Deformities of the lower limb in the growing child

GPs are often called on by concerned parents to assess limb deformities in infants and children.

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General practitioners are often asked to assess bowleg and knock-knee deformities in infants, children and adolescents. For the child without underlying pathology the parental concern is that of cosmesis or clumsiness. Often there is a family history of developmental deformity of the lower limbs that was successfully treated with a splint or a shoe insert. Normal developmental changes in alignment do not need any treatment and children were often treated unnecessarily in the past.

The same principle applies to the assessment for malrotation of the lower limb of the growing child. It is very rare to find a true rotational malalignment in the physiologically normal child. In the vast majority of growing children it will correct spontaneously without treatment. Surgery is not indicated and an orthosis, boots and shoe inserts do not have any effect.

The aim of this review is to give the general practitioner guidelines to managing this problem. Furthermore it touches on some pathological alignment and rotational deformities that need surgical intervention.

The challenge for the general practitioner is to decide who must be referred. Fewer than 2% of these patients will need treatment. The key to identifying these patients is a good history and clinical examination.

Alignment of the lower limb in the growing child

What is angular alignment of the lower limb?

Angular alignment is most commonly assessed in the frontal plane. It is described as the relationship of the deformed part of the limb to the midline of the patient and the joint just proximal to the deformity. Genu varum (bowing of the legs) is when the tibia is bent towards the midline of the patient in relation to the knee joint. Genu valgum (knock knees) is when the tibia is bent away from the midline of the patient in relation to the knee joint.

Angular alignment should also be assessed from the lateral view. The leg can be in procurvatum (flexion) or recurvatum (hyperextension). Most commonly these deformities are seen around the knee.

What is rotational alignment of the lower limb?

The normal physiological development of the rotation of the lower limb also takes place in a specific pattern. The rotational changes occur in concert with the angular changes, but the examiner should analyse the components separately.

Rotational malalignment may occur at the hip or tibia: it is rare to have rotational malalignment at other levels. Hip anteversion is the angle of the femur neck relative to the distal femoral metaphysis, and is up to 45° in the infant. It gradually decreases for practical purposes to the adult value of 25° by the age of 11 years.

Internal and external rotation of the hip should be equal on examination; inequality may be caused by excessive or inadequate anteversion. Clinically this presents as in-toeing with excessive anteversion (very common) or out-toeing with excessive retroversion (very rare) (Figs 1 and 2).

Tibial rotation is usually noted at the proximal metaphysis of the tibia. The in-turned foot in relation to a neutral knee (patella facing directly superiorly in supine patient, anteriorly in the standing

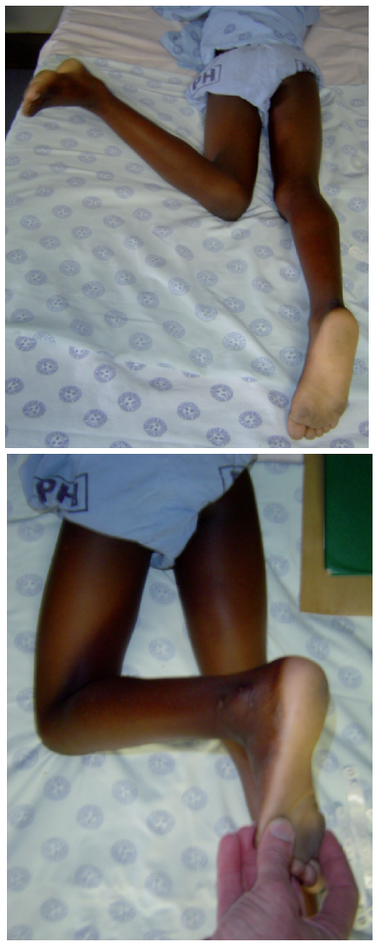


Fig. 1 and 2. Symmetrical rotation of the hip is a reflection of normal anteversion of the hip.

patient) is due to metaphyseal internal rotation and if excessive is called internal tibial torsion.

Physiological changes in angular alignment of the growing child

During the 1970s a radiological study was undertaken in Finland by Salenius and Vankka, where they assessed the tibiofemoral angle in the growing child.[1] They found that before the age of 1 year the legs are in pronounced varus. This changes to valgus alignment by the age of 3 years. The valgus may be pronounced but gradually corrects until by the age of 7 years it should be only 6°.

During the early phases of walking the infant's femur has external torsion distally and the tibia has internal torsion. This causes a lateral thrust that will cause varus of the legs. It is unclear what exactly causes the change into valgus. It is possible that it is caused by the widening pelvis.

Quite often the varus or valgus is more apparent than real. In bowleg this is because internal rotation of the proximal tibia is combined with the genu varus. In knock-knee recurvatum of the knee occurs in combination with the genu valgus. The combined deformity then looks much worse when the patient is standing or walking (Figs 3 and 4).

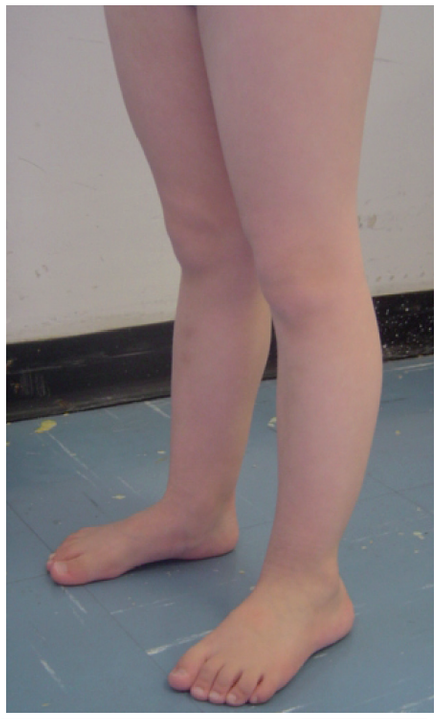
History

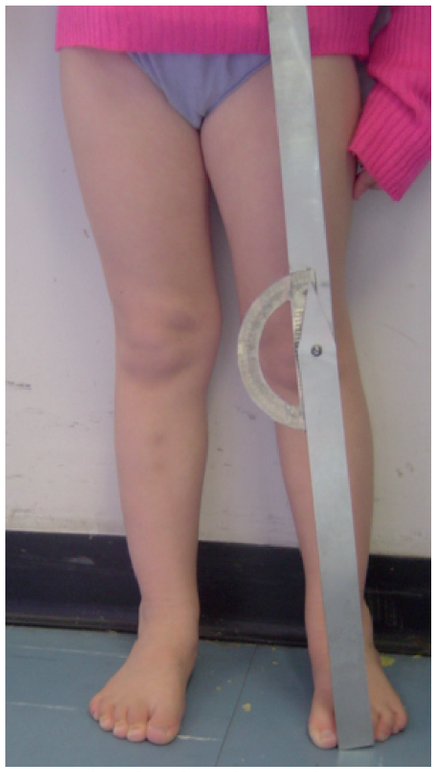
The following points must be covered when taking a history:

- Perinatal history to exclude prematurity or prolonged hospitalisation associated with other health problems.
- Brief history of milestones to exclude neurological disease.
- Feeding history – beware of the parent with a food obsession. The incidence of nutritional rickets is decreasing in South Africa.
- Family history of hereditary metabolic bone disease or dwarfism. Hypophosphataemic rickets is the most common type.

Examination

- Observe the gait while the child walks away and towards the examiner (unassisted).
- Observe the alignment of the leg standing and supine. Use a goniometer. Asses varus/valgus as well as rotational findings separately.
- Examine for ligamentous laxity.
- Examine the child lying down (then you can exclude apparent varus or valgus).
- Break up the varus/valgus as well as rotational findings. Measure the thigh-foot angle, which is an indicator of tibial rotation.
- Measure the standing *intercondylar distance* with the ankles pressed together when quantitating bowlegs.
- Measure the *intermalleolar distance* in the knock-kneed with the recurvatum corrected and the knees lightly pressed together to qauntitate knock-knees.
- Encourage taking photographs every 4 months to document resolution or progression.





Figs 3 and 4. Physiological genu valgus measured with goniometrer, more pronounced because of recurvatum.

Physiological genu varus

Physiological genu varus is shown in Figs 5 - 7. Physiological bowing is defined as >10^0 bilateral femoral-tibial varus in a child older than 18 months. There is usually a very strong family history. These children start walking early (<1 year) and are characteristically agile.

Management

Inform the parents that bowing should resolve and give a target age (usually by 2 years for varus or after approximately 6 months of walking). Explain to them that it will be followed by physiological valgus. Follow-up may be needed, mainly to reassure the parent. Accompanying tibial torsion is expected to resolve.

Repeat the physical examination within a couple of months or if you feel the parents need reassurance. Management of the paediatric patient with a musculoskeletal problem seldom necessitates a dramatic decision.

Physiological genu valgum

Knock-knees in children are less of a parental concern than bowlegs. Physiological knock-knee typically occurs between 3 and 5 years, when the femoral-tibial angle is at its maximum. Physiological knock-knees are typically symmetrical. Flatfoot appearance is often noted first. These children may present with medial foot and knee pain. At age 3 - 4 years it reaches its maximum of 8 - 10^0, and gradually decreases to 5 - 7^0 at 6 - 7 years.

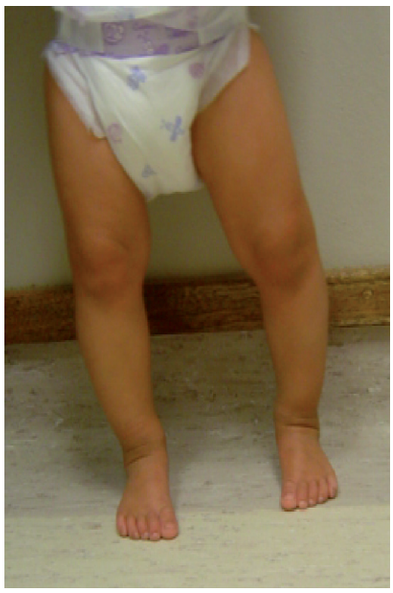
Management

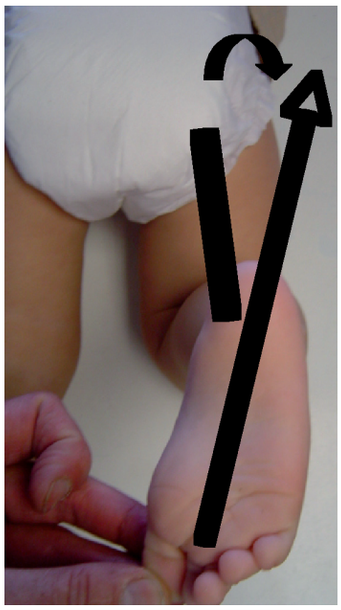
Spontaneous correction is expected by 7 years. No bracing is required. Conservative treatment (splints, shoes) is ineffective. Where deformity is more pronounced, or persistent, follow-up is recommended every 4 - 6 months. If there is no resolution the orthopaedic surgeon will consider surgery (hemi-epiphyseodesis or proximal tibial osteotomy).

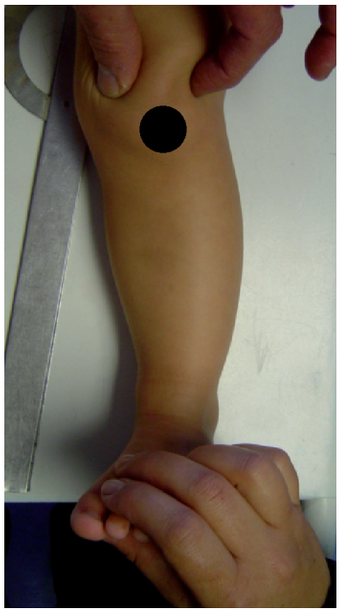
Indications for orthopaedic referral

- Older than 2 years with deformity.
- Femoral-tibial angle 20^0 measured with goniometer.
- Lateral thrust of the knee.
- Short stature.
- Suspected metabolic bone disease.
- Asymmetrical deformity.

X-rays fall in the domain of the orthopaedic surgeon and will be done at referral. They must be done in a specific way to assess







Figs 5 - 7. Physiological genu varus, assessing the thigh-foot angle and also demonstrating the neutral patella directed superiorly and with the foot in internal rotation. Also pronounced apparent varus due to internal tibial rotation.

the alignment abnormality and the bone quality.

If you see patients with genu valgum frequently it is a good idea to give the parents a hand-out to study at home.

Information for parents

- Many children in diapers have bowlegs.
- Because of the limb rotation the bowing is often more apparent than real.
- Bowlegs usually correct spontaneously by the age of 3 years.
- This is followed by a period of knock-knees, which will also correct.
- Simple methods of treatment do not work and are unnecessary.
- Deformities due to an underlying metabolic disease are rare and need the attention of an orthopaedic surgeon.
- Intermalleolar distance for knock-knees and intercondylar distance for bowlegs may be useful when monitoring the findings.
- Orthopaedic surgeons will measure correctly taken X-rays to determine malalignment.
- Serial photographs of the standing patient taken every 4 months will be very useful for follow-up.

Pathological angular malalignment

This occurs when the alignment falls outside the physiological range, especially in association with underlying pathology (Table I). If deformity is asymmetrical it may be pathological. The commonest causes are rickets, Blount's disease and trauma.

Rickets deformities

Rickets is caused by a number of metabolic abnormalities. The most important groups are:

- nutritional – calcium, vitamin D deficiency
- hypophosphataemic rickets
- renal osteodystrophy
- primary renal tubular acidosis.

Clinical signs are stunting of growth, softening of the skull (craniotabes), prominence of the suture lines (hot-cross bun) and prominence of frontal bones (frontal bossing). The thoracic cage shows thoracic kyphosis (rachitic cat-back), thickening of the costochondral junctions (rachitic rosary) and pectus carinatum. A Harrison's sulcus is an indentation at the insertion of the diaphragm and a 'pot belly' abdominal deformity is often present. Enlargement of the wrists, ankles, knees, and elbows is called wine-glass deformity. Children show apathy and irritability. They prefer to sit rather than to stand or to walk. Widening of the physis is seen on X-rays.

An elevated serum alkaline phosphatase confirms the diagnosis of rickets. It is treated with calcium and/or phosphate as well as physiologically active vitamin D, depending on the cause. The medical management falls in the domain of a geneticist or paediatrician. The alignment abnormalities must be measured on X-ray. Deformities often require surgical management. Figs 8 - 10 depict clinical and radiological signs of rickets.

Blount's disease – pathological genu vara

Predisposing factors for the development of the condition include obesity, early walking, and black ancestry. Obesity and early walking exaggerate the impact of physiological bowing and increase the stress placed on the physis of the proximal tibia.

The metaphyseal-diaphyseal (MD) angle helps with the grading of Blount's disease. The MD angle is obtained by measuring the angle formed between a line drawn parallel to the top of the proximal tibial metaphysis and another line drawn perpendicular to the long axis of the shaft of the tibia. An MD angle of more than 11° is associated with the mild form of Blount's disease, but it can even increase up to 60°. It is very often associated with internal rotation of the proximal tibia.

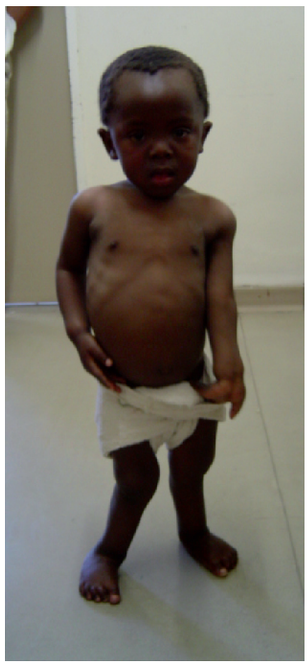
Management

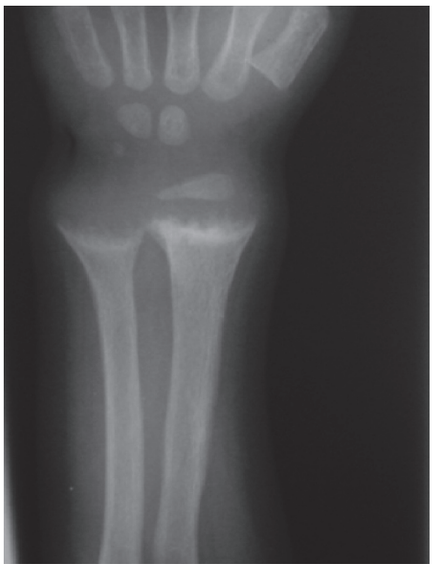
Non-operative treatment

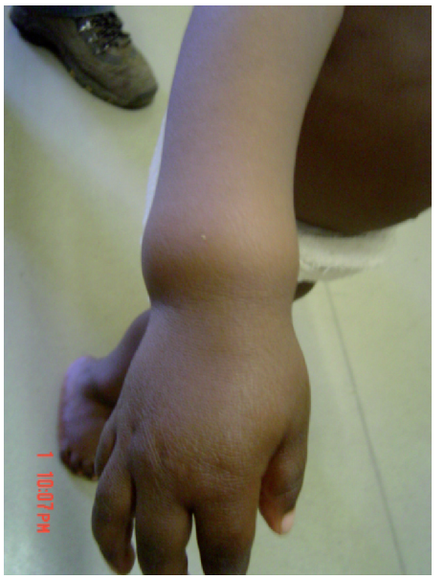
Brace treatment may be considered in children under 2½ years old (Figs 11 and 12). Good patient compliance is usually achieved in the child with unilateral deformity.

Table I. Diseases causing deformity

Varus angulation	Valgus angulation
Blount's disease	Skeletal dysplasia
X-linked hypophosphataemic rickets	Metabolic rickets
Nutritional rickets	Post-traumatic
Skeletal dysplasia	Multiple hereditary exostoses
Osteogenesis imperfecta	Osteogenesis imperfecta
Neoplastic disease	







Figs 8 - 10. Clinical and radiological signs of rickets.

Operative treatment

Surgery is performed in the older child, especially if there is severe deformity, obesity or bilateral involvement (Figs 13 - 15).

Pathological genu valgum

Spontaneous correction might not occur in post-traumatic valgus (a specific problem after proximal tibial fractures in children) and may necessitate surgery.

It is rare to get knock-knees after the age of 6 - 7 years but sometimes persistent pathological knock-knees develop in the young adolescent; deformity arises from asymmetrical growth in the distal femur which does not resolve spontaneously.

Temporary hemi-epiphysiodesis is often done at the age of 7 with an 8-plate. (Figs 16 and 17). The surgery during adolescence is a hemi-epiphysiodesis using stapling or percutaneous screws (Metaìzeau technique). There should be reliable follow-up, because metal should be removed when the mechanical axis is corrected to avoid overcorrection.

Pathological rotational malalignment

During cruising and early walking the feet are externally rotated because the external rotators of the hip are shortened due to lack of use in the postnatal period. As the walking improves the rotators will stretch and the external rotation will correct spontaneously.

Persistent out-toeing is sometimes seen with underlying neurological disease. In-toeing is a more common finding and may be due to excessive anteversion of the hip or internal tibial torsion. The important task of the orthopaedic surgeon is to determine weather the patient has an underlying pathological condition such as a neurological disease that may cause torsion.

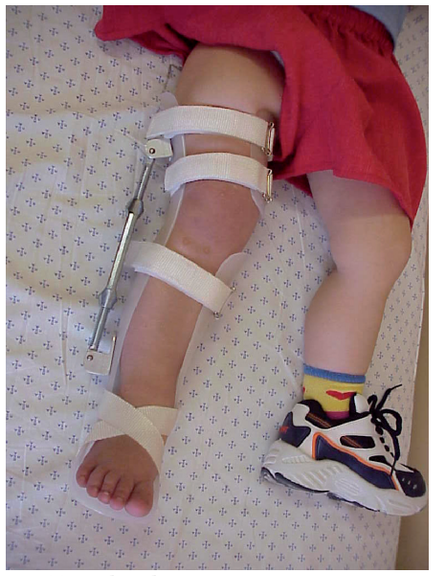


Fig. 11. Night splint.

Femoral anteversion is not associated with any functional deficit or long-term risk of osteoarthritis. It may improve spontaneously and the gait always improves in these children because the child will develop compensatory external tibial rotation. Femoral anteversion can be accurately measured with a CAT scan of the femoral neck angle in relation to the posterior femoral condylar line.

Internal tibial rotation is also associated with good function. It is extremely rare to do corrective derotation osteotomies. It may be indicated for patients with underlying neurological disease.

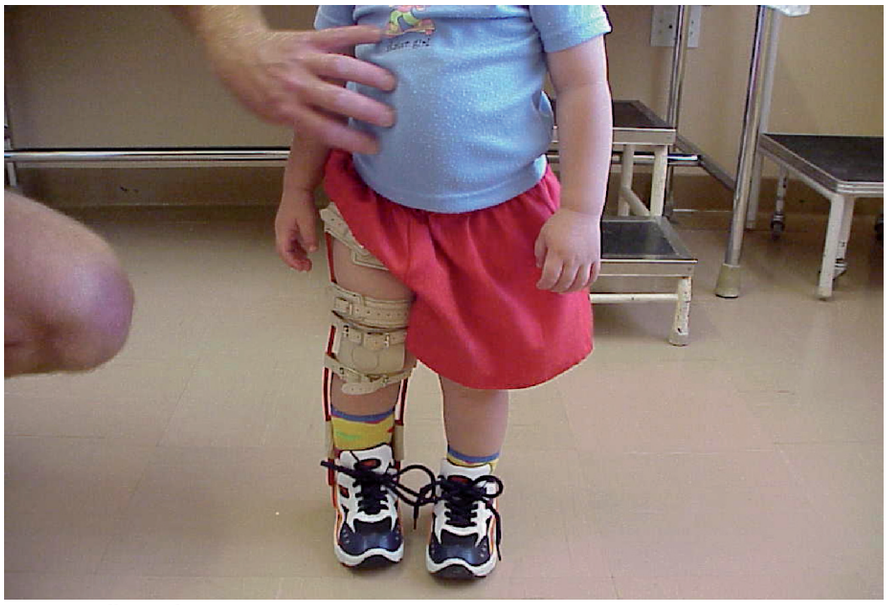


Fig. 12. Walking splint.

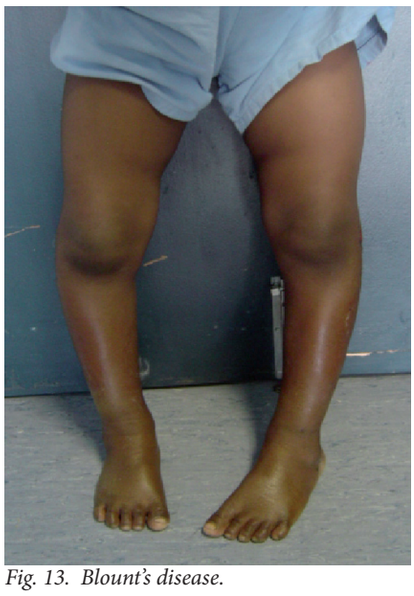


Fig. 13. Blount's disease.

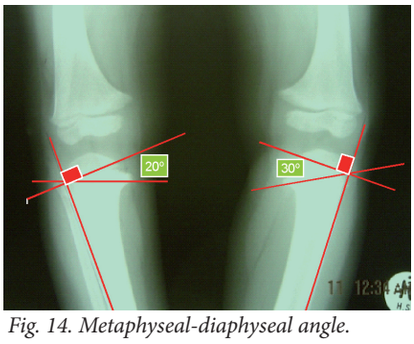


Fig. 14. Metaphyseal-diaphyseal angle.

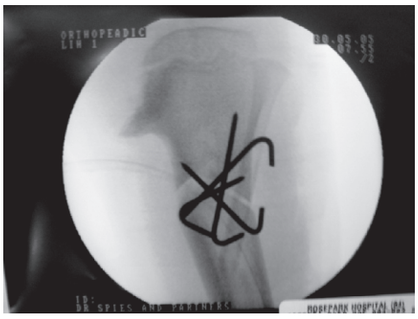


Fig. 15. Post-surgical X-rays.

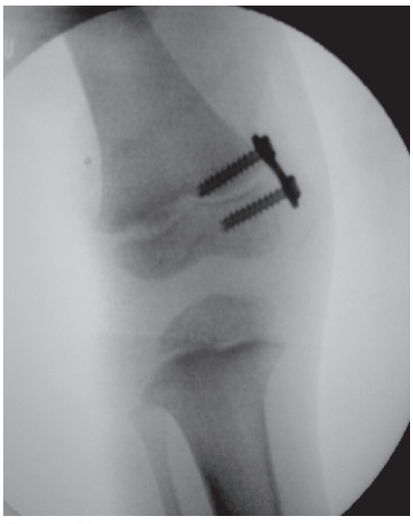


Fig. 16. Valgus corrected with 8-plate.

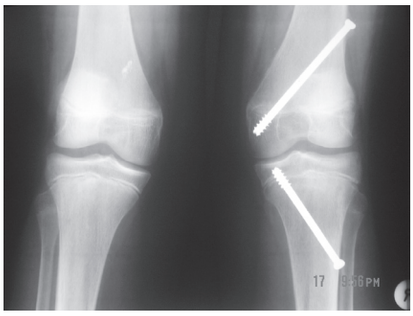


Fig. 17. Hemi-epiphysiodesis.

Conclusion

The assessment for a possible underlying pathological condition in the management of alignment abnormalities of the legs is important. It is not easy to convince parents that their child does not need treatment for a condition that will correct spontaneously.

Reference

1. Salenius P, Vankka E. The development of the tibiofemoral angle in children. *J Bone Joint Surg* 1975; 57A: 259-261.

In a nutshell

- The alignment of a child's leg changes during normal growth from genu varus up to 18 months to genu valgus up to 7 years of age.
- The foot appears to in-toe when the child starts to walk, but this corrects itself.
- Most apparent deformities correct spontaneously.
- Orthoses are unnecessary.
- Only a small number of children have pathological deformities requiring treatment.
- Children with a possible underlying cause or severe deformity should be referred for an orthopaedic opinion.

Single Suture

Doctors in danger

Apparently the urge to kill one's doctor is not uncommon, particularly in patients who are in pain, undergoing physical rehabilitation or seeking legal compensation for disability. This is according to David Fishbain and colleagues at the University of Miami, Florida, who surveyed some 2 000 Americans on their interaction with doctors.

Reassuringly, they say that few doctors are actually killed by their patients, but, less comforting, thousands are attacked and injured. Understanding who is likely to have the urge to kill and why, could reduce attacks, according to Fishbain. He says that his work shows just how stressful being assessed for compensation can be and suggests reforms in how such decisions are made.

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