Fractures of the femur are the most incapacitating fractures in children. Conservative treatment necessitates a long stay in hospital for traction and subsequent immobilisation in an uncomfortable cast. This treatment is not well tolerated, especially in adolescents. Moreover, near the end of growth, accurate reduction is necessary, as malunion is no longer correctable by growth. Stable elastic intramedullary nailing uses two flexible nails which are introduced percutaneously either through the lower metaphysis or the subtrochanteric area. This technique does not disturb the healing of the fracture. The elasticity of the device allows slight movement at the fracture site which favours union. Reduction and stabilisation are adequate and the operative risk is very low. A cast is not required, functional recovery is rapid and the patient is allowed to walk with crutches after seven to ten days according to the type of fracture. This technique is very efficient in adolescents and can be used after the age of seven years when conservative treatment is unsuccessful.

Surgery may be required for fractures of the femur in children, but the techniques used for adults are not well adapted to the growing bone and can lead to complications. Stable elastic intramedullary nailing (SEIN) provides fixation and allows rapid functional recovery. It avoids long and uncomfortable immobilisation in a cast without increasing the risk of complications. Introduction of the nails is usually easy to perform in the femur because the medullary canal is wide.

### Subtrochanteric and diaphyseal fractures (Fig. 1)

The patient is placed on a traction table. A degree of reduction must be attained which provides some overlap between the medullary canals on either side of the fracture. Longitudinal skin incisions 2 to 3 cm long are made on the lateral and medial aspects of the distal femoral metaphysis at the level of the upper border of the patella. The entry hole into the bone is made using an awl about 2 cm above the distal growth plate of the femur. It is preferable to introduce the first nail on the side where the fragments overlap (Fig. 1). It is hammered up the medullary canal to within a few millimetres of the fracture site. The second nail is inserted in a similar fashion. Both nails are directed so that they diverge superiorly. The quality of reduction is controlled radiographically. If angulation persists, it is corrected by external manipulation. The traction is removed and the two nails are impacted into the cancellous bone of the proximal metaphysis. A final radiographic check is made of the fixation and of the axis of the bone with the help of a metal rod placed on the anterior surface of the thigh. Any deformity must be corrected by altering the position of the nails.
nails. Valgus or varus angulation can be corrected by rotation of the nail whose convexity faces in the same direction as the deformation through 180˚ (Fig. 2). The two curves, which were originally diametrically opposite, are now facing and exert their force in the same direction, opposing the deforming forces and correcting axial deformation. With sagittal angulation, the two nails are directed so that their convexity opposes the deformation.

The bases of the nails are bent to 90˚ at the level of the lower metaphysis, and cut to leave 1 to 1.5 cm beneath the skin.

The skin is closed. Before waking the patient up, the knee is flexed to 90˚ to sink the nails into the fibres of the vastus medialis and lateralis and to avoid stiffness of the knee.

It is then essential to ensure that there is no malrotation by assessing the internal and external rotation of the hip. If there is a significant difference between the two hips, the child must be repositioned and the nailing redone. The nails are withdrawn so that they lie free within the medullary canal. After manually correcting the malrotation, they are again impacted into the proximal cancellous bone.

Finally, a compression bandage is applied around the thigh and knee.

**Distal metaphyseal fracture (Fig. 3)**
If nailing is carried out from distal to proximal as with diaphyseal fractures, the nail will make too little contact with the bone of the distal fragment, leaving an unstable construct. The nails must therefore be inserted from proximal to distal and diverge in the distal fragment.

A fracture table is not necessary, as these unstable fractures are usually easy to reduce and maintain as required.

An incision, 5 to 6 cm long, is made on the lateral side of the subtrochanteric area. The lateral surface of the bone immediately below the great trochanter is exposed. Using a drill, two holes are made in the cortex. They are directed obliquely in relation to the axis of the femoral shaft so as to facilitate insertion of the nails.

The nail is usually curved less and its point is bent less sharply than with diaphyseal fractures. The two nails are inserted and gradually advanced down the medullary canal. Before reaching the metaphyseal cancellous bone their tips diverge in the coronal plane and point slightly posteriorly in the sagittal plane, stopping is a few millimetres short of the fracture.

The fracture is then reduced and held by the surgeon while the assistant hammers the nails into the distal fragments. They can subsequently be driven across the epiphysis, ensuring that each enters one condyle and remains a few millimetres short of the articular surface. Crossing the epiphyseal plate with two nails will not harm future growth. However, it is necessary to avoid multiple per-
forations while trying to achieve correct placement of the nail.

The bases of the nails are bent at a right angle and cut 1 to 2 cm away from the bone. The wound is closed.

**Post-operative care**

The child is nursed supine without splinting. The lower limb rests slightly elevated on a pillow. Static quadriceps exercises are begun on the first day after the operation. Between the third and the fifth day, active knee extension should be possible, the child being able to lift the heel off the bed. Mobilisation is then begun non-weight-bearing with elbow crutches.

Between the second and fifth post-operative days the nails may back out due to slight telescoping at the fracture site. Subsequent skin problems may arise. This risk can be minimised by correct positioning of the bases of the nails, but it is impossible to eliminate completely. The patient and his relatives must therefore be warned of such an eventual-ity, which may require a short anaesthetic to cut the nails by a further centimetre.

Moderate stiffness of the knee is nearly always present due to irritation of the vastus medialis or lateralis. It is sometimes slightly painful and is accompanied by a globular appearance of the knee. Nonetheless, the knee will move from about 5° to 90°. Three to four months after removal of the nails, normal movement will be regained. These problems do not arise with descending nailing. The absence of metal in contact with the soft tissues at the knee ensures painless movement.

Partial weight-bearing of about 10 to 20 kg is allowed around the 15th post-operative day for a transverse fracture and the 20th day for oblique, spiral or comminuted fractures. Full weight-bearing is possible at three weeks for transverse fractures, at six weeks for unstable injuries.

The nails are removed between the third and the sixth month. If they are causing significant symptoms, they may be removed as soon as the callus appears to be strong enough as judged by radiographs.

**Indications for SEIN in fractures of the femur**

Most paediatric orthopaedic surgeons condemn plating of fractures of the femur in children. The remaining options are closed treatment and SEIN.

**Before seven years of age.** In a young child, closed treatment of fractures causes no inconvenience. The required period of immobilisation poses few problems during the pre-school years. Healing is usually rapid and the potential for remodelling considerable. The incidence of malrotation is low at 3% to 5%. These younger children frequently refuse to flex the knee or bear weight for six to eight weeks after operation and therefore will not benefit from the two main advantages of SEIN, namely a shorter period of immobilisation and better reduction, which is not necessary in the very young.

**After 12 years of age.** In the adolescent it may be difficult to obtain and maintain a satisfactory reduction, whilst moderate residual deformities become less correctable by remodelling. Slower healing demands a longer period of immobilisation, which is uncomfortable and much less well accepted in this age group. A long period of schooling may be missed. Nailing provides a satisfactory means of maintaining reduction with a short period of immobilisation. The risk of subsequent overgrowth of the limb is similar to that after closed treatment.

**From 7 to 12 years.** In this age group, other factors will determine the methods of treatment used:

*Type of fracture.* Transverse and short oblique fractures are the best indications for SEIN. They are the easiest to nail and the results are generally good. However, if one is prepared to accept some operative difficulties, all types of fractures can be efficiently stabilised with SEIN with appropriate experience. It is advisable to first gain sufficient expertise with transverse fractures before embarking on nailing spiral frac-

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**Fig. 3**

A. The two nails are introduced through the lateral aspect of the diaphysis, just distal to the great trochanter. They are pushed down to near the fracture site. B. The fracture is reduced. C. The nails are pushed into the distal fragment.
tures. Subsequently fractures with a butterfly fragment may be attempted and finally complex comminuted fractures.

The site. No problems usually arise with diaphyseal or metaphyseal fractures such as supracondylar fractures and displacement of the lower femoral physis. However, SEIN is contraindicated in fractures of the femoral neck and trochanteric region, because these require exact anatomical and strong fixation. Subtrochanteric fractures are difficult to stabilise, frequently requiring three nails to obtain satisfactory fixation.

Other factors. It is difficult in a cast to maintain the reduction of a fracture in patients who are heavy or very muscular.

For children with neuromuscular conditions or bone fragility, the period of immobilisation must be kept to a minimum. Although the quality of bone healing may be uncertain in these patients, SEIN remains superior to plating because it avoids the zone of pressure at the interface between the rigid plate and the fragile cortical bone. The nails function as a scaffold and protect the bone from chronic deformity. The sliding constructs have definite advantages here.

With polytrauma, multiple fractures, head injuries and other conditions which necessitate intensive nursing care, SEIN should be preferred to immobilisation in a cast.

Absence from school is related to the length of immobilisation. An average child with a femoral fracture managed by closed treatment will almost certainly have to repeat a school year. The detrimental psychological impact of this justifies the use of SEIN.

SEIN offers the advantages of a biological method of treatment and decreases the cost by shortening the length of hospital stay and post-operative care.

References