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Rotational Deformities of the Lower Limb in Children

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Abstract

Rotational deformities are common lower extremity abnormalities in children. Rotational problems include in-toeing and out-toeing. In-toeing is caused by one of the three types of deformity: metatarsus adductus, internal tibial torsion, and increased femoral anteversion. Out-toeing is less common than intoeing, and its causes are similar but opposite to those of intoeing. These include femoral retroversion and external tibial torsion. An accurate diagnosis can be made with careful history and physical examination, which includes torsional profile (a four- component composite of measurements of the lower extremities). Charts of normal values and values with two standard deviations for each component of the torsional profile are available. In most cases, the abnormality improves with time. A careful physical examination, explanation of the natural history, and serial measurements are usually reassuring to the parents. Treatment is usually conservative. Special shoes, cast, or braces are rarely beneficial and have no proven efficacy. Surgery is reserved for older children with deformity from three to four standard deviations from the normal.

Key Words: Rotational deformity, Intoeing gait, Out-toeing gait, Lower limb

Introduction

"Toeing in" and "Toeing out" are the two most common complaints in pediatric orthopedics that mainly have physiologic origin. Making an accurate diagnosis along with a proper concept of its natural development comprise the mainstay of treatment.[1] Various factors are responsible for "Toeing in" and "Toeing out" in different ages. An accurate evaluation of the lower limb rotational pattern while considering the child's age could help to find the cause.

Terminology

There are several terms that may need explanation at the beginning. The word "version" is referred to normal range of rotation around the longitudinal axis of a long bone or limb. A range of more than two standard deviation errors is often taken as implying "Torsion", and is considered as abnormal.

For measuring the degree of rotation, imaginary lines are considered in proximal and distal of femur and tibia, called as reference axes.

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In femur, the proximal axis is drawn from the center of femur body at the level of lesser trochanter to the femoral head, and the distal axis is drawn from the most posterior part of junction of femoral condyles.[2]

The proximal axis of tibia is drawn from the most posterior parts of tibial condyles, and the distal axis passes from medial and lateral malleoli. There will be no rotational deformity if both the proximal and distal axes are in the same plane. An external rotation of proximal axis of femur relative to the distal axis is called "Anteversion" and "Antetorsion", whereas its internal rotation is termed "Retroversion" and "Retrotortion". The internal and external rotation of distal axis of tibia (relative to the proximal axis) is termed internal and external tibial version (torsion), respectively. A rotational deformity is simple if it is the result of a rotation in one anatomic plane. However, the rotational deformity can also be of additive type (combination of femoral antetorsion and internal tibial torsion), or compensatory (combination of femoral antetorsion and lateral tibial torsion).[2]

During embryonic development, limb rotation is influenced by limb growth and molding properties of the uterus. Fetus legs (approximately in the 8th week of gestation) are in praying position. There will be an internal rotation of the limb for the foot to be in plantigrade position. Uterus pressing effect results in outward rotation of the femur (to reduce anteversion) and inward rotation of tibia. At the time of birth the femur anteversion is as high as 30 to 40 degrees, and the tibia version is zero. Later, during the growing age both the femur and tibia tend to rotate outwards; thus the femur anteversioin reaches to 10 to 15 degrees and the tibia version to 15 degrees. Nevertheless, the natural history consists of medial tibial torsion and femoral anteversion improvement.[3,4,5]

Torsion and Version Measurement

Clinical and radiologic methods are used for version measurement with the clinical method having less accuracy than radiologic (using CT scan) 8. There are three methods for tibial version measurement. In the first method (thigh-foot angle measurement), the child lies down prone with the knee 90° flexed. The foot and ankle is then held in neutral position so that the plantar surface is parallel with the ceiling. The angle between the line along the thigh and the line along the foot sole is the thigh foot angle.[1,2]

In the 2nd method, ask the child to sit on the edge of the examining table with the legs dangling free, with the posterior leg firmly pressed to the table edge. By putting the thumb and index fingers on the medial and lateral malleoli the transmaleolar axis is identified. The angle between this line and the table age shows the tibial version.[1,2]

In the 3rd method, again the child sits on the edge of the examining table, with his ankle being held at a 90° angle relative to the leg. A perpendicular line is then drawn from tibial tubercle. This line should cross the 2nd metatarsal. However, the degree of deviation from 2nd metatarsal indicates the tibial version. Femur version can be measured indirectly by hip external and internal rotation evaluation with the child lying prone and the knees flexed 90°. In this method, the legs are moved away (without force and just using gravity) (hip internal rotation).[1,2,6]

Vice versa, moving the legs toward each other means external rotation of hips. Normal hip internal rotation decreases by age to below 60° to 70° (normal upper limit). Numbers above this indicates femoral antetorsion. The minimum external rotation of hip is 25° and numbers below that are considered as femoral antetorsion. The normal thigh-foot angle is 10° (-5° to +30°).[7]

Etiology

Rotational deformities of the lower limb could be the result of bone deformities, neuromuscular disorders, and soft tissue contractures. So neuromuscular problems and soft tissue contractures should be looked for before the bone deformities are addressed during physical examination. A thorough physical examination is needed to rule out spastic and athetoid cerebral palsy, upper motor lesions, cord lesions such as

myelomeningocele, iliotibial band and achilles tendon contractures.[6] Tibia vara, more grown fibula compared to tibia (tibial hemimelia and achondroplasia) as uncommon causes, abnormal inward deformities of femur and tibia as well as foot deformities (metatarsus adductus and halux adductus) are the most important bony causes of "toeing-in" among children. A protective "toeing in" is also observed in children of developmental genu valgum ages or those with flexible pes planovalgus.[8] This posture shifts body's center of gravity to the centre of foot that prevents early fatigue and foot strains.[4,9]

The intrauterine condition of fetus (hips in external rotation), and the prone posture of infant before walking age causes external hip rotators contracture. Hence, most of toddlers have an "out teoing" during early walking days that hides femoral anterversion in consequence. As the child grows the contracture resolves, the hip internal rotation increases and the "out teoing" intensity decrease.[5,7]

Vertical talus, fibular hemimelia, hip dislocation, developmental coxa vara in children, slipped capital femoral epiphysis, tarsal coalition, lateral femoral torsion (especially in obese adolescents) and lateral tibial torsion are other causes of "out toeing" in older children.

In premature and low birth weight neonates, "out toeing" persists a long time after walking due to lack of uterine molding effect (for inward rotation of legs). Muscular dystrophies are another cause of "out toeing".[4,5]

History

In clinical history attention should be paid to gestational and labor history, presentation at the time of labor, prematurity, weight at birth, the foot condition during early days after birth, developmental status, child's preference in using one hand before age of two, improving or worsening trend, and the ensuing disability. Insignificant "in-toeing" helps child to run but a more severe "in-toeing" leads to recurrent fallings.[2,6]

A child walking with femoral antetorsion (knees looking inwards), may seem rather clumsy. On the other hand, severe degrees of "out-toeing" could lead to early fatigue, foot strain and anterior knee pain due to patello-femoral joint problems. A positive family history is of paramount importance as it predicts the child's deformity process evolution.

Evaluation and treatment

Care should be taken to the standing, walking, and running styles. A thorough neuromuscular examination of hip is necessary. In order to determine the severity of deformity, rotational profile of right and left lower limbs should be evaluated and written. In rotational profile one must include the four indices: 1- Foot progression angle; 2- Femoral version; 3- Tibial version; 4- Foot deformity.

In order to measure the foot progression angle (FPA), one must measure the angle between the line along the foot sole during walking and movement direction. If the child's foot looks outwards relative to the movement direction the angle degree will be positive (+). If the child's foot looks inwards relative to the movement direction the angle degree will be negative (-). A high positive degree indicates "out-toeing", and a high negative degree shows "in-toeing". Numbers -5° to -10°, -10° to -15°, and more than -15° are assigned to mild, moderate, and severe deformities. The normal value of FPA is +10 (ranges form -3 to +20).

Femoral version measuring method has been described before. For tibial vision measurement we use the thigh-foot angle method. The 4th index relates to deformities such as metatarsus adductus and halux adductus. Normally, the foot outer border is a straight line. The outer border convexity means metatarsus adductus.

Imaging methods (CT scan and radiography) are indicated when the severity of internal and external rotation of the hips are not the same, or the surgery is indicated.[10]

The best treatment approach to rotational deformities of the lower limb in children is a correct diagnosis followed by identifying the level and severity of involvement. A regular visit and proper assurance is necessary. "In-toeing" will gradually resolve as the lower limb rotates

outwards with age. A medical shoe or insole seems to be of no value in this regard. Rotational nocturnal open casts have limited use and should not be recommended during the waking hours. Moreover, their long term benefit has not been proved yet. 99% of rotational deformities improve spontaneously, and surgical intervention is needed in just 1% after the age of 8 to 10.[11]

The most common responsible factor for "out-toeing" in toddlers is contracture of the hip external rotator muscles. This is usually considered as normal and resolves gradually.

The most common causes for "in-toeing" during the first two years are adducted great toe, metatarsus adductus, and internal tibial rotation. Adducted great toe is a dynamic deformity secondary to over strain of abductor pollicis longus. This condition is self-limiting and resolves with increasing age and nervous system maturity. The most important point in the approach to metatarsus adductus is determining the rigidity. The flexile types have good prognosis and improve by time. Rigid types are usually characterized by a sulcus in medial border of foot, and do not improve spontaneously. In this group treatment includes bracing or casting of the affected foot. Internal tibial rotation is a bilateral entity with the left side often being more severely affected. In physical examination the thigh-foot angle is negative.[12] Due to the natural history of tibial external rotation no specific treatment is needed. In few cases in whom the deformity does not improve by increasing age and the thigh-foot angle is below 10 °, a correction tibial osteotomy is helpful.

From the age of 3 onwards, the femoral anteversion is the most common cause of "In-toeing". This condition is more common among girls with ligamentous hyperlaxity. The affected children tend to sit in a "**W**" position. Their knees look inward at standing. On physical examination the hip internal rotation is more than 75° and external rotation is less than 25°. The severity reaches its peak at the age of 4 to 6 years old, and improves steadily afterwards. Non-surgical interventions are of limited value in these patients; therefore, a correction osteotomy is performed after the age of 8 to 10 years. Primary external tibial torsion is not a common entity. It is usually secondary to femoral antetorsion, iliotibial band or Achilles tendon contracture. In the first step one need to exclude secondary causes. On physical examination the thigh-foot angle has increased. In the primary form, the deformity progresses by increasing age leading to patients referring before adolescence. External tibial torsion can cause anterior knee pain and foot strain due to disturbance of patello-femoral joint. In cases with thigh-angle of more than 35° to 40° a correction osteotomy could be performed after the age of 8 to 10 years.

Femoral retrotorsion is rare and is seen in two forms: 1- primary or developmental, and 2- slipped capital femoral epiphysis. On physical examination the internal rotation has decreased dramatically and the external increased. This deformity can lead to pain and long term degenerative changes of the hip joint.[13,14,15] It does not improve by age.

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