

# Lower Extremity Rotational and Angular Issues in Children



James F. Mooney III, MD

## KEYWORDS

• Angular deformity • Rotational deformity • Femoral anteversion • Tibial torsion

## KEY POINTS

- There is a wide range of normal lower extremity positioning in growing children.
- Angular and rotational status in children tends to follow standard developmental pathways over time.
- Little or no intervention, beyond reassurance, is necessary for most patients, and their parents, who present with concerns regarding rotational or angular issues in children.

## INTRODUCTION/OVERVIEW

Parental questions and concerns regarding lower extremity rotational and angular status are some of the most common musculoskeletal issues facing primary care physicians and pediatric orthopedic surgeons.<sup>1</sup> As such, it is important that all physicians providing care for children have a thorough understanding of appropriate methods of examination and of the natural history of these physical findings. In most patients, the natural history is benign, with self-resolution without the necessity of any active treatment as the general rule. However, there are rare patients who require further evaluation, and in some cases orthopedic management, to reach the end of skeletal development and growth with a normal rotational and/or angular profile of the lower extremities.

## THE MUSCULOSKELETAL EVALUATION/PHYSICAL EXAMINATION

An appropriate musculoskeletal evaluation in children includes both a comprehensive history and physical examination. The parents should be questioned regarding birth history, issues during pregnancy, development, and attainment of motor milestones.

---

Disclosure: None.

Department of Orthopaedic Surgery, Medical University of South Carolina, 96 Jonathan Lucas Street, CSB708, Charleston, SC 29425, USA

E-mail address: [jfm3md@aol.com](mailto:jfm3md@aol.com)

Pediatr Clin N Am 61 (2014) 1175–1183

<http://dx.doi.org/10.1016/j.pcl.2014.08.006>

[pediatric.theclinics.com](http://pediatric.theclinics.com)

0031-3955/14/\$ – see front matter © 2014 Elsevier Inc. All rights reserved.

In addition, it is important to determine whether there is any family history of orthopedic or musculoskeletal disorders, particularly those that may cause pathologic rotational or angular deformities. In addition, it is valuable to ascertain whether the perceived abnormality is affecting the child's function or development in any way, such as causing gait problems, shoe wear issues, or tripping/falling. Overall, it is imperative to begin to differentiate those patients who are in the wide range of normal variants from those with significant developmental or structural abnormalities. Most patients are within the wide range of normal, but it is necessary to be aware of the possibility of true disorder. Children with significantly abnormal rotational or angular deformities, in conjunction with apparent positive familial or development history, should be referred for specialized musculoskeletal evaluation.

In addition to the patient history, it is essential that a detailed, but focused, musculoskeletal physical examination be performed on all patients with parental concerns. The examination should be performed in a standardized fashion, and should address all sites of potential abnormality. It is important that all primary care physicians taking care of children are capable of performing this examination, and attainment of this skill set must be part of any primary care training program. It is not acceptable simply to refer all musculoskeletal evaluations and questions to a specialist, because most of these parental issues and concerns are of a benign nature, are part of normal development, and require little more than knowledgeable reassurance.

The musculoskeletal examination does not need to be time consuming or lengthy, but does need to be thorough. A complete examination requires evaluation of the static and dynamic status of the lower limbs. It is important to look at the overall position of the limbs while the child is at rest, and, if the child has reached walking age, during standing and gait. The child must be undressed, or at least placed in a gown or disposable shorts to perform a proper examination (Fig. 1). Watching the child walk around the room may be acceptable, but with older or bigger children it may be best to view patients while they are walking away from and toward the examiner in a hallway or corridor. In addition, the general overview should include review of height and weight, stature, skin condition or lesions, limb girth, and appropriateness of development for chronologic age. All normal and abnormal findings should be documented in the medical record.

Staheli and colleagues<sup>2</sup> described and elucidated the concept of the child's rotational profile in 1985. These investigators evaluated 1000 normal children and adults, assessing lower extremity passive range of motion and rotational positioning of the



Fig. 1. A child standing in appropriately sized disposable shorts.

lower extremities. The data generated provide the largest single assessment of these issues, and constitutes what the clinicians consider to be normal values to this day. All components of this profile should be evaluated as part of the musculoskeletal examination. The components include external and internal rotation of the hips (assessing femoral version), thigh-foot axis (tibial torsion) (**Fig. 2**), transmalleolar angle, and foot progression angle with gait. Addressing another aspect of lower extremity rotation, Smith, Bleck and colleagues<sup>3</sup> promoted the concept of the heel bisector, which is useful in assessing rotation of the foot secondary to foot deformity. Although specifics of foot deformity and the heel bisector were not part of the original study by Staheli and colleagues,<sup>2</sup> it should be part of the general evaluation of a patient seen for rotational concerns.

The static or nonambulatory portion of the examination evaluating the child's rotational profile ideally should be performed with the patient prone (**Fig. 3**). This position provides the best assessment of lower extremity rotation, and allows the physician to view both limbs simultaneously. Sometimes this is a challenge in young patients because of agitation, and, with practice, a high-quality examination can be done with the patient supine, reclining slightly in the parent's lap. Visualization of the patient while walking is necessary to determine dynamic rotation during gait, and to assess the patient's foot progression angle. Patients who intoe during the stance phase of gait are considered to have negative foot progression angles, whereas those who out-toe have positive values.

The review of lower extremity angulation is done best with the patient standing, but can be assessed fairly well while sitting in those children unable or unwilling to stand. It is important to view the child while the patient is standing, both from the front and from the rear, to gain the best view of lower extremity limb angulation during weight bearing. Again, it is essential that the child be placed in a gown, shorts, or some other nonobstructive clothing to perform an adequate lower extremity evaluation.

## SPECIFIC ISSUES

### *Intoeing/Out-toeing*

Rotational issues in children, specifically intoeing and out-toeing, are among the most common musculoskeletal issues facing the primary care physician in office practice. It is important to know that most rotational issues are self-limiting, and require no active treatment.<sup>4</sup> Parental concerns regarding intoeing seem to far outnumber those regarding out-toeing in clinical practice. The possible sources of intoeing are femoral



**Fig. 2.** Assessment of thigh-foot angle.



**Fig. 3.** A patient lying prone for examination of internal rotation of the hips.

anteversion, internal tibial torsion, and metatarsus adductus. Patients often present with intoeing secondary to a combination of these causes.

### ***Femoral Anteversion***

Femoral anteversion is the most common cause of perceived abnormal intoeing in childhood.<sup>4</sup> Version, or torsion, of the femoral neck is the angle between the axis of the femoral neck and the transverse axis of the knee. More simply, it is the angle that the femoral neck extends anteriorly from the shaft of the femur. This angle sets the amount of active and passive range of rotation at the hip. Neonates have an average of 40° of anteversion. This angle generally decreases, without intervention, to an average adult level of 15° by approximately 8 or 9 years of age.

Intoeing secondary to increased anteversion tends to be more common in girls than in boys, and is usually symmetric. Children with increased anteversion often run with a circumduction gait because of the internal rotation at the hip, and the parents may note that the child W-sits rather than sitting cross-legged. Physical examination shows increased internal rotation at the hip versus external rotation, and the foot progression angle is negative.

The natural history of intoeing secondary to increased femoral anteversion is almost universally benign. As noted previously, the increased internal rotation resolves as the femoral anteversion changes up to 8 or 9 years of age, and no intervention is required. Special shoes, braces, and bars between the shoes have not been shown to have any positive effect, and there is evidence of negative psychological impact of the use of orthopedic shoes and braces later in life.<sup>5,6</sup> Admonishment against W-sitting is of no value, because that position is the position of comfort for the child, and is in no way detrimental to normal development. Contrary to generations of misinformation, W-sitting does not lead to, or promote, intoeing in children. Children stop sitting in this position when they are able to sit cross-legged more comfortably, and this occurs as the natural progression to a mature value of femoral anteversion occurs. The only intervention that changes the natural history is the use of surgical femoral derotational osteotomy, and the indications for such a procedure in a neurologically normal child are extremely limited. Osteotomy is reserved for those children more than 8 or 9 years of age with severe functional or cosmetic limitations secondary to retained femoral anteversion greater than 45° to 50° and greater than 80° of internal rotation at the hip on physical examination.

Out-toeing secondary to abnormal decrease in femoral anteversion is uncommon. Physical examination in such a child shows a marked decrease in expected internal rotation at the hip, and increased external rotation. Because this is an unusual rotational profile for a child, this finding generally requires further evaluation and possibly subspecialist referral. Although no physical abnormality is found in many cases, decreased femoral anteversion, or in some cases true femoral retroversion, may be associated with congenital abnormalities of the proximal femur or lower limb, or may predispose the patient to other functional issues involving the lower extremity.

### ***Internal and External Tibial Torsion***

Internal tibial torsion is a common cause of intoeing in children, and often is seen in combination with increased femoral anteversion. Physical examination is necessary to differentiate between the two causes, and those patients with internal tibial torsion show an internally rotated thigh-foot angle (Fig. 4) and negative foot progression angle. Most patients have symmetric, bilateral involvement, but in unilateral cases the left limb seems to be more commonly involved. The cause of internal tibial torsion is unclear, but it is thought to be secondary to intrauterine positioning in most cases.

Patients with increased internal tibial torsion may have concomitant bowing of the lower leg (genu varum), which is a common finding in children less than 3 years of age. The combination of bowing and internal rotation may make the deformities appear more severe, and the physician must take care to assess and document both deformities. Issues regarding the natural history of genu varum are discussed later.



**Fig. 4.** Thigh-foot angle examination showing mild internal tibial torsion. (From Lincoln TL, Suen PW. Common rotational variations in children. *J Am Acad Orthop Surg* 2003;11(5):313; with permission.)

Most internal tibial torsion resolves spontaneously by the age of 4 to 5 years. For many years, patients were managed with special shoes and/or connecting bars (eg, Denis-Browne shoes and bars), which were worn at nights and during naps. Such items are not recommended at this time, because the rotation will resolve without intervention, and the shoes/bars do not provide any benefit to the deformity. Those few children who have persistent internal tibial torsion rarely have any significant issues, and residual torsion does not increase the risk of degenerative joint disease. Only those patients with severe residual deformity (>3 standard deviations beyond the mean) that causes severe functional or cosmetic abnormalities, and who are not expected to self-correct any further, are candidates for tibial derotational osteotomy.<sup>4</sup> In patients with internal torsion associated with neuromuscular disorders (eg, cerebral palsy, myelodysplasia), or in conjunction with other pathologic limb deformities (eg, clubfeet), tibial derotational osteotomy may be indicated more frequently.

In rare cases, a child presents with an out-toeing gait and examination is consistent with a diagnosis of external tibial torsion. These patients have positive foot progression angles, and externally rotated thigh/foot angles. Because tibial torsion tends to externally rotate up to the age of 4 to 5 years, preexisting external tibial torsion may increase. There is some evidence of an increased risk of patellofemoral pain and instability in patients with significant external tibial torsion. As such, those uncommon patients with severe external tibial torsion may require further evaluation by a pediatric orthopedic specialist and possibly surgical intervention.

### ***Metatarsus Adductus***

---

The third potential source of intoeing and lower extremity internal rotation deformity is metatarsus adductus (**Fig. 5**). Such children present with a C-shaped foot and parental complaints of intoeing. The cause of the deformity is unclear, but is most likely a function of intrauterine positioning. Physical examination shows a foot with medial deviation of the midfoot and forefoot, but with a neutral or slightly valgus hindfoot. There is no evidence of a tight heel cord or equinus hindfoot, and in most cases the deformity is flexible. Most children and infants with true metatarsus adductus have bilateral and fairly symmetric deformities.

Metatarsus adductus may be classified based on the amount of medial deviation as determined by the heel bisector angle, or by the flexibility of the deformity.<sup>3</sup> Further



**Fig. 5.** Patient with mild, bilateral metatarsus adductus. (From Lincoln TL, Suen PW. Common rotational variations in children. *J Am Acad Orthop Surg* 2003;11(5):316; with permission.)

radiographic evaluation is unnecessary in young patients, and plain radiographs are not indicated except in rare cases.

Most metatarsus adductus deformities are mild and flexible, and generally resolve without intervention of any kind. Parental stretching programs may be instituted, but probably do not have any effect beyond simple reassurance. Ponseti and Becker<sup>7</sup> reported more than 300 patients with flexible metatarsus adductus, and in all cases there was improvement at 3 to 4 years of age without any formal treatment. Casting and special shoes are reserved for those patients with severe and rigid deformities, and these are a distinct minority of patients. Adjustable shoes have been shown to be as clinically effective, and more cost-effective, than serial casting programs for those rare patients requiring intervention.<sup>8,9</sup> Surgery is indicated only for those patients who fail casting for severe and rigid deformities, or who present late with deformities that affect shoe wear and function.

## ANGULAR DEFORMITIES

### *Overview*

---

Knee alignment in children changes during skeletal development, and tends to do so in a predictable pattern in most patients. Most children start with an element of genu varum (bowed legs), progress toward neutral alignment with growth, and then may develop significant genu valgum (knock knees) before returning to the common mild physiologic valgus alignment of the lower limb around 5 or 6 years of age.

### *Genu Varum*

---

Bowed legs are a common concern of parents, grandparents, and other caregivers. A large percentage of pediatric patients develop, or are born with, some degree of genu varum, often in conjunction with physiologic internal tibial torsion.<sup>10</sup> The exact cause of this bowing is unclear, but because of its common nature, and because most cases resolve with time, this deformity is often described as physiologic bowing.

As noted, the exact cause of physiologic bowing is unclear. Multiple studies have documented the normal range of bowing for children during development. These norms seem to hold for children of multiple geographic and racial backgrounds. Salenius and Vankka, as well as Engel and Staheli, showed that pediatric knee alignment is initially 10° to 15° of varus (bowlegged) at birth, and reaches a neutral alignment by approximately 2 years of age. A more recent study of children in Turkey confirmed this natural history in that patient population.<sup>11,12</sup> In most cases, this bowing is bilateral and symmetric, and involves both the tibia and the distal femur. Intervention with orthotics, bracing, or connective bars is not indicated in most cases. Bowing that is of more concern, and for which further evaluation (radiographs, specialist consultation) may be indicated, includes that seen in patients with apparent unilateral bowing, evidence of associated endocrine abnormalities, or those patients who do not improve spontaneously by the age of 2 years.

Physical assessment of angular deformities, similar to examination of the patient's rotational profile, is best performed with the patient standing. Weight bearing accentuates the lower extremity angular status, and in most cases parents become concerned about this once the child begins to stand and walk. As with any examination of the lower extremities, it is important for the physician to look at the child with the legs uncovered by clothing, and to watch the child stand or walk. In addition, it is valuable to assess the patient's overall height and weight, and to document these on a growth chart.

Most patients with genu varum require no active treatment of any kind, because the natural history of this type of bowing is for the deformity to resolve spontaneously over

time. The limbs progress back toward neutral and then to moderate valgus in most children. Bracing, special shoes, and inserts are not indicated, and have no effect on physiologic bowing. Reassurance should be the treatment of choice. Bracing or surgical intervention may be indicated in a small percentage of patients (eg, infantile Blount disease, skeletal dysplasias, bony manifestations of endocrine or renal abnormalities), but this is at the discretion of a pediatric orthopedic surgeon, possibly in conjunction with care of other pediatric specialists.

### ***Genu Valgum***

---

Genu valgum (knock knees) is a common finding in patients between the ages of 3 and 6 years. As noted previously, lower extremity angular development tends to move into a valgus alignment starting at approximately 3 years of age. At times, this valgus positioning appears severe, and may reach 20°. Families may have concerns about not only the alignment of the limb but the appearance of clumsiness and running pattern, as well as the effect that such positioning will have on the child's future development.

Salenius and Vankka showed that the maximum genu valgum during normal development was approximately 12° to 13°. However, higher levels of valgus are common, and most patients normalize without intervention. The child should be examined as for any musculoskeletal evaluation, and height and weight should be documented.

Radiographs and further specialty evaluation should be reserved for patients with severe deformities, particularly if the patient is greater than 5 to 6 years of age. Other indications for referral and/or radiographs include significant deviations from the norm for height or weight, unilateral or asymmetric deformity, or those patients in whom an endocrine abnormality or skeletal dysplasia is suspected.

No intervention beyond reassurance is indicated in most patients with genu valgum. Shoes, shoe inserts, connecting bars, and/or bracing have no role in these patients, despite their widespread use in the past. The natural history studies on this subject are clear as to the self-resolving and benign nature of genu valgum in most patients, as it is in genu varum. Surgical management is reserved for those patients who do not resolve spontaneously or who have extreme deformity.

### **SUMMARY**

Parental concerns regarding rotational and angular deformities of the lower limbs in children are common. As such, it is important for the primary care provider to understand and master the basics of the lower extremity musculoskeletal examination. In addition, it is important for the primary care provider to understand the natural history of lower extremity rotational and angular development. However, the natural history is well documented, and is predictable in most cases. Most lower extremity rotational and angular issues resolve spontaneously with time, and as such require no intervention of any kind. Reassurance of the family is the only treatment indicated in almost all cases. In the rare patients with severe or unusual deformities, or in those patients who do not seem to follow the expected and predicted natural history, further evaluation or specialty referral may be indicated.

### **REFERENCES**

1. Hsu EY, Schwend RM, Julia L. How many referrals to a pediatric orthopaedic hospital specialty clinic are primary care problems? *J Pediatr Orthop* 2012;32(7): 727–31.
2. Staheli LT, Corbett M, Wyss C, et al. Lower extremity rotational problems in children. *J Bone Joint Surg Am* 1985;67A:39–47.

3. Smith JT, Bleck EE, Gamble JG, et al. Simple method of documenting metatarsus adductus. *J Pediatr Orthop* 1991;11:679–80.
4. Lincoln TL, Suen PW. Common rotational variations in children. *J Am Acad Orthop Surg* 2003;11(5):312–20.
5. Wenger DR, Mauldin D, Speck G, et al. Corrective shoes and inserts as treatment for flexible flatfoot in infants and children. *J Bone Joint Surg Am* 1989;71:800–10.
6. Driano A, Staheli L, Staheli LT. Psychosocial development and corrective shoe-wear use in childhood. *J Pediatr Orthop* 1998;18(3):346–9.
7. Ponseti IV, Becker JR. Congenital metatarsus adductus: the results of treatment. *J Bone Joint Surg Am* 1966;48:702–11.
8. Allen WD, Weiner DS, Riley PM. The treatment of rigid metatarsus adductovarus with the use of a new hinged adjustable shoe orthosis. *Foot Ankle* 1993;14(8): 450–4.
9. Herzenberg JE, Burghardt RD. Treatment of resistant metatarsus adductus: prospective randomized trial of casting versus orthosis. *J Orthop Sci* 2014;8(2): 193–201.
10. Greene WB. Genu varum and genu valgum in children. Instructional course lectures. Chapter 15. Park Ridge (IL): AAOS; 1993. p. 151–9.
11. Heath CH, Staheli LT. Normal limits of knee angle in white children – genu varum and genu valgum. *J Pediatr Orthop* 1993;13(2):259–62.
12. Arazi M, Ogun TC, Memik R. Normal development of the tibiofemoral angle in children: a clinical study of 590 normal subjects fro 3 – 17 years of age. *J Pediatr Orthop* 2001;21(2):264–7.