesity.[1] However, if the patient presents with excessive heel eversion (picture 1) or talonavicular instability (prominent talar head medially) (picture 2) and possible equinus, they should be monitored closely. Conservative treatment for such patients includes stretching of the Achilles tendon and UCBL orthotics to maintain normal joint alignment and congruity[5] and ideally to increase heel stability. In addition, casting of the very young patient and bracing at night can also be effective. A study by Bordelon showed clinical and radiographic improvement in pediatric flatfoot patients with the use of orthotics.[6]

Figure 5: Notice the right foot improvement in the heel position which is now perpendicular to the ground with loss of talar bulging. The left side has talar bulging, heel valgus, and a valgus deviation of the heel. This foot has responded well to surgical intervention via a flexible flatfoot implant.

Figure 6: This picture depicts a view from the front indicating an improvement in arch height with no talar bulging with the use of a flatfoot implant.

Symptomatic patients will typically complain of pain and/or decreases in activity level with failure of conservative therapy. In addition, cramping in the posterior calf region can also accompany painful flexible pediatric flatfoot. Pain is often noted along the medial side of the foot, sinus tarsi, leg, and knee. Patients will relate a decrease in activity and endurance as well as pain in footgear at the prominent medial talar head and lateral heel due to eversion (Figure 3). Initial treatment should include activity adjustments and orthotics (Figure 4). Stretching and NSAIDs can be used as needed. If symptoms do not improve, evaluation of possible contributing factors should be assessed: obesity, ligamentous laxity, hypotonia, and proximal limb pathology. If conservative treatments and modification continue to fail, surgical intervention should be considered.[3]

Surgery is always a last resort

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Figure 7: This shows improvement in arch height and good first ray orientation of the surgically corrected flatfoot implant foot.

Figure 8: This is the non-surgical foot. Notice the decreased medial arch with talar bulging.

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but can yield very beneficial results. Realistic outcomes have to be discussed with the child and the parents prior to any surgical intervention. Prior to this discussion, the surgeon must have a grasp on the planar dominance of the deformity, any concomitant medical conditions, and the activity level of the patient. In addition, consideration of the severity, flexibility, and progression of the deformity have to be discussed with everyone.

Flatfoot reconstructive surgery is typically a combination of osseous, soft tissue and arthroreisis procedures. In severe cases, arthrodesis should be considered. Once again, having a firm grasp on the planes of deformity for proper selection of procedures is paramount to success in these types of surgical procedures.

The first deformity that one should address is the calcaneal equinus. Percutaneous tendo-Achilles lengthening, open tendo-Achilles lengthening or gastrocnemius recession are acceptable procedures, as long as one achieves greater than 10 degrees of dorsiflexion at the ankle joint. One will often find a correction of the excessive subtalar joint eversion with Achilles lengthening. Overcorrection, of course, has to be avoided.

Sagittal Plane

Sagittal plane deformities should include a combination of the following: Kidner, flexor digitorum Longus transfer, Lowman procedure, Young procedure, medial arch suspension (MAS), Cotton osteotomy and spring ligament repair (Table 1).

Frontal Plane

Frontal Plane corrective procedures are calcaneal slide osteotomy, reverse Dwyer, Silver, and subtalar joint arthroreisis. (Table 2)

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TABLE 1
Sagittal Plane Procedures

PROCEDURE	DESCRIPTION
Kidner	Removal of accessory navicular, transposition of posterior tibial tendon to reduce slack.
FDL Transfer	Sacrifice FDL distally to transfer to navicular or along the PT tendon. Attach distal stump to FHL.
Lowman	TAL, TN wedge arthrodesis, TA under navicular and suture spring ligament, desmoplasty of the T-N ligaments.
Young	TAL, TA transposed with navicular creating new plantar ligament, advancement of spring ligament on self.
MAS	Young plus PT tendon advancement, tightening of spring ligament, and FDL transfer.
Cotton	Opening wedge of medial cuneiform, cut parallel to N-C joint, keep plantar cortex intact, reduction of elevatus, stabilize medial column.

TABLE 2
Frontal Plane Procedures

PROCEDURE	DESCRIPTION
Calcaneal Slide	Medial translation of posterior fragment of calcaneus, corrects frontal plane deformity, alters pull of gastroc-soleus muscle group.
Reverse Dwyer	Lateral closing wedge located between the posterior STJ facet and the Achilles attachment.
Silver	Opening wedge bone graph on lateral calcaneus. Posterior calcaneus is translated plantarly and medially.
Arthroreisis	Usually performed with implanted that limits STJ eversion.

Transverse Plane

Transverse plane deformities can be addressed with an Evans osteotomy, cuboid osteotomy, calcaneal-cuboid distraction arthrodesis or medial cunieform osteotomy. (Table 3)

Arthroereisis

Arthroereisis is a very effective and powerful treatment option. This implant, inserted in the sinus tarsi, blocks abnormal anterior talar displacement and adduction, and further prevents calcaneal eversion. This procedure is effective in the flexible deformity population by allowing the subtalar joint to function in a corrected position. It is important to note that primary frontal plane deformity can be corrected with this procedure (Figures 5,6,7, 8). Once the implant has been placed, the surgical foot needs to be loaded by pressing up on the lateral column to see if any additional medial column work is needed due to forefoot supinatus.

Arthroereisis is a very effective and powerful treatment option.

Arthrodesis should only be considered as a very last resort treatment. It is most commonly used in patients who have had previous flatfoot reconstructions that have failed. In those cases, the procedure of choice is a triple arthrodesis.[4]

All surgical patients should follow up regularly for observation and orthotics treatment through the remainder of adolescence.

Rigid Flatfoot

Maintaining joint motion and joint salvage are key to correction of the symptomatic pediatric flatfoot. However, rigid presentation of pediatric flatfoot can be divided into two primary diagnoses: tarsal coalitions and congenital convex pes valgus (vertical talus). Tarsal coalitions can be fibrous, cartilaginous or osseous. The more common coalitions are calcaneonavicular or talocalcaneal middle facet.

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TABLE 3
Transverse Plane Procedures

PROCEDURE	DESCRIPTION
Evans	Lateral column lengthening procedure. Opening wedge approx 1.5 cm from calcanealcuboid joint with insert of bone graft or block plate. Triplanar correction (primarily transverse) with realignment of midtarsal joint and reduction of calcaneal eversion. Improvement of arch height and stabilization.
Medial Based Osteotomy	Medial base wedge to allow for shortening of the medial column and reduction of the abduction deformity.

TABLE 4
Surgical Procedures Based on Age for Vertical Talus

AGE	PROCEDURES
1-4	Open reduction and realignment of talonavicular and subtalar joints.
3-4	In severe deformities, the navicular may need to be resected.
4-8	Open reductions, soft tissue release (dorsal talonavicular ligament, plantar calcaneonavicular lig, anterior portion of superficial deltoid lig. Possible lengthening of peroneal, EHL, EDL tendons.
12+	Triple arthrodesis

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Other possible, but less frequent, coalitions are talonavicular, calcanealcuboid, naviculocuboid and naviculocuneiform.[7] Subtalar joint coalitions restrict motion, thus causing secondary arthritic changes, and joint salvage becomes impossible. Patients will present with pain due to a recent increase in activity or weight gain. Patients may or may not have peroneal muscle spasm. Physical exam will reveal little or no rearfoot range of motion with an abrupt endpoint. Radiographic and advanced imaging such as CAT scans or MRI's should be explored for further assessment of possible additional coalitions and for surgical planning purposes.

Calcaneonavicular Coalitions

Calcaneonavicular coalitions can be visualized via lateral and lateral oblique radiographs. Depending on the level of ossification, a projection is usually noted from the calcaneus to the inferolateral navicular. Talocalcaneal middle facet coalitions can be identified on lateral projections by the presence of a 'halo' sign, or on Harris-Beath projects the facets are irregular and non-parallel. CT scans are useful for talocalcaneal middle facet coalitions as well as in patients with multiple coalitions. MRI can be best utilized in skeletally immature patients or in patients with non-osseous coalitions.[3]

Initially, treatment for coalitions should include shoe modification, custom orthotics, NSAIDs, cast immobilization, reduced activity, and weight loss regimen. If after several months, the patient is still experiencing pain or limitations in activity, surgical treatment should be considered and discussed with the patient. Surgical treatment is performed by either resection of coalitions or arthrodesis.[3] The patient and the patient's parents need to be well informed regarding the pros/cons of each procedure.

Congenital Vertical Talus

Congenital vertical talus is seen in infants and very young children. It is identified by a rigid rocker bottom foot and severe equinus. Congenital vertical talus can be an isolated finding but is more commonly associated with other congenital abnormalities: arthrogryphosis, myelomeningocele, spinal dysraphism, prune belly syndrome, de barsy syndrome, congenital metacarpotalar syndrome, Rasmussen syndrome, etc.[3,6]

At birth, physical exam should reveal a rounded medial and plantar surface due to the abnormal position of the talus. Other clinical findings are ankle joint equinus, dislocation of the talonavicular joint, contracture of the long-toe flexors, peroneal tendons, and anterior compartment tendons.

Radiographic evaluation will reveal a talus that nearly parallels the tibia, with weight-bearing lateral projections. The calcaneus is in severe equinus, as well. Advanced imaging, including CT, MRI, and ultrasound should be utilized for pre-surgical planning.

Surgical planning is determined based on the patient's age and severity of deformity. Surgical procedures can include open reduction and realignment of joints, excision of navicular, soft tissue procedures, and triple arthrodesis (Table 4).[7]

Pediatric flatfoot is a process that can have a profound impact on a young person's life. As a physician, treatment can be very rewarding but also challenging. As surgeons, we need to remember the goal: to provide a stable, functional, pain-free foot. It is critical to diagnose the correct presentation of flatfoot and formulate a thorough treatment plan, both conservatively and surgically. An open dialogue with the patient and the parents is paramount in achieving optimal results.

A clear outline of treatment with expectations should be reviewed and discussed as well. Also, educating and communicating with a good physical therapist regarding the procedures we perform is also very important in achieving a rewarding result. This, in turn, can lead to several referrals from our physical therapist colleagues.

With proper preparation, communication, and family support, a podiatric physician should be well prepared to assist the pediatric patient toward a successful surgical or conservative outcome. ■

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Dr Baronofsky is currently in private practice in Illinois. He graduated from Scholl College of Podiatric Medicine in 2007 and the St Joseph/North Chicago VAMC Residency Program in 2010.

EXAMINATION

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See answer sheet on page 185.

1) What type of radiograph is the most important in the evaluation of pediatric flatfoot?
   A) Lateral
   B) Anteroposterior
   C) Medial oblique
   D) Neutral weight-bearing

2) What is the name of the weight-bearing maneuver to evaluate if the pediatric flatfoot is rigid or flexible?
   A) Silverskoid
   B) Huebschner
   C) Homan
   D) Thompson

3) What factors need to be assessed in the pediatric patient prior to surgery?
   A) Concomitant medical conditions
   B) Activity level of patient
   C) Severity, flexibility, and progression of deformity
   D) All of the above

4) Arthroereisis is effective in treatment of pediatric flatfoot by:
   A) Correcting rigid deformity
   B) Correcting transverse plane deformity
   C) Blocking anterior displacement of the talus
   D) Correcting sagittal plane deformity

5) In a rigid pediatric flatfoot, what two conditions should the clinician be suspicious of?
   A) Tarsal coalition
   B) Congenital convex pes valgus
   C) Both A and B
   D) Neither A or B

6) Which test is most accurate for diagnosing fibrous coalitions?
   A) CAT scan
   B) MRI
   C) Ultrasound
   D) None of the above

7) Which plane(s) of deformity are primarily corrected in an arthroreisis procedure?
   A) Sagittal
   B) Transverse
   C) Frontal
   D) All of the above

8) Which of the following diagnoses should be explored if a patient's symptoms do not improve with conservative treatment?
   A) Obesity
   B) Ligamentous laxity
   C) Proximal limb pathology
   D) All of the above

9) Which of the following are effective in surgically treating equinus?
   A) Percutaneous tendo-Achilles lengthening
   B) Gastrocnemius tendon recession
   C) Open tendo-Achilles lengthening
   D) All of the above

10) Calcaneonavicular coalitions are best visualized on which radiographic projection?
   A) Lateral
   B) Anteroposterior
   C) Harris Beath
   D) Medial oblique

11) Which of the following are consistent with flexible flatfoot on lateral radiograph?
   A) Anterior break in Cyma line
   B) Increased talar declination
   C) Increased calcaneal inclination
   D) Increased talocalcaneal angle

12) Which of the following conservative treatments are effective for treating flexible flatfoot?
   A) Stretching program
   B) Orthoses
   C) Casting
   D) All of the above

13) All of the following are characteristics of congenital vertical talus except:
   A) Rounded lateral surface
   B) Severe ankle joint equinus
   C) Talus parallel to tibia on weight-bearing radiograph
   D) Dislocation of the talonavicular joint

14) At what age is the triple arthrodesis procedure recommended for patients with congenital vertical talus?
   A) 1-4 years
   B) 3-4 years
   C) 4-8 years
   D) 12 plus years

15) Conservative treatment for coalitions include:
   A) Custom orthoses
   B) NSAIDs
   C) Casting
   D) All of the above

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EXAMINATION

(cont'd)

16) The following is true in relation to talocalcaneal middle facet coalitions.
- A) Halo sign
- B) Parallel facets on Harris-Beath views
- C) A and B
- D) None of the above

17) Tarsal coalitions can be:
- A) Fibrous, osseous, myotendinous
- B) Osseous, myotendinous, cartilaginous
- C) Myotendinous, cartilaginous, fibrous
- D) Cartilaginous, fibrous, osseous

18) Evans calcaneal osteotomy can correct deformities that exist in which plane?
- A) Frontal
- B) Transverse
- C) Sagittal plane
- D) All of the above

19) The Silverskoild test assesses what?
- A) Plane of deformity
- B) Equinus
- C) Rigid vs. flexible flatfoot
- D) Tarsal coalition

20) Talocalcaneal middle facet coalitions can be identified on lateral projections by the presence of a(n):
- A) Halo sign
- B) Anteater sign
- C) Comma sign
- D) Thompson sign

See answer sheet on page 185.

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EXAM #7/10
Evaluation and Surgical Management of Flexible Pediatric Flatfoot (Yeager and Baronofsky)

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