Lower Extremity Angular and Rotational Deformity

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A slip of the foot you may soon recover, but a slip of the tongue you may never get over. —Benjamin Franklin

Learning Objectives:
1. Identify normal variations in gait and posture
2. Become familiar with normal physiologic variations in foot, knee, and leg development
3. Learn basic examination maneuvers to help distinguish normal from pathologic variations
4. Develop management plans for children with in-toeing, out-toeing, bowed legs, or knocked-knees

Primary Reference:

CASE ONE:

Matt Atarsus comes in for his 2 month check-up. His father has a pressing concern. “You know doc, everything has been going ok. But my co-worker said that Matt’s feet look different than his baby’s did. Since then I have noticed that his toes are kind of turned in. What should we do? Will he need surgery?” On examination you note that the lateral borders of his feet are convex and his forefeet are deviated toward the midline.

1. What is the most common cause of in-toeing in infants? How can you differentiate this cause from conditions requiring more aggressive intervention?

In-toeing in infants from birth to 1 year old is most commonly caused by metatarsus adductus, a congenital foot deformity which occurs in 1 in 1000 to 5000 births, and may be bilateral in 50-60% of cases. The moderator can refer learners to figure 2 in the recommended reading. The etiology is unknown, but it is theorized to be due to in utero positioning or muscle imbalance in the foot. In metatarsus adductus, the lateral borders of the feet are convex with medial deviation of the forefeet. While holding the hindfoot securely, the examiner should be able to move the forefoot laterally such that the foot appears normal. This can be done objectively by measuring the “heel bisector angle.” In a normal foot, a straight line drawn from the middle of the heel should bisect the first web space. In metatarsus adductus, this line bisects more laterally on the forefoot (e.g., the fourth toe).

On initial evaluation, if the examiner is unable to easily stretch the foot back to a neutral position, the patient should be referred for orthopedic evaluation. If the foot is flexible, the deformity will usually correct with stretching. Parents should be instructed to stretch the forefoot laterally (to relax tight medial structures) with every diaper change. If no correction has been achieved with stretching by 4 to 6 months of age, then an orthopedic consultation should be obtained, as casting may be necessary.

On initial presentation, it is important to exclude other conditions that cause in-toeing that may require orthopedic consultation, with casting or corrective surgery. The examiner must ensure that the in-toeing is not due to deformity of the ankle. The heel should look neutrally aligned when observed posteriorly, and the ankle should have full range of motion, especially to dorsiflexion (thus excluding equinus). Other foot deformities must be identified, including cavus foot (high arch), and heel varus. The presence of a plantar flexed foot (equinus) in addition to cavus foot would be consistent with clubfoot. Metatarsus primus varus is a condition in which the lateral border of the foot appears normal and there is an isolated rigid adducted first metatarsal. Both clubfoot and metatarsus primus varus require early casting and possible corrective surgery depending on severity. In addition, the examiner should determine the stability of the hip, as children with metatarsus adductus have a 10% incidence of developmental hip dysplasia.

Moderators may refer learners to diagrams of the conditions listed above to assist with visual diagnosis.
CASE TWO:

Matt’s heel bisector angle normalizes by 6 months and he is walking by his 12-month visit. At his birthday party, his mother notices that Tim Beal, a 24-month-old in Matt’s daycare, is tripping more than the other children. Mrs. Atarsus approaches Tim’s mother. “I noticed that Tim’s feet are turned in. We had the same problem with Matt and I know just who you should see!”

Tim comes to your office that week. You watch him walk barefoot in the hallway and note in-toeing of his left foot, however the lateral borders of his feet are normal (not convex).

2. What is the most likely cause of in-toeing at Tim’s age? What else will you look for on exam, and how will you proceed with treatment?

In children ages 1 to 3 years old, the most common cause of in-toeing is internal tibial torsion. The diagnosis can be confirmed with a simple exam maneuver to determine the “foot-thigh axis.” The moderator should refer learners to figure 3 in the accompanying article for this discussion. With the child lying prone, flex the knee to 90 degrees, and look at the foot from above. Draw the lines of axis along the femur and along the foot. These lines will intersect at the center of the heel. The foot-thigh angle is the angle of the foot relative to the thigh. Normal alignment is a thigh-foot angle between 10 to 15 degrees, with the foot slightly externally rotated relative to the thigh; an angle greater than this defines tibial torsion.

Internal tibial torsion is typically managed by observation alone since it spontaneously resolves by ages 4 to 6.

3. What would your approach have been had each of these children presented with out-toeing instead?

Out-toeing is less common than in-toeing. There are two common causes, femoral retroversion and external tibial torsion.

At birth and in the prewalking child, the femoral head is typically well anterior to the frontal plane of the femur, at approximately a 40 degree angle from this plane, and as the child grows, this angle decreases to approximately 10-15 degrees, gradually moving towards the plane of the femur. However, some infants have femoral retroversion, caused by external rotation contracture of the hip, often due to uterine packing. On examination, if an infant with femoral retroversion is placed standing, his feet will turn out nearly 90 degrees. In addition, the child’s hips can be externally rotated to almost 90 degrees, but internal rotation is limited. If femoral retroversion does not resolve by 2 to 3 years of age, orthopedic referral is needed, as surgical correction may be necessary to minimize future risk of stress fractures, slipped capital femoral epiphysis, and osteoarthritis.

External tibial torsion is a common cause of out-toeing in older children, between ages 4 and 7, and is usually unilateral. It can be detected on physical exam using the same technique used to diagnose internal tibial torsion, except that one would find the foot externally rotated relative to the thigh beyond the normal 10-15 degrees. Operative indication is age older than 10 with a thigh-foot angle of more than 40 degrees. Patella-femoral pain and instability are typical complaints.

CASE THREE:

News of your skill in evaluating gait spreads through the community! Wanda a 5-year-old girl, is brought into your office because her mom wants to know why she is “pigeon-toed.” She thinks it may be because Wanda often sits in a W-position.

4. What is the most common cause of in-toeing in this age group? What is the significance of W-sitting in this scenario?

Femoral anteverision, the most common cause of in-toeing in children over 3 to 4 years of age, is the anterior angulation or tilt of the axis of the femoral neck in relation to the shaft of the femur or transcondylar axis of the knee. Typically presenting between ages 4 and 7, it is more common in girls and usually has a bilateral presentation. While the standing appearance is of in-ing and knees internally rotated, the key to the diagnosis of femoral anteverision lies in the evaluation of hip internal and external rotation.
The moderator should refer learners to figures 4 and 5 of the reading. Place the child in the prone position and flex the knees to 90 degrees (as you did in the evaluation of tibial torsion). The hips of a child with femoral anteversion will demonstrate extreme internal rotation (e.g., 90 degrees) with limited external rotation (e.g., 10 degrees).

The effect of W-sitting on the normal history of spontaneous resolution of femoral anteversion is a controversial topic. Studies indicate that modification of activity, sitting restrictions, and special orthotic devices have no effect on femoral anteversion. However, some patients who have femoral anteversion and sit in the W position may get compensatory external tibial torsion to keep the foot progression angle normal and may see increased torsional forces at the knee with patellar malalignment. The examiner should check for the presence of external tibial torsion during serial visits. Femoral anteversion resolves spontaneously in 80% of children by age 8 to 10, thus observation with exams every 12 to 24 months is all that is indicated up to that point. The development of external tibial torsion or the failure of femoral anteversion to resolve by ages 10 to 12 is an indication for orthopedic referral.

CASE FOUR:

Beauregard is brought in by his mom at age 3 years 6 months because she thinks he is bowlegged.

5. What is the natural progression of physiologic tibiofemoral angles in children? How will you determine if his “bowlegged” appearance (genu varum) is pathologic?

Infants are born with genu varum which is greatest at around 18 months of age, corrects to neutral alignment at about 2 years, and overcorrects to excessive genu valgum, peaking at age 4. At this point, the genu valgum decreases to the normal physiologic valgus of approximately 7 degrees at ages 5 to 6 years.

In addition to getting a thorough history it is important to carefully observe the child. Examine both limbs in the frontal and sagittal planes, both standing still and with a dynamic component. Pinpoint where the deformity is (i.e., femur, tibia, both) and how acute or gradual it appears. Checking for ligamentous stability in the knee joint is also an important part of the examination.

The examiner must determine if the child has physiologic or pathologic genu varum. Physiologic genu varum is the most common cause of bowlegs in a toddler, more common in black children, and often with a history of early walking. On examination, the deformity will appear gradual and involves the entire limb (i.e., femur and tibia). If radiographs are obtained (see indications below), they will demonstrate equal beaking of distal femoral and proximal femoral metaphyses with no physeal changes in physiologic genu varum. Management involves serial examination and parental education.

In contrast, tibia vara or Blount’s disease demonstrates more localized varus deformity of the proximal tibia, without involvement of the femur, and is the most common cause of pathologic genu varum. The natural history involves progression with rare spontaneous resolution. Two types exist based on age of onset, before or after 5 years old, and are respectively called infantile and late-onset (or adolescent) tibia vara. Infantile tibia vara is bilateral in 80% of cases and has a higher association with internal tibial torsion. The deformity develops after excessive stress to the proximal tibia medial physis, which then leads to slower growth and progressive varus.

Late-onset tibia vara is less common, usually unilateral, and more prevalent in black males, obese children, and teenagers.

Vitamin D-resistant rickets should be considered in older patients with progressive bilateral genu varum involving the distal femur and proximal femur. Medical management with vitamin D administration and phosphate replacement therapy, in addition to surgical corrective measures may be required.

Bilateral genu varum with physeal cupping and widening at distal femur and proximal tibia may also be seen in renal osteodystrophy or renal failure if the renal failure occurs in younger children with retained varus malignment. The renal illness should be addressed prior to surgical intervention to ensure lasting results.

6. What are the indications for X-rays in the evaluation of genu varum?
If the child’s angular deformity appears within the normal physiologic range for his age then no films are indicated. However, if the deformity is localized, or the child is of short stature, then full-length lower extremity radiographs obtained with the knees pointing straight forward are recommended. If the child’s knees are not in the true AP plane, then rotation may affect the angles you measure. In examining the radiographs, scrutiny in regards to the physes is also essential.

Orthopedic consultation is recommended in cases of suspected tibia vara. Treatments range from bracing to surgery, depending on age and severity of deformity.

7. How would approach the patient had the chief complaint been “knock-knees” (genu valgum) instead?

The vast majority of genu valgum presentations in children are physiologic rather than pathologic. Genu valgum within two standard deviations of the mean are considered physiologic. Pathologic deformity tends to be unilateral.

Physiologic genu valgum peaks at age 4, while idiopathic genu valgum results from failure of resolution of this physiologic genu valgum with persistence or progression of the valgus deformity. Children with idiopathic genu valgum are often obese, flatfooted and have ligamentous laxity. Flattening of the lateral femoral condyle is seen on x-rays.

Posttraumatic genu valgum may occur when there is deforming injury that is inadequately reduced or an undetected physeal injury that leads to impaired growth of the affected physeal portion.

Metabolic derangements such as vitamin D-resistant and vitamin-D deficient rickets, though more commonly associated with varus deformity, can also cause pathologic genu valgum. Renal osteodystrophy, on the other hand, is more typically associated with valgus deformity. The timing of the metabolic insult in relation to the physiologic changes in alignment is thought to determine what deformity is seen. Neuromuscular disorders such as cerebral palsy often predispose children to have pes valgus (outward deviation of the feet at the talocalcaneal joint) and external tibial torsion, which cause valgus deformity at the knee.

In children less than 7 years old with symmetric genu valgum, normal stature, and tibiofemoral angle measuring less than 15 degrees, the deformity is likely physiologic and no further diagnostic tests are needed. No treatment is needed for physiologic genu valgum, and bracing is not indicated.

If the deformity is drastic, asymmetric, or present with other abnormalities such as height less than the 25th percentile then AP full length lower extremity radiographs should be obtained for evaluation.

If the child is less than 10 years old, has a tibiofemoral angle over 15 to 20 degrees with an intramalleolar distance of more than 8 cm, has asymmetric involvement or short stature, or progressive deformity after age 4 then serial radiographs and examination are recommended. If a tibiofemoral angle of more than 15 degrees or an intra-malleolar distance greater than 10cm persists after age 10, then spontaneous resolution is unlikely and surgical treatment is indicated. Surgery aims to restore the normal mechanical axis and alignment of the joint. It is important to remember with any of the metabolic derangements that medical stabilization of the metabolic issue prior to and after surgery is essential to the success of the procedure.

Additional References: