Lower limb alignment

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Abstract

The alignment of the paediatric lower limb undergoes changes alongside normal skeletal development. It is important to understand certain angular changes with age in order to differentiate normal lower limbs from pathological conditions. There are two systems of axes that we can use to describe alignment: mechanical and anatomical. They refer to two different concepts and must be used separately. Both the mechanical and anatomical axes can be used to assess the location of a deformity and to gauge treatment response during growth.

Keywords alignment; anatomical; deformity; lower limb; mechanical

Introduction

During childhood, the axes of the lower limbs usually undergo various changes as part of skeletal development. We use the term ‘alignment’ to quantify how far an axis deviates from a straight line joining two points in the coronal, sagittal or axial planes of the lower limb. This straight line between two points can refer to the mechanical axis or an anatomical axis, which are two different concepts that should not be mistaken as being the same. Deviation from the normal axis may be due to either translation or angulation. By convention, we use the terms valgus and varus when describing lateral and medial angulation, and external and internal rotation when describing axial angulation. Translation can also be medial, lateral, anterior, posterior, short or long. We usually refer to the distal segment of a limb in relationship to the proximal segment. This system of deformity description is actually a form of Euclidean geometry from Ancient Greek times, which describes the location of a coordinate system in the three—dimensional ‘x, y and z’ axes. To make geometric calculations simpler, we often choose to analyze each plane separately (coronal, sagittal and axial) and therefore reduce the problem to two dimensions.[1]

Alignment can be measured clinically or using imaging studies, depending on how accurately certain bony landmarks can be palpated. When the alignment falls outside the normal range, it is important to consider how this will affect the function and longevity of the joints above and below. Sometimes the alignment can resolve with continued normal growth but this is not always the case. Follow-up is usually indicated to chart a progressive deformity and so that surgical interventions can be planned. There are a number of techniques that can be utilized to correct alignment, including guided growth,[2] epiphyseodesis, osteotomies and acute or gradual correction. The latter may utilise internal implants, external fixation devices or lengthening nails. Correction of alignment can be difficult when the location of the deformity is close to a joint or when there are multiple deformities present. Sometimes, a secondary deformity can be created intentionally to compensate for a primary deformity in order to realign a mechanical axis.

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Normal alignment

The assessment of alignment usually begins with clinical observation, with the child stood up, walking and then lying down, depending on their age. When the child is observed from the side, a straight line should pass vertically down from the cervical spine and through the centres of the hip, knee and ankle. Spinal deformities such as kyphosis or scoliosis can present as apparent lower limb deformities when a compensating posture is adopted. Asking the patient to walk and observing the head movements, shoulder height, spine balance and pelvic obliquity can also help reveal deformities. If there is a short leg gait, the clinical leg length difference can be calculated by asking the patient to stand on incremental blocks until they feel balanced (Figure 1).

If there is valgus deformity at the knee, a simple measure is to place both knees together and measure the ankle intermalleolar distance. A varus knee deformity can be measured by the distance between each medial femoral epicondyles. With the patient lying supine, both leg lengths can be measured from ASIS to medial malleolus. This also gives an opportunity to observe both limbs together and comment on any asymmetry. If there is a fixed flexion deformity in one limb, the opposite limb should be placed into the same position in order to compare. Galleazi's test and Bryant's test can be used to determine where the limb shortening is occurring. Hip version can be assessed by Craig's or Gage's tests. The range of movement of both the hip and knee should then be tested (abduction, adduction, flexion and extension). A flexion deformity at the hip should also be assessed by Thomas's test. The final part of the examination involves turning the patient into the prone position and testing rotation at the hip, followed by observation of the thigh foot angle and heel bisector (Figure 2).

As mentioned previously, the lower limb has both a mechanical axis and an anatomical axis. The mechanical axis is a standing weight-bearing axis, which assumes that all the body's weight travels from both hips to both ankles in a straight line when the pelvis is level. It can be measured from radiographs by asking the patient to stand against an imaging plate that is large enough to image both legs. If serial radiographs are taken, they must be accurately joined together. In the coronal plane, the patella must be pointing forwards and the pelvis should be level using blocks under a shorter limb. In the sagittal plane, the legs should be imaged separately, with one leg straight and the other flexed forwards to avoid obscuring the view. The mechanical axis of the femur in the sagittal plane usually runs outside the bone due to femoral neck anteversion so the anatomical axis is more often used. The anatomic axis follows a path in the centre

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Figure 1 An 11-year-old boy with Nail Patella Syndrome. Blocks are used under his short leg and the limbs are inspected from all sides.

Figure 2 Testing the rotational profile is best achieved with the patient lying prone. Hip mal-rotation, tibial torsion and foot deformity can all be assessed in this position.

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