

## Approach to pediatric rotational limb deformities

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### Abstract

Pediatric lower extremity complaints are a common source of concern for parents. Gait concerns such as in-toeing are considered a developmental variant of childhood growth and are a common reason for visits to a pediatrician. In-toeing specifically is a common anatomic structural variation encountered by pediatric primary care providers and pediatric orthopedic specialists and may be accentuated between six months and five years during which children are developing their coordination skills. This study focuses on the three most common causes of in-toeing in the pediatric population; femoral anteversion (FA), tibial torsion (TT), and metatarsus adductus (MA) with the purpose of providing a brief review to give providers confidence in addressing these common developmental abnormalities.

### Introduction

Pediatric lower extremity complaints are a common source of concern for parents. Gait concerns such as in-toeing are considered a developmental variant of childhood growth and are a common reason for visits to a pediatrician. In-toeing specifically is a common anatomic structural variation encountered by pediatric primary care providers and pediatric orthopedic specialists and may be accentuated between six months and five years during which children are developing their coordination skills. This study focuses on the three most common causes of in-toeing in the pediatric population; femoral anteversion (FA), tibial torsion (TT), and metatarsus adductus (MA) with the purpose of providing a brief review to give providers confidence in addressing these common developmental abnormalities.

### Packaging disorders

Femoral anteversion, tibial torsion, and metatarsus adductus fall under the umbrella term of packaging disorders. These abnormalities are defined as extrinsic constraint deformities secondary to in-utero crowding.<sup>1</sup> In utero crowding can occur due to factors in the mother, fetus, or a combination of the two. During the seventh week of gestation, internal rotation of the lower limb occurs accompanied by external rotation of the hip and femur. This positioning directly reflects newborn posture; flexed and externally rotated hips with internally rotated lower legs and feet. Interestingly, an observational study conducted in 2007 found no significant difference in limb orientation or a higher incidence of rotational deformity in infants born in either vertex and breech position.<sup>2</sup>

For most patients, in-toeing-related diagnoses are considered normal developmental variants. Furthermore, parental concerns can be addressed by reassuring them that the vast majority of in-toeing cases resolve spontaneously. More specifically, Faulks, Brown, and Birch conducted a large retrospective study concluding that of 926 patients referred to an in-toeing clinic, 95% of the children had a benign disposition with general complaints of clumsy gait, limited agility, and or visual/cosmetic concerns about in-toeing.<sup>3</sup> The remaining 5% of the children had a non-benign diagnosis such as cerebral palsy, weakness, autism, seizures, shunted hydrocephalus, developmental delays, agenesis of the corpus callosum, trisomy 13, and other structural abnormalities including clubfoot, gastroschisis, and congenital vertebral anomalies.<sup>3</sup>

### Metatarsus adductus

Metatarsus adductus is the most common cause of in-toeing in infants under one year of age.<sup>4</sup> This disorder has increased incidence in first, late, and twin pregnancies and occurs in 1/1000 births with similar incidence between males and females.<sup>5</sup> While the spectrum of pediatric foot deformities is much broader, metatarsus adductus is defined as adduction of the forefoot at the tarsometatarsal joint causing abnormal alignment of the forefoot and hindfoot.<sup>5</sup> MA can be flexible, semi-flexible, or rigid, depending on how far the foot can be passively flexed relative to midline. For example, in semi-flexible MA, the forefoot can be passively flexed to the midline point, but no further.

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### Tibial torsion

Internal tibial torsion is the simplest of the three conditions. It is characterized by internal rotation of the tibia. This is the most common cause of in-toeing in toddlers age 1-3, is often bilateral, and most often does not persist beyond 6 years of age.<sup>6</sup> Infants typically have a mean measurement at 5° internal rotation (range, -30° to +20°) while children age 8 years and beyond typically average 10° external rotation (range, -5° to +30°).<sup>6</sup>

### Femoral anteversion

Femoral anteversion is most often diagnosed between 3-6 years of age; late presentation is primarily due to the fact that the condition is masked in children under three years by physiologic external contracture of the hip.<sup>7</sup> Femoral version is the angular difference between the axis of the femoral neck and the transcondylar axis of the knee. At birth, normal femoral anteversion is 30-40° and typically decreases to the normal adult value of 15° by skeletal maturity.<sup>6</sup>

Femoral anteversion results in increased internal rotation of the hip with characteristic features include medially-facing patellae and “egg-beater” leg movements with running.<sup>6</sup> Of note, studies have demonstrated a genetic predisposition to FA as it tends to cluster in families and is twice as frequent in girls than boys.<sup>7</sup>

## The examination

The primary objective during an encounter with a child suspected of having a rotational deformity is to address parental concerns and rule out pathologic etiologies. Important components of the history include birth history, developmental milestones, family history of rotational deformities, and the general clinical course of the concern. This would include onset, severity, and symmetry of the defect. Children with unilateral or asymmetric in-toeing should raise concern for other pathologic etiologies and warrants further investigation. Other complaints that raise suspicion for a pathologic etiology include pain, rapid-onset of symptoms, and limping.

The following examination techniques are considered the standard; however, variations exist such as having a patient positioned prone or supine for measurement taking. The only tools required are a goniometer to obtain precise measurements. The examination should also include observing the patient’s gait if the child is ambulatory. X-rays are not typically indicated in the evaluation of rotational complaints but can be considered if there is pain or another atypical component to the patient’s complaint. The presence of pain may indicate other differential diagnosis including but not limited to congenital hip dysplasia, slipped capital femoral epiphysis (SCFE), and neoplasm.

## Examination of femoral anteversion

Femoral anteversion can be quantified via prone measurements of internal and external rotation of the hip. With the assistance of a goniometer, the provider measures the limits of internal and external rotation of the hip. Care should be taken to ensure the pelvis is flat against a table, as any pelvic rotation at the limits of motion will render measurements incorrect. The diagnosis of femoral anteversion is confirmed if internal rotation is greater than 60° or external rotation is less than 45°.<sup>7</sup> In

addition, a child able to sit in the W position is pathognomonic for femoral anteversion, although measurements should still be obtained.

## Examination of tibial torsion

The diagnosis of tibial torsion can be accomplished by using the prone thigh-foot angle. In the normally developed patient, there should be little or no rotation of the foot in relation to the femur. A provider will start by drawing an imaginary line through the forefoot and hindfoot. When a patient is within anatomically normal limits, the line should run parallel to the femoral shaft. Any significant inward or outward rotation establishes the presence and degree of tibial torsion.<sup>8</sup> This same method can be used to evaluate external tibial torsion.

## Examination of metatarsus adductus

The foot has numerous potential deformities that require specialist treatment, but for the purposes of this review it is limited to only metatarsus adductus as most severe deformities are recognized and treated near birth. Although a nonspecific test, observing the patient’s gait to assess the foot progression angle is beneficial in establishing the severity of in-toeing. A provider would have a patient walk in a straight line while observing the long axis of the foot through the swing phase of the gait. If the foot deviates internally or externally to any significant degree, the presence of in-toeing or out-toeing would be apparent to an observer. Furthermore, the foot would be further assessed by drawing an imaginary line through the plantar aspect of the foot. Normal anatomy is considered when the hindfoot transects the second and third intermetatarsal space. An abnormal test would be present if the imaginary line transected lateral to the second and third metatarsal space. Of note, the rear foot must be normal/minimally pronated to make the diagnosis. Any inversion of the rearfoot, forefoot plantarflexion, or any equinus of the ankle reclassifies the deformity into talipes equinovarus or a subset of pes planus.<sup>9</sup>

## Management of FA, TT, and MA

With regards to metatarsus adductus, treatment is dependent on the degree of flexibility of the adducted forefoot. Flexible and

semi-flexible metatarsus adductus can be managed with reassurance and observation at six months of age. For children who have not demonstrated any improvement of MA by six months, serial casting may be indicated.<sup>5</sup> Special footwear and casting have not been shown to be of any benefit prior to six months.<sup>10</sup> In cases of persistent, rigid MA, surgery is controversial. In a prospective study evaluating children undergoing tarsometatarsal capsulotomy, there was a 41% failure rate and 50% incidence of long-term pain and bony prominence formation at the tarsometatarsal joints.<sup>11</sup> Tibial torsion most often corrects by age five.<sup>6</sup> Primary management includes observation and reassurance due mainly to the fact that it is considered a physiologic variant with rare long-term sequelae.<sup>12</sup> Numerous studies have shown no benefit with the use of orthotics, braces, or special shoes for tibial torsion.<sup>13</sup> Surgical treatment with isolated supramalleolar rotational osteotomy is rare and only indicated in patients older than eight with severe, persistent in-toeing causing functional constraints.<sup>14</sup> Femoral anteversion typically results in spontaneous resolution by age 11 with management consisting of observation and reassurance.<sup>13</sup> Twister cables, bracing, splinting, and shoe wedges have not been found to be effective in treatment of femoral anteversion.<sup>15,16</sup> In patients with persistent FA that exhibit severe rotational deformity or FA that affects gait, femoral derotational osteotomy with internal fixation using an intramedullary femoral nail may be indicated.<sup>6</sup>

## Rotational deformities and arthritis potential

The theory that rotational deformities of the femur and tibia increase incidence and severity of osteoarthritis over a lifetime has been discussed in multiple peer-reviewed journals. In 2017, a study evaluating 1158 cadaveric tibia and femora was conducted to establish a link between rotational deformities and arthritis. The criterion for arthritis grading was established on a scale of Grade 0 to Grade 3 that included the acetabulum, proximal femur, and patellofemoral joint. Subsequent averages of the arthritic regions were compiled against the measured rotational deformities present to give a final score using various statistical analyses. It was noted that although race and age were positive predictors for arthritis, no correlation between increased tibial torsion or increased femoral anteversion and arthritis of either joint was established.<sup>12</sup> It is well established that rotational deformities often self-resolve, and are appropriately managed

with observation.<sup>12</sup> The lack of evidence correlating generally benign rotational deformities with arthritis allows healthcare providers to confidently reassure patients that long-term consequences of these abnormalities are extremely limited.

## Conclusions

In conclusion, the three primary causes of in-toeing in pediatric patients are physiologic variants of development and most often do not require intervention as spontaneous resolution is expected in the majority of cases. The approach to pediatric gait abnormalities does not automatically warrant a referral to a specialist. A vast majority of in-toeing complaints can be tackled with confidence by the primary care practitioner. By using the information presented, gait complaints have the potential to be evaluated and triaged in single patient visits. Although there are non-benign causes of in-toeing, knowing the basics of the benign etiologies will allow for the provider to better recognize high risk patients. X-rays are not discouraged, but judicious use should be applied. If a provider is in doubt, the first study to be ordered should be of the pelvis. This allows one to easily rule out SCFE and other emergent diagnoses that may lead to permanent disability if overlooked. Additional studies can be ordered as needed, but generally are not required for the average patient.

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