Lower Extremity Disorders in Children and Adolescents
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Pediatrics in Review 2009;30;287
DOI: 10.1542/pir.30-8-287

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Lower Extremity Disorders in Children and Adolescents

Brian G. Smith, MD*

Author Disclosure
Dr Smith has disclosed no financial relationships relevant to this article. This commentary does not contain a discussion of an unapproved/ investigative use of a commercial product/ device.

Objectives
After completing this article, readers should be able to:

1. Recognize and distinguish congenital clubfoot from metatarsus adductus.
2. Understand treatments and approaches to pes planovalgus or flatfoot.
3. Describe the natural history of torsional lower extremity deformities in children.
4. Discuss the differential diagnosis of idiopathic toe walking in children.

Clubfoot
Congenital talipes equinovarus or clubfoot is one of the oldest known congenital deformities, and its diagnosis and treatment date back to the time of Hippocrates.

With a personal experience of clubfoot treatment over the past 50 years, Ignacio Ponseti from the University of Iowa has maintained that careful serial manipulation and casting followed by a percutaneous heel cord release yields better outcomes than the more extensive posteromedial release performed commonly in the past 2 decades.

Epidemiology
Clubfoot occurs in about 1 in 1,000 live births and is more common in certain races or ethnic groups. For example, among South Pacific natives, the incidence of clubfoot is 7 per 1,000. Involvement is bilateral in about 50% of patients, and there is a male predominance of 2:1.

Pathogenesis
The precise pathogenesis of congenital clubfoot remains unclear. This complex disorder possibly involves genetic, neurologic, muscular, and intrauterine compression influences. A genetic predisposition exists, but a specific genetic cause has not been identified at this time.

Physical Findings and Presentation
Clubfoot may be identified by prenatal ultrasonography as early as 12 weeks of gestational age. Definitive diagnosis is by clinical examination after birth and is characterized by the four components of clubfoot: equinus positioning, cavus positioning, metatarsus adductus, and hindfoot varus (Fig. 1).

On physical examination, the foot is resistant to passive correction of the fixed hindfoot varus and typically maintains a rigid equinus position. The hindfoot involvement separates clubfoot from metatarsus adductus. Also in the differential diagnosis of this deformity is a congenital rocker bottom foot and a calcaneovalgus foot, both of which are distinguished from clubfoot by forefoot abduction. Additional evaluation, including imaging studies, seldom is necessary prior to initiation of casting.

Treatment
Ponseti’s technique involves serial weekly cast changes to correct forefoot adduction and hindfoot varus deformities, followed by a percutaneous tendo-achilles lengthening for most patients. Bracing with the Denis-Browne bar and wearing straight last shoes full-time for the first few months, then wearing them at night for years, also are critical parts of treatment. With this approach, open posteromedial release surgery can be limited to fewer than 10% of patients born with clubfoot. The technique achieves excellent functional results with minimal morbidity.

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Early referral to an orthopedist is recommended, with treatment ideally starting in the first weeks after birth, although good results can be attained even at late ages. Long-term outcomes, based on the work of Ponseti, are very favorable for a plantigrade, functional foot. About 10% to 20% of children may need a second operation to balance the foot by transferring the anterior tibialis tendon at around 4 to 6 years of age. Lack of compliance with wearing the bar and shoes as prescribed has been associated with worse outcomes.

**Metatarsus Adductus**

Metatarsus adductus (MTA) is a congenital foot deformity characterized by adduction or medial deviation of the forefoot relative to the hind foot. Unlike the clubfoot deformity, there is no hind foot varus or equinus deformity of the foot and ankle.

**Epidemiology**

The incidence of MTA has been estimated to be approximately 1 in 1,000 to 1,500 births but may be higher in infants who have a positive family history. Approximately 50% to 60% of affected infants have bilateral involvement.

**Pathogenesis**

Although the exact cause of MTA remains undefined, current theories include muscle imbalance in the foot, a congenitally abnormal medial cuneiform bone, and subluxation of the tarsal-metatarsal joints. In addition, this condition historically was reported to be associated with hip dysplasia, a component of the “molded baby” syndrome that included the triad of developmental dysplasia of the hip, MTA, and torticollis. More recent studies have documented no association of MTA with developmental dysplasia of the hip. Consequently, screening...
ultrasonography of the hip no longer is necessary in this condition. (1)

**Clinical Aspects**

The typical findings in a patient born with MTA include a convex lateral border of the foot and a medial instep skin crease in addition to the medial deviation of the forefoot (Fig. 2). Flexibility or rigidity of the deformity can be assessed clinically by abducting or laterally deviating the forefoot while holding the hind foot. The severity of the adduction can be determined by placing a straight edge in the mid-portion of the heel and determining where it intersects the forefoot. Normally, the heel bisector should intersect the second toe or first web space.

Differential diagnosis includes clubfoot, skewfoot (deviation of the forefoot medially with hind foot valgus), and in older children, cavovarus feet. Diagnosis is based on clinical findings; imaging studies are not needed to validate treatment.

**Treatment**

Therapy directed at stretching the tight medial structures of the infant’s foot typically are very effective in correcting this deformity. The technique includes stabilizing the heel with one hand and abducting the forefoot or pulling the great toe in the direction of the little toe. Such manipulation can be performed easily by the parents and is recommended at diaper changes starting in the newborn period. Studies suggest that most infants correct with manipulation by 4 to 6 months of age if MTA is diagnosed early and treated.

Usually, no more than 10% to 15% of children require additional treatment, which may include reverse last shoes, casting, and rarely, soft-tissue release of the tight medial structures.

**Prognosis**

Most patients born with MTA respond well to manipulation and stretching of the feet. Persistent adduction deformity in a 4- to 6-month-old should prompt referral to an orthopedist for additional care. Fewer than 5% of affected patients have any residual issues over the long term.

**Flatfoot**

Pes planus, or flatfoot, is the typical condition of most children’s feet until 6 years of age. Nearly all children flatten the medial longitudinal arch of the foot when bearing weight because of generalized ligamentous laxity. Once the child’s foot becomes more mature at 6 to 8 years of age, the medial arch maintains elevation on standing in most children. Because flatfoot is so common in childhood, a flexible flatfoot may be considered a normal variant in growing children rather than a pathologic condition.

A small subset of patients have persistent flatfoot that may become painful in adolescence. This condition often is associated with obesity, external tibial torsion, or possibly a tight heel cord. As many as 10% to 15% of American adults have flatfoot.

**Physical Findings and Presentation**

The key initial assessment of the child presenting with flatfoot is to determine flexibility. A medial longitudinal arch collapse during standing can be restored in most children by recumbency or sitting, and the arch elevates with toe standing. Passive elevation of the great toe also raises the arch.

Another physical finding to assess is the presence of hind foot valgus or lateral position of the heel. Toe standing causes medial deviation of the heel in normal feet and is a sign that both the flat arch and heel position are flexible.

A hindfoot that does not invert with toe standing may be an indication of some other disorder, such as peroneal spasm, tarsal coalition, or even inflammatory arthritis of the subtalar joint. The final important findings to assess are heel cord excursion and ankle dorsiflexion. Heel cord tightness may be the reason for hind foot valgus, may cause a painful flatfoot in adolescents, and always should be evaluated.

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**Figure 2.** Metatarsus adductus, demonstrating medial deviation of forefoot and convex lateral border of the foot.
Treatment
Studies have indicated that putting a small arch support such as a “cookie” or scaphoid pad into the shoe of a small child does not influence or promote development of the arch, which is more related to the genetics or “destiny” of the child. Thus, for children younger than age 8 years, treatment rarely is indicated, and reassurance of expected improvement is all that is necessary for most patients.

For the teenager presenting with a painful flatfoot, the diagnosis of a tight heel cord prompts the recommendation for a heel cord stretching program, possibly directed by a physical therapist. Orthotics also may be beneficial. If pain persists after these measures, referral to an orthopedist is recommended.

Idiopathic Toe Walking
Idiopathic toe walking (ITW) is the persistence of toe-toe gait beyond age 3 years. Many toddlers experiment with different walking techniques, but children typically acquire a heel-toe gait pattern by age 4 years. If toe walking persists after age 7 to 8 years, a heel cord contracture may prevent spontaneous resolution.

Although the natural history of ITW is unknown, what seems fairly common in children is rare among adults, suggesting that many patients improve or resolve the tendency as their bodies get bigger and heavier. No studies document long-term deleterious effects on the feet or ankles of patients whose toe walking persists in adulthood.

Physical Findings
Initially, patients who have ITW demonstrate no specific abnormalities on static examination, only on observation when walking. With time, heel cord contracture and calf hypertrophy develop. Long-term, ITW may cause a compensating external tibial torsion and splaying of the forefoot, which may not regress with correction of ITW.

Most important on examination is to assess and determine the presence of a tendo-achilles contracture because this finding affects treatment decisions.

Differential Diagnosis
Toe walking may be caused by a variety of conditions, including cerebral palsy (especially diplegia or hemiplegia), muscle weakness disorders such as Duchenne muscular dystrophy, and even a tethered spinal cord or other neurologic conditions. Autism also has been associated with toe walking, especially the high functioning subtype or Asperger syndrome.

Separating ITW from mild diplegia can be difficult; gait analysis may be one method. Patients who have ITW without heel cord contractures may be able to walk on their heels, whereas those who have diplegia and cerebral palsy seldom can. Children afflicted with muscle weakness disorders often are very slow runners compared with patients who have ITW. Normal blood findings, such as aldolase and creatine kinase concentrations, and genetic data suggest a diagnosis of ITW rather than underlying muscle disease.

Tibial Torsion
Tibial torsion is a rotational deviation of the tibia such that the foot is malaligned with the knee. Internal tibial torsion is more common than external tibial torsion and is an internally rotated position of the child’s foot during ambulation, causing an in-toeing gait pattern.

Pathogenesis
Internal tibial torsion is considered to be caused by intrauterine “packaging.” The left leg is affected more commonly, but involvement frequently is bilateral. Some children may be predisposed to internal tibial torsion, based on family history. Internal tibial torsion also may be associated with bowleggedness (infantile tibial vara), especially in children who walk early at 8 to 9 months of age.
External tibial torsion may be an acquired rotational deformity developed as compensation for persistent femoral anteversion. Either type of tibial torsion may present in a child who has a neuromuscular disorder such as cerebral palsy or myelodysplasia.

Clinical Aspects
Internal tibial torsion is a common cause of frequent tripping in a 1- to 3-year-old toddler who has in-toeing. Tibial torsion is diagnosed by examination in the prone position, sometimes with the child in the mother’s lap. The relationship of the foot to the thigh defines the “thigh-foot angle,” with the normal angle having the foot rotated 10 to 15 degrees external relative to the long axis of the thigh. Rotational position of the foot toward the midline is internal tibial torsion (Fig. 3), and rotation of the foot beyond 20 degrees external to the thigh is external tibial torsion.

Typically, radiographs are not needed to assess tibial torsion, but occasionally computed tomography scans of the hip, knee, and ankle can be used to document rotation in those patients undergoing surgical correction of torsional deformities.

Treatment
The natural history of internal tibial torsion is spontaneous resolution by the age of 5 or 6 years for most patients. Other than reassuring the parents, no treatment is needed. Little science supports the use of braces or bars and shoes to correct rotational malalignment, despite a long history of their use. In comparison, external tibial torsion may persist during growth and, in some cases, worsen.

Surgery involving derotational distal tibial osteotomy may be needed in patients older than age 6 years if significant clinical deformity from either internal or external tibial torsion affects function or gait.

Prognosis
Although most patients who have internal tibial torsion have a benign course, those who have external tibial torsion may need referral and surgery. As long as patients remain within 2 standard deviations of the mean, based on thigh-foot angle measurements, observation and reassurance are all that most need.

Femoral Anteversion
Femoral anteversion refers specifically to the angulation or tilt of the femoral neck relative to the shaft of the femur. The normal version (angulation) of the femoral neck is 15 degrees. Anteversion refers to inclination more than 20 degrees and retroversion is version less than 10 degrees. Increased internal rotation of the hip results from increased femoral anteversion and may reflect capsular laxity in addition to anteversion.

Pathogenesis
Newborns typically have anteversion of 40 degrees, yet the typical adult has anteversion of 15 degrees. During normal growth and development, femoral anteversion regresses by 25 degrees, or approximately 2 degrees per year from birth to age 12 years. Femoral anteversion may persist in patients who have abnormal muscle tone, such as spasticity in children who have cerebral palsy, or excessive joint laxity.
Clinical Aspects
Any child presenting with in-toeing who is older than 3 or 4 years of age likely has femoral anteversion as the cause. Physical findings are seen best on prone examination, where the hip rotation is assessed most easily and accurately. Increased medial thigh rotation or internal rotation beyond 60 to 65 degrees is consistent with a diagnosis of femoral anteversion (Fig. 4), which often is associated with a decrease in external hip rotation (Fig. 5). Internal rotation of the hip less than 20 degrees may be considered to be femoral retroversion. Patients who have femoral retroversion may have associated pes planus and external tibial torsion, as well as being overweight.

Radiographic studies seldom are necessary to document femoral anteversion, although computed tomography scan, as in tibial torsion, may be useful to the surgeon for patients undergoing correction. Research has validated that a careful physical examination is an accurate method of diagnosing femoral anteversion. (2)

Treatment
Anteversion as a cause of in-toeing in children typically resolves by age 10 to 12 years. Rarely is surgical treatment required. Persistent severe anteversion associated with in-toeing that causes functional impairment may be treated with femoral derotation osteotomy. The need for correction occurs more commonly in children who have cerebral palsy or collagen vascular disorders that cause persistent anteversion due to abnormal mechanics or joint laxity, respectively.

Parents concerned about in-toeing caused by femoral anteversion in younger children can be reassured that growth helps with remodeling. Although used in the past, bracing, twister cables, and shoe modifications are ineffective and are not recommended. Normal or mature adult gait is not achieved in most children until age 6 to 8 years. Thus, maturity often helps in resolving in-toeing. Whether W-sitting (Fig. 6) is deleterious or delays natural remodeling of anteversion is controversial. Some patients who have femoral anteversion and persist in “W” sitting acquire compensatory external tibial torsion, which results in a normal foot progressive angle. However, the torsional forces at the knee may lead to patella femoral malalignment and pain, often termed the “miserable malalignment syndrome.”

Prognosis
The association of persistent femoral anteversion and hip arthritis has been sought, but natural history studies have not confirmed any relationship. Patella-femoral arthritis may be more common in patients who have anteversion with acquired external tibial torsion.
Recent studies suggest that an in-toeing gait may be beneficial in certain activities and sports. Therefore, parents may be assured that persistent increased femoral anteversion should not compromise athletic performance.

The relationship of femoral retroversion to slipped capital femoral epiphysis also has been explored. Although femoral retroversion alone may not predispose to slipped capital femoral epiphysis, often affected patients have associated factors such as obesity that combine to place them at risk for a slipped epiphysis.

**Summary**

- Lower extremity disorders of children present commonly to the pediatric office and are a source of significant parental anxiety.
- A careful history and physical examination often yield the diagnosis.
- Most of these disorders require only observation and reassurance of the parents that the conditions will improve with time.
- Some disorders, such as clubfoot, need prompt referral, but most lower extremity disorders can be monitored by the pediatrician in the office and resolve with growth.

**References**

PIR Quiz

Quiz also available online at pedsinreview.aappublications.org.

1. A mother brings in her 3-year-old son because she thinks he “walks funny.” On physical examination, you note that he consistently walks on his toes. Other findings, including those on neurologic examination, are normal. Which of the following statements about this boy’s condition is true?

   A. Bracing of the feet and lower legs should be initiated immediately.
   B. He should be tested for muscular dystrophy.
   C. He likely will not perform well in sports.
   D. Heel cord contracture likely will develop if the toe walking continues.
   E. There is a high probability that he has an underlying spinal cord disorder.

2. Which of the following is a characteristic of metatarsus adductus?

   A. Hindfoot equinus deformity.
   B. Hindfoot varus deformity.
   C. Hindfoot valgus deformity.
   D. Lateral deviation of the forefoot.
   E. Medial crease of the instep.

3. A 7-year-old girl is brought to your clinic for in-toeing that has persisted since she was about 3 years of age. She frequently sits in a “W” pattern on the floor while watching television. Physical examination reveals markedly increased internal rotation of the hips while prone. Which of the following statements regarding this girl’s condition is true?

   A. Computed tomography scan is indicated to confirm the diagnosis.
   B. She is at high risk for developing osteoarthritis of the hips later in life.
   C. She likely will be able to participate in sports without difficulty.
   D. She should begin wearing medial pads in her shoes to correct the in-toeing.
   E. The in-toeing likely is due to a dietary deficiency.

4. You are evaluating an 18-month-old boy whose mother thinks he is “pigeon-toed.” He began walking at 12 months and walks well, but in-toeing is noted on examination. Range of motion at the hips, knees, and ankles is normal. Which of the following is the most likely cause of his gait disturbance?

   A. Blount disease.
   B. Femoral anteversion.
   C. Internal tibial torsion.
   D. Metatarsus adductus.
   E. Pes planus.
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*Pediatrics in Review* 2009;30;287  
DOI: 10.1542/pir.30-8-287

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