A large proportion of referrals from primary care to paediatric orthopaedic clinics involve ‘bowed legs’ and ‘knocked knees’. It is important for the treating surgeon to understand the normal development of a child’s lower limbs in order to ascertain what is ‘normal’ and what is abnormal.

Assessment
Clinical assessment is aimed at distinguishing physiological from pathological deformities. The following factors must alert the clinician to possible pathology if elicited in the history and/or examination:

- Pain
- Asymmetrical deformity
- Severe deformity
- Deformity not in keeping with normal development
- Suspected syndrome (e.g., short stature) or associated musculoskeletal abnormalities

Clinical examination should also focus on excluding any rotational abnormalities and ligamentous laxity as these can exaggerate the appearance of coronal plane deformities. The intercondylar distance should be measured with the medial malleolus in contact and should be less than 6 cm in genu varum. The intermalleolar distance is measured with the knees in contact and should be less than 8 cm in those with genu valgum.\(^1\)

A long leg alignment radiograph (teleoroentgenogram) is a full-length standing anteroposterior (AP) of the lower limbs with the x-ray beam centred at the anteriorly facing patella (Fig. 1). This is only required in cases where pathology is suspected or for pre-operative planning. The mechanical axis refers to a line drawn from the centre of the femoral head to the centre of the ankle joint. This line should pass through the centre of the knee joint and if it does not, there is Mechanical Axis Deviation (MAD). Genu varum occurs when the MAD is medial to the centre of the knee joint and genu valgum occurs when the MAD is lateral.

Normal Development
In 1975, Salenius and Vankka\(^2\) described the development of the tibiofemoral angle during growth (Figure 2). At birth, genu varum is common and is believed to be secondary to intrauterine positioning which leads to contracture of the medial aspect of the knee joint capsule.\(^3\) Mild internal tibial torsion is common and the result of these two normal positions is most noticeable when the child starts to weight-bear.\(^4\) The child externally rotates the tibia to allow the foot to point forwards and this in turn places the anteriorly bowed femur into a lateral profile, resulting in symmetrical bowed legs. Referral for ‘bowed legs’ is very common between 10 and 14 months, a period when the average child starts to stand and ambulate but early walking has been documented in children of Afro-Caribbean descent and therefore referrals for this subset of children may occur earlier.

This ‘physiological’ genu varum corrects itself over time as the contracture stretches and from the age of two onwards, a genu valgum deformity is encountered. Genu valgum (10° to 15°) occurs between the ages of three and four and it is in this age group when referral for ‘knock knees’ is most common. This ‘physiological’ genu valgum corrects itself to the normal adult valgum of 7° to 8° by the age of between six and seven. Genu valgum may be accentuated by fat thighs, ligamentous laxity and pes planus. In addition, torsional abnormalities such as persistent femoral neck anteverision with compensatory external tibial torsion will make a ‘physiological’ genu valgum look more severe. Education and reassurance is the mainstay of treatment for the parents if the deformity is deemed to be physiological.

Pathological Genu Varum
Pathological causes of genu varum should be considered if the deformity is unilateral, asymmetrical or in the child over the age of three (Table 1).

Blount’s Disease
In this condition, growth disturbance in the proximal medial tibial physeal leads to proximal tibial vara (Fig. 3). Blount’s disease has preponderance for early walking obese children of Afro-Caribbean and Scandinavian descent. The pathophysiology is thought to be based on the Heuter-Volkmann principle of growth inhibition caused by excessive compressive forces and is often bilateral. It may be classified into infantile (age less than four), juvenile (age between four to ten) and adolescent (age greater than ten) types based on age of onset. Lagensköld’s classification depicts the radiographic changes seen and grades the severity of the proximal tibial changes.\(^5\) Drennan’s angle (metaphyseal-diaphyseal angle) of greater than 11° is suggestive of Blount’s disease but use of 16° as the cut-off may lead to a lower incidence of false positives, especially in the younger child.\(^6,7\) Management options include hemiepiphysodesis, guided growth, osteotomies with fixation and osteotomies with circular frame correction. Recurrence is more commonly seen in those who are older at the time of osteotomy, in Blount’s Disease of higher Lagensköld stages and in those who undergo surgery and have a lack of post-operative valgus overcorrection.\(^8\) Corrective osteotomy before the age of four is associated with lower recurrence rates.\(^6,9\)

Rickets
Nutritional and vitamin-D-resistant (hypophosphataemic) rickets are metabolic causes of genu varum. Risk factors for nutritional rickets include dietary factors, darker skin pigmentation, the practice of covering up or use of sun screens.
with SPF > 8. Therefore, ethnic minorities are more at risk of developing rickets and given affected children are often in the lower tenth percentile with regard to height, biochemical screening should be performed in these subsets of patients. Radiographic abnormalities include widening of the physe as a result of lack of calcification in the provisional calcific zone, cupping of the physe and bowing of the long bones (Fig. 4). Treatment involves vitamin-D supplementation as well as phosphate supplementation in cases of vitamin-D-resistant rickets. Medical therapy can lead to resolving of the radiographic changes mentioned.

**Pathological Genu Valgum**

Pathological causes of genu valgum should be considered if the deformity is unilateral, asymmetrical, progressive or in the child under the age of two years (Table 2).

**Idiopathic** When physiologic variants fail to resolve and the genu valgum persists or worsens, idiopathic genu valgum is the diagnosis. It is believed to be as a result of prolonged excessive forces through the lateral aspect of the knee joint. Associated factors include obesity, ligamentous laxity, pes planus and lateral femoral condyle hypoplasia (Fig. 5). The suggestion that fracture hyperaemia leads to stimulation of the medial proximal tibial physis is the most accepted theory. Fractures of the distal femoral or proximal tibia physis may be complicated by partial growth arrests (Fig. 6). The susceptibility of these physes to a growth arrest is thought to be due to the large and convoluted anatomy of the physe. Renal Osteodystrophy Like rickets, renal osteodystrophy can lead to both varus and valgus deformities. However, unlike rickets, renal osteodystrophy more commonly leads to genu valgum. This is believed to be due to the pattern of mechanical loading of the physes as determined by the alignment of the knee at the time the disease manifests itself. Renal osteodystrophy manifests itself in older children with genu valgus whereas rickets is often present at an early age when the child is in genu varum. Treatment of deformities in this scenario is best performed once the renal disease has been stabilised by medical treatment or transplantation.

**Conclusion**

The treating clinician must be familiar with normal development of the lower limb in children and be familiar with factors in the history and examination that should raise the possibility of the deformity being pathological.
References