CHAPTER **12**

A SYSTEMATIC APPROACH TO PEDIATRIC FLATFOOT: What to Do and When to Do It

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Pediatric flatfoot is a common, yet challenging deformity. Infants are usually born with a flexible flatfoot and typically do not develop a normal arch until around 7 to 10 years old. One of the biggest challenges for the physician is differentiating a normal or physiologic flatfoot from the pathological deformity. After appropriate diagnosis, the next critical step is selecting the proper treatment protocol. There are numerous treatment protocols and surgical procedures available for the intervention of pediatric flatfoot. The author will review various surgical procedures and present indications for appropriate selection of each.

Pediatric flatfoot can be divided into flexible and rigid categories. The majority of these deformities are flexible and will be the primary focus of this article. The flexible flatfoot may be physiologic or pathological.[1] The astute foot and ankle surgeon should be able to differentiate the deformities, make an accurate diagnosis, and instill proper treatment. Fortunately, most flexible flatfeet are physiologic and asymptomatic and require no treatment.[2-4] Periodic observation may be instilled however just to monitor for any progression of deformity. Lin et al[5] reviewed the natural history of feet in preschool children and found a decrease in the incidence of flexible flatfoot, including severity, with age and increased body height and weight. A total of 57% of children ages 2 to 3 years had moderate or severe flatfeet compared with 21% at age 5 to 6 years. This is an indication that these physiologic pediatric flatfeet undergo spontaneous correction.

Unfortunately however, pathologic flexible flatfoot in children has been shown to have an incidence ranging from 2.7% to 4%.[6-10] These are the deformities that require treatment. If left untreated, these pathologic flatfoot deformities usually progress and result in painful, disabling end stage pes valgo planus feet.

EVALUATION

Proper diagnosis is contingent upon a thorough history and physical examination. A full history should be obtained including the onset of deformity, progression of the deformity, pain associated with deformity, family history of foot deformities, and concurrent medical conditions, such as neurological disorders. Although some degree of pain is usually associated with a pathologic flatfoot, its absence does not mean treatment is not warranted. Younger children often do not complain of pain; however, other subjective symptoms may be present. These may include generalized foot, ankle, or leg fatigue, night cramps, clumsiness, excessive shoe wear, athletic abstinence, avoidance of walking distances, and pursuing sedentary activities. The younger child may want to be carried and complain that their feet are tried. The child may become inactive and not want to participate in normal age-appropriate activities or have to stop the activity secondary to pain or fatigue. When pain is present, it is typically dull, aching or throbbing pain or cramping along the medial longitudinal arch and/or lateral foot around the sinus tarsi region. The child may also just have generalized fatigue of the lower extremity, or even low back or knee pain.

The physical examination should include the overall severity of the deformity, range of motion and flexibility of the deformity, muscle strength and spasticity, evaluation of areas of tenderness, and a gait evaluation. The foot should be evaluated in both a weight bearing and non-weight bearing attitude. Children with a flexible flatfoot typically present with a relatively normal appearing foot and arch when non-weight bearing. Upon weight bearing however, calcaneal eversion and collapse of the medial longitudinal arch will typically result. Other clinical findings may include medial bulging of the talar head, excessive forefoot abduction, and equinus.

It is important to evaluate the amount of flexibility present in the deformity and assess for the possibility of a tarsal coalition. In the flexible flatfoot, the deformity can be manually reduced. The arch is easily recreated in stance with the Hubscher maneuver and the heels become inverted when standing on the toes. Muscle strength and spasms should also be evaluated. Peroneal muscle spasms could signify a tarsal coalition but may also result secondary to pain and guarding from the deformity itself. An equinus deformity is very commonly associated with pes valgo planus. The lower extremity should be evaluated with the knee extended and flexed to determine the degree of muscle involvement when an equinus deformity is present. Finally, a gait evaluation should be performed.

The position of the foot should be noted at heel strike and throughout contact. An early heel off is sometimes noted with an equinus deformity. Although pes valgo planus is typically a triplanar deformity, often times the deformity is dominant in one plane. Therefore, planal dominance should be assessed so that proper treatment including appropriate selection of surgical procedures can be employed.

Weight bearing radiographs should also be obtained. It is typical to see an increase in Kite's angle or the talocalcaneal angle, an increase in the talar declination angle, and an increase in the calcaneocuboid angle. The calcaneal inclination angle is usually decreased and there can be an anterior break in the cyma line. If one is suspicious of a tarsal coalition further imaging studies such as computed tomography or magnetic resonance imaging can be performed for a more complete evaluation.

TREATMENT

After appropriate diagnosis of a pathologic flatfoot, the next critical step is selecting the proper treatment protocol. Treatment protocols vary greatly and depend on many factors including the severity of the deformity, the flexibility of the deformity, the progression of the deformity, pain associated with the deformity, and the age of the child. As with the majority of other foot and ankle deformities, conservative therapies are attempted before any surgical intervention for pediatric flatfoot. Conservative therapies may include but are not limited to manipulation and stretching, activity modifications, appropriate shoe gear, orthoses, and anti-inflammatory medications.

Unless severe deformities are present, such as vertical talus, conservative therapies are typically the only form of treatment the author performs on children under the age of 3. Serial casting and manipulation can be performed for those under the age of 1. At this age the foot is still somewhat moldable and often correction of the deformity can be obtained. Casting may also be attempted for those over this age however the results are usually not as good, and children are often reluctant to casting once they have begun to walk. Bracing is another option and can be utilized during hours of sleep.

SURGICAL OPTIONS

Indications for surgical repair include failure of all conservative therapies to reduce the patient's pain or prevent progression of the deformity. Surgical considerations include severity of the deformity, flexibility of the deformity, planal dominance, concomitant medical conditions, patient's age, and functional demands.

Surgical procedures can generally be divided into four categories: soft tissue, arthroereisis, osteotomies, and arthrodesis. The goal of surgery in the pediatric patient is to reduce or eliminate pain, reduce deformity and restore normal joint alignment, and preserve joint motion when possible. There are many soft tissue procedures utilized in the correction of pediatric flatfoot deformities. Most of these procedures are performed to stabilize the medial arch or correct for an equinus deformity. Although these soft tissue procedures can be very effective, they are typically adjunctive procedures and are rarely successful as an isolated technique for correction of flexible flatfoot.

Arthroereisis

The arthroereisis implant is extra-articular and limits excessive or abnormal motion across the subtalar joint. It is designed to block abnormal talar motion without damaging the subtalar joint itself. The implant is placed in the sinus tarsi and blocks abnormal anterior talar displacement and adduction and prevents calcaneal eversion. This repositioning then allows the subtalar joint to function in a corrected position. The author prefers this technique in the younger patient with a flexible deformity typically between the ages of 3 and 12 years old (Figure 1). With the anatomic realignment after placement of the arthroereisis implant, the peroneus longus tendon functions more efficiently by restoring plantarflexion of the first ray and stabilizing the medial forefoot. After placement of the arthroereisis implant however, the medial arch should be assessed to determine if any deformity remains necessitating adjunctive procedures to provide for adequate correction.

When arthroereisis is performed at an early enough age, often it is the only procedure that needs to be performed. If further surgical procedures are necessary however to stabilize the medial arch or to correct for further deformity, typically it consists of soft tissue procedures such as a Young's tenosuspension and/or tightening of the spring ligament. Less commonly, in this age group and for this degree of deformity, osteotomies or arthrodesis in the medial arch can be performed to achieve stability and correction. It is critical that the surgeon also identify and correct an equinus deformity if present. A gastrocnemius recession is performed if only the gastrocnemius muscle is tight. If both the gasctrocnemius and soleus muscles are tight then an Achilles tendon lengthening is performed.

The arthroereisis procedure is geared towards correcting a rearfoot deformity with a frontal plane dominance; therefore, it should not be utilized in a flaftfoot deformity with an absence of calcaneal eversion. This procedure should also be avoided in rigid

Figure 1A. Preoperative radiograph of a 9-year-old with a flexible flatfoot deformity with chief complaint of arch pain.

Figure 1C. Postoperative radiograph showing correction of the deformity following an arthroereisis and an Achilles tendon lengthening. Notice the improvement in the talocalcaneal angle and talar declination angle.

Figure 1B. Preoperative view.

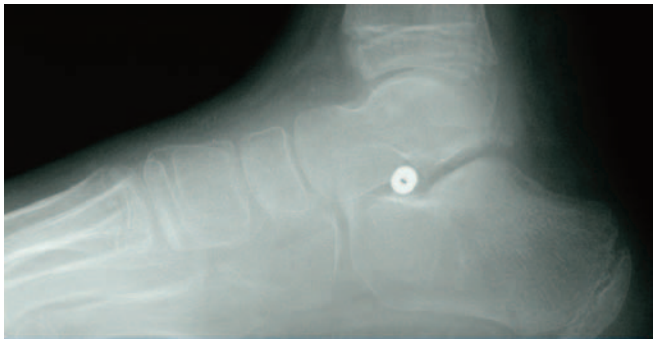

Figure 1D. Postoperative view.

deformities. Often a rigid deformity is the result of a tarsal coalition. If the coalition is resected and the deformity becomes flexible, an arthroereisis procedure may then be considered. The arthroereisis implant is typically left in the patient indefinitely unless the implant is malaligned or causing the patient pain.

Osteotomies

Osteotomies for the correction of pediatric flatfoot primarily consist of calcaneal osteotomies and midfoot osteotomies in the medial arch. Although the use of arthroereisis has been successfully described for correction of flatfoot deformities in the older child and adult populations, the author usually prefers surgical correction for flexible flatfoot deformities with osteotomies over the utilization of arthroereisis for most patients in this age category.

Evans calcaneal osteotomy. For the adolescent or preadolescent child with more significant deformities, the author will typically perform an Evans calcaneal osteotomy as the primary surgical procedure. The Evans calcaneal osteotomy is a powerful procedure that provides triplanar correction. When it was first popularized it was primarily

Figure 2A. Clinical photograph of a 10-year-old with bilateral painful flexible flatfoot deformities. Heel valgus and medial arch collapse with bulging of the talar head are seen.

Figure 2C. Preoperative radiograph reveals significant increase in the talar declination angle and talocalcaneal angles. At least 50% of the talar head is uncovered.

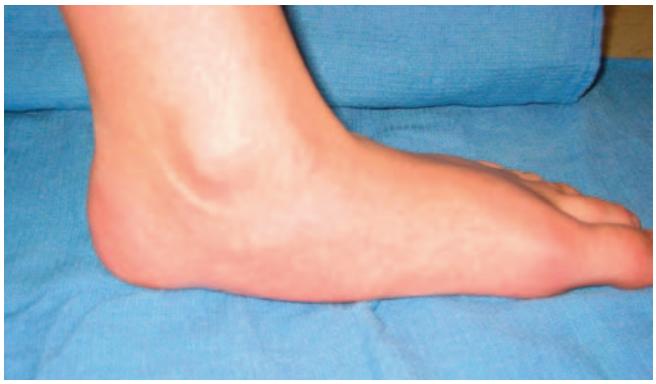

Figure 2B. Clinical view.

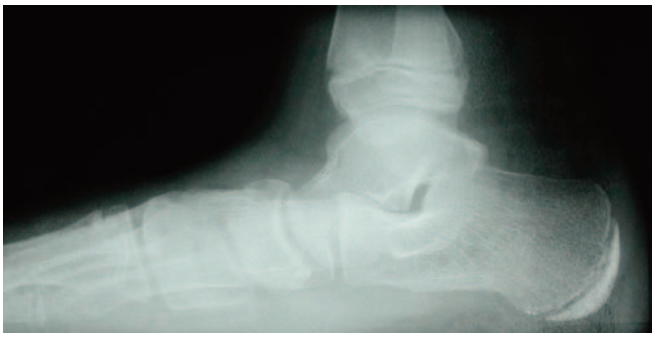

Figure 2D. Preoperative radiograph.

Figure 2E. Postoperative radiograph showing significant improvement in the talar declination, talocalcaneal, calcaneal inclination, and calcaneocuboid angles. Surgical procedures included an Evans calcaneal osteotomy, Cotton medial cuneiform osteotomy, and an Achilles tendon lengthening. This displays the triplanal correction obtained with the Evans calcaneal osteotomy.

Figure 2F. Postoperative radiograph.

Figure 2G. Postoperative clinical photograph displays a rectus heel position and reconstitution of the medial arch.

Figure 2H. Postoperative clinical view.

utilized as a procedure to produce correction in the transverse plane; however, correction also occurs in the sagittal and frontal planes as well. This laterally based opening wedge osteotomy effectively lengthens the lateral column and reduces the forefoot abduction and transverse plane deformity. In addition, realignment of the midtarsal joint is achieved and calcaneal eversion and frontal plane deformity is reduced. This procedure also places tension on the long plantar ligaments and provides significant arch elevation and stabilization reducing the sagittal plane deformity.

Correct placement of the osteotomy is critical for success of the procedure. It should be made approximately 1 cm proximal to the calcaneocuboid joint and perpendicular to the lateral wall of the calcaneus. This location avoids critical structures such as the middle facet of the subtalar joint. Care should be taken when placing the osteotomy so that it is not too close to the calcaneocuboid joint. This could cause the anterior fragment of the calcaneus to be too small and displace or even fracture under pressure. Allogeneic bone graft, preferably tricortical iliac crest graft, is typically used for this opening wedge osteotomy. The calcaneus is very vascular and allogeneic bone incorporates well without any healing problems noted by the author.

In adolescents, the graft size should not exceed approximately 12 mm and taper down to 3 to 4 mm. Larger grafts will cause increased pressure along the calcaneocuboid joint possibly resulting in arthritic changes of the area; although pediatric patients are more tolerant of this. Also, larger grafts can be compressed and absorb resulting in loss of correction. Since the bone graft is under significant compression, dislocation is rare, and fixation is not commonly utilized. If the site feels unstable however, fixation can be obtained with a Kirschner-wire.

Although this procedure places the peroneus longus tendon under tension by lengthening the lateral column, typically, a forefoot supinatus deformity persists and must be addressed. In most cases, the Evans calcaneal osteotomy is accompanied by additional procedures in order to reduce the forefoot varus and stabilize the medial column. Most commonly, this includes a Cotton medial cuneiform osteotomy with or without additional soft tissues procedures of the medial arch (Figure 2). The equinus deformity is also corrected with a gastrocnemius recession or Achilles tendon lengthening as indicated.

Under correction is less likely with the Evans calcaneal osteotomy than with many other procedures. Risk factors for under correction include a high talocalcaneal angle on the AP radiograph and a high degree of calcaneal valgus.

Posterior calcaneal displacement osteotomy. Although the Evans calcaneal osteotomy provides for triplanal

correction, it is primarily focused on transverse plane deformities. If a frontal plane deformity is dominant or remains after correction with an Evans calcaneal osteotomy, a medial displacement osteotomy can be performed in the posterior calcaneus (Figure 3). This posterior calcaneal displacement osteotomy restores the normal angle of the long axis of the calcaneus to the floor and neutralizes abnormal pronatory forces. The medial shift of the posterior calcaneus alters the pull of the gastrocnemius-soleus muscle group slightly medial to the axis of the subtalar joint. This effectively places the achillis tendon slightly medial and increases the varus pull on the hindfoot.

This osteotomy is made approximately 1 cm posterior to the posterior facet and is angled approximately 45 degrees to the weight-bearing surface. In addition to medial displacement, the osteotomy can also be displaced plantarly and anteriorly to achieve additional correction. If an equinus deformity is present however, this must be released prior to permanent positioning of the osteotomy so that adequate correction can be achieved. Fixation of the osteotomy can be obtained with pin or screw fixation or if the growth plate is still open, a step-off plate can be utilized.

In most cases, the posterior displacement calcaneal osteotomy is not utilized as an isolated procedure and additional procedures in the medial arch are necessary to achieve adequate correction of the deformity. Also, this procedure is most successful for reduction of frontal plane deformities and it cannot correct for large amounts of forefoot abduction.

Cotton medial cuneiform osteotomy. The Cotton osteotomy is performed when there is structural elevation of the medial column. The author will commonly utilize this procedure as an ancillary procedure when performing the Evans calcaneal osteotomy (Figures 2, 3). The Evans calcaneal osteotomy corrects forefoot abduction however a forefoot supinatus deformity typically remains. The Cotton osteotomy can effectively plantarflex the medial column and aid in stabilization.

The Cotton osteotomy is a dorsally based opening wedge osteotomy in the medial cuneiform. Usually, the same tricortical iliac crest bone graft that was utilized for the Evans calcaneal osteotomy can be utilized for this osteotomy. This wedge is wider dorsally and tapers plantarly. The largest portion of the graft typically measures 4 to 5 mm. Fixation is usually not necessary for this osteotomy since it is placed under compression and typically does not displace. If needed, a Kirschner-wire can be placed for stability.

Arthrodesis

When selecting surgical procedures for the correction of pediatric flatfoot deformity, attempts should be made for joint salvage and maintenance of joint motion whenever possible. There are some patients however, where joint salvage is not possible in order to obtain adequate correction of the deformity and reduce pain. This is particularly true for subtalar joint coalitions. Due to the significant restriction of the joint motion, secondary arthritic changes often occur and joint salvage is impossible. Although the surgeon may have good

Figure 3A. Clinical photograph of a 10-year-old with bilateral painful flatfoot deformities. Notice the significant heel valgus and medial arch collapse.

Figure 3B. Clinical view.

Figure 3C. Preoperative radiograph reveals significant increase in the talar declination angle, talocalcaneal angle, and calcaneocuboid angle. The majority of the talar head is uncovered and the AP radiograph looks like a medial oblique.

Figure 3E. Postoperative radiograph showing significant improvement. The talar declination, talocalcaneal, calcaneal inclination, and calcaneocuboid angles are all improved and the talar head is articulating with the navicular. Surgical procedures included an Evans calcaneal osteotomy, a posterior calcaneal displacement osteotomy, a Cotton medial cuneiform osteotomy, and an Achilles tendon lengthening. A step-off plate was utilized for fixation of the posterior calcaneal osteotomy since the growth plate was still open. A very large graft, 14 mm, was placed for the Evans calcaneal osteotomy and some compression and displacement of the graft resulted. Fortunately, correction was maintained and the patient is clinically asymptomatic.

Figure 3D. Preoperative view.

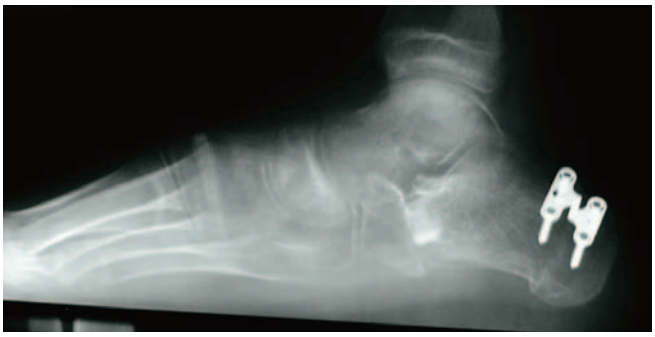

Figure 3F. Postoperative view.

Figure 3G. Postoperative clinical photograph displays a good rectus heel position and significant improvement of the medial arch.

Figure 3H. Postoperative clinical view.

intentions in trying to salvage joints in younger patients, it is often best to perform a definitive procedure, such as arthrodesis. If the deformity cannot be adequately reduced and a stable foot cannot be obtained with joint salvage procedures, the surgeon must consider arthrodesis even in the pediatric patient (Figure 4). If the deformity and arthritic changes are too severe, joint salvage should not be attempted. This will only result in continued pain and deformity and subject the patient to additional surgery.

Although rearfoot arthrodesis procedures occasionally have to be performed in the pediatric patient to obtain a successful surgical result, foot function following these procedures is significantly altered. Arthrodesis procedures of the medial arch however can afford for good correction and stability while the foot remains functional. Arthrodesis of the naviculocuneiform joint for the correction of pediatric flatfoot is typically not utilized as an isolated technique but as an ancillary procedure (Figure 5).

If significant deformity remains in the medial arch after other procedures such as an Evans calcaneal osteotomy, the author will commonly perform a naviculocuneiform arthrodesis. This is particularly effective when a significant naviculocuneiform fault or sag is appreciated. This is a powerful procedure and provides great support and stability to the medial longitudinal arch; however, the author will still try to achieve stability and correction with joint salvage procedures in the pediatric patient when possible. In addition, if a hallux abducto valgus deformity is present, a Lapidus or first metatarsal cuneiform arthrodesis can be performed. This procedure not only corrects the bunion deformity but it also provides additional stability to the medial arch.

CONCLUSION

Treatment of pediatric flatfoot can be very rewarding. The key to successful treatment is to correctly diagnose the deformity and individualize treatment. Pediatric flatfoot is

Figure 4A. Preoperative radiograph of a 13-year-old with a tarsal coalition and a painful rigid flatfoot.

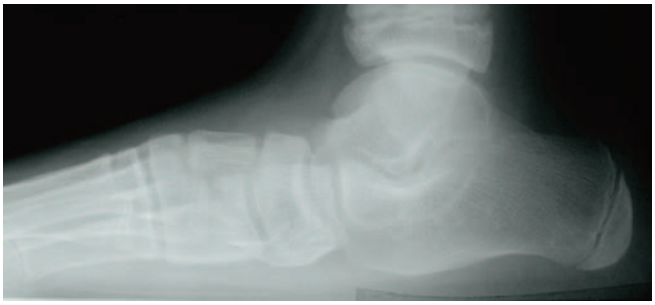

Figure 4B. Preoperative radiograph.

a complex deformity that varies from patient to patient. Patient age, severity of deformity, and flexibility of the deformity should help guide your treatment protocol and surgical procedure selection. Conservative treatments should always be attempted prior to any surgical intervention. The goal of surgical reconstruction is to produce a stable, functional, pain free foot.

The author has provided basic criteria to help determine appropriate procedure selection. It is important to remember that most flatfoot reconstructions consist of multiple procedures in order to achieve adequate correction. For the younger patient, the author prefers subtalar joint arthroereisis. For the adolescent and pre-adolescent child with more significant deformities the author prefers calcaneal and medial column osteotomies. Ancillary soft tissues procedures of the medial arch can also be performed when necessary. Arthrodesis may be warranted for severe deformities and arthritis or to afford for additional medial column stability. Finally, the equinus deformity must always be corrected when present for a successful result.

Figure 4C. An attempt was made at resection of the coalition but the patient had continued pain and deformity and a second surgery was performed. Even though the child was only 13, he had a severe, rigid, painful deformity and joint salvage was not possible. A triple arthrodesis was performed with good results and relief of his pain.

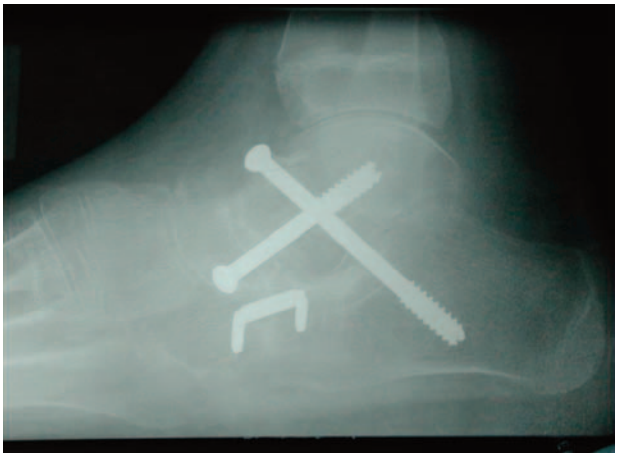

Figure 4D.

Figure 5A. Preoperative radiograph of a 13-year-old with back pain and lateral column pain. Notice the significant decreased calcaneal inclination angle and increased talocalcaneal angles. There is also a naviculocuneiform fault or sag and an anterior break in the cyma line.

Figure 5B. Preoperative radiograph.

Figure 5C. Postoperative radiograph of an Evans calcaneal osteotomy, naviculocuneiform arthrodesis, and Achilles tendon lengthening. Notice the corrected position of the naviculocuneiform joint affording increased arch stability. Overall alignment was significantly improved.

Figure 5D. Postoperative radiograph.

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