INJURIES TO THE DISTAL TIBIAL EPIPHYSIS*

G. SCHWEITZER,† F.R.A.C.S., *Department of Orthopaedics, Baragwanath Hospital and the University of the Witwatersrand, Johannesburg*

Fractures and dislocations in the region of the ankle joint are commonly seen in adults. Injuries to this region in children, in particular injuries to the distal tibial epiphysis, are relatively uncommon. Some idea of the frequency of the latter may be obtained from a paper by Carothers and Crenshaw.[1] These authors report that at the Campbell Clinic there were 54 cases over a 30-year period. In one of the fracture clinics at Baragwanath Hospital, where 60 - 70 patients are seen each week, only 2 cases have been seen over a 12-month period.

Injuries to the distal tibial epiphysis are less common than injuries to the distal radial epiphysis, to the capitellar epiphysis of the humerus and to the proximal radial epiphysis. Injuries to the distal tibial epiphysis are more common than injuries to the distal femoral, proximal humeral and proximal tibial epiphysis and the epiphysis of the femoral head and phalangeal epiphyses of hand and foot.

ANATOMY AND PATHOLOGY

The tibia is preformed in cartilage. According to *Gray's Anatomy*[2] the ossification centre for the distal end of the bone appears in the first year of postnatal life. This epiphysis fuses with the shaft at about the age of 15 years in the female and at the age of 17 in the male. Salter and Harris[3] claim that this centre contributes 45% of the total longitudinal growth of the bone. The epiphysis for the distal end of the fibu'a contributes 40% of the longitudinal growth of that bone.

*Date received: 19 March 1969.
†Present address: Department of Surgery, Medical School, Durban.

The epiphysis of a growing bone consists of 4 parts (Fig. 1). These are:

1. The articular cartilage at the end of the bone.
2. The bony epiphyseal centre.
3. The cartilaginous epiphyseal plate.
4. A layer of ossifying cartilage.

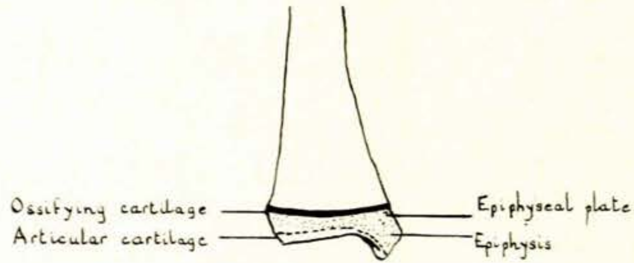

Fig. 1. The distal tibial epiphysis and the adjacent epiphyseal plate and articular cartilage.

The epiphyseal plate consists of 4 layers: Cartilage cells in the resting phase; cartilage cells undergoing rapid proliferation; hypertrophying cartilage cells; and an area where cartilage cells are being replaced by endochondral ossification. This layer abuts on the metaphysis.

The cartilage cells are embedded in an acellular matrix which gives strength and resilience to the epiphyseal plate. The presence of this matrix enables the epiphyseal plate to resist shearing stresses. Calcification of the matrix occurs in the plane between the hypertrophying cartilage cells and the area where endochondral ossification is occurring. In an epiphyseal separation the line of fracture lies between calcified and non-calcified portions of the matrix. As a result, following epiphyseal separation, the growing cartilage cells remain attached to the epiphysis. If the blood supply to the epiphysis is not damaged by the injuring force or by attempts at reduction, normal growth of the epiphysis should continue. The growth of the epiphysis takes place from the articular cartilage and from the epiphyseal plate. Damage to this cartilage may occur in fractures which cross the epiphyseal plate and the articular cartilage vertically or obliquely. It may also occur in injuries where the cartilage is crushed.

Pathology

Injury may occur at any time before the epiphysis fuses. It is more common in boys than in girls. This is probably due to the greater participation by boys in body-contact sports. The fracture is usually simple but may be compound. In the latter, growth disturbance is more likely because of the greater force involved in its production and because of the danger of infection. The epiphysis may also be damaged during surgical procedures such as drainage of osteomyelitis, excision of bone cysts or tumours, and insertion of screws and plates.

Following injury to an epiphysis in experimental animals, healing occurs by an increase in the number of cartilage cells in the proliferating layer of the epiphyseal plate. This occurs because there is a temporary delay in endochondral ossification following injury. If a fracture crosses the epiphyseal plate and the articular cartilage, the gap created tends to fill with bone and premature fusion of the epiphysis occurs.

TYPES OF INJURY TO THE DISTAL TIBIAL EPIPHYSIS

There are 3 main types: Type I—separation of the epiphysis through the junction between the calcified and non-calcified portions of the epiphyseal plate; type II—vertical and oblique fractures involving the articular cartilage, the epiphysis, epiphyseal plate and metaphysis; and type III—crush fractures, which involve the articular cartilage, the epiphysis and the epiphyseal plate.

Type I

In this type of injury the periosteum is torn on the convex side. A triangular fragment of the metaphysis is often avulsed and lies on the concave side (Fig. 2). This triangular fragment may become jammed between the tibia and fibula and may make closed reduction of the fracture impossible. The presence of this triangular metaphyseal fragment on an X-ray film is known as the Thurston Holland sign.

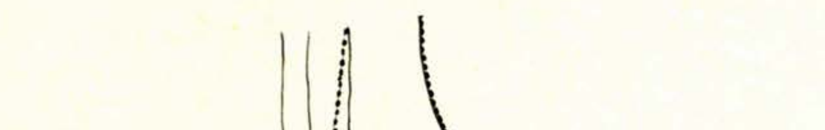

Fig. 2. Abduction type injury. The periosteum on the convex surface is torn, while on the concave surface it is intact.

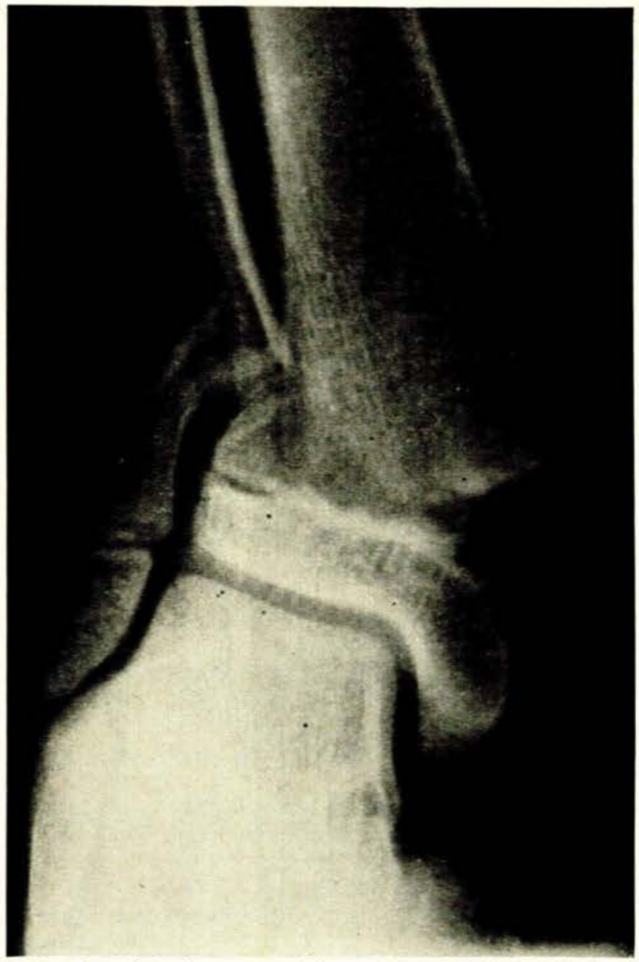

Fig. 3. Abduction type injury. The associated fibular fracture is usually greenstick in nature.

Usually, when reduced, this fracture is stable because of the intact periosteum on the concave side. Unless gross damage to the nutrient vessels occurs at the time of injury, or as a result of attempts at reduction, there is no growth disturbance. Very rarely this type of fracture reduces spontaneously. In these cases the only clue to injury may be the history and the presence of swelling and tenderness at the fracture site. In this type of injury the displacement may be lateral, medial or posterior, depending on the direction of the force. Figs. 2 and 3 show the displacement which occurs in an abduction type injury. In the latter type of fracture there is often an associated fracture of the fibula. This is also the type of fracture where jamming of the triangular metaphyseal fragment between the tibia and the fibula may occur.

Adduction injuries produce the reverse type of deformity, as seen in Fig. 4.

The commonest form of displacement is posterior. It is produced by an external rotation eversion type of injury and is illustrated in Fig. 5. Injuries in the type I group are usually sustained in car accidents and in body-contact sports.

Type II

In vertical or oblique fractures which cross the articular cartilage, the epiphysis and the epiphyseal plate, the degree of lateral displacement is variable. The displacement may be slight, as in Fig. 6, or it may be marked and involve the metaphysis as in Fig. 7. This type of injury is associated with a premature fusion of the epiphysis and with a disturbance of the vertical growth of the tibia. In fractures involving the lateral part of the epiphysis a valgus deformity of the ankle results from the growth disturbance. Fractures involving the medial part of the epiphysis produce a varus deformity.

Kleiger and Mankin[4] described 8 cases of vertical and oblique fractures of the lateral portion of the distal tibial epiphysis. They attributed this type of fracture to a lateral rotation force applied at the ankle. In a similar way a medial rotation force applied to the ankle will result in injury to the medial part of the epiphysis.

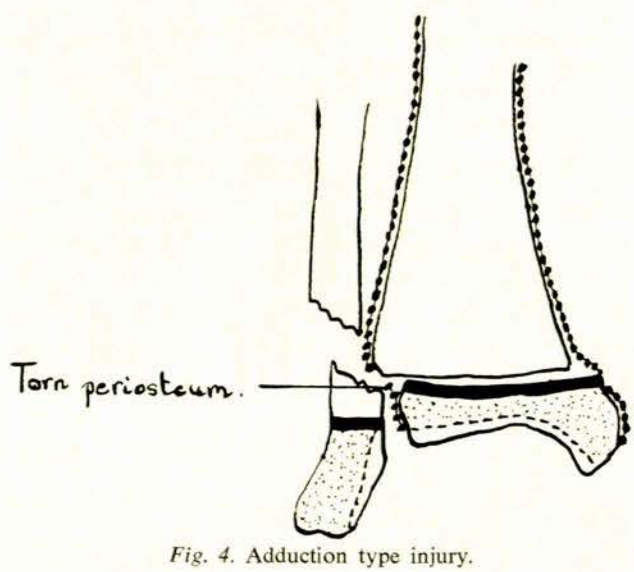

Fig. 4. Adduction type injury.

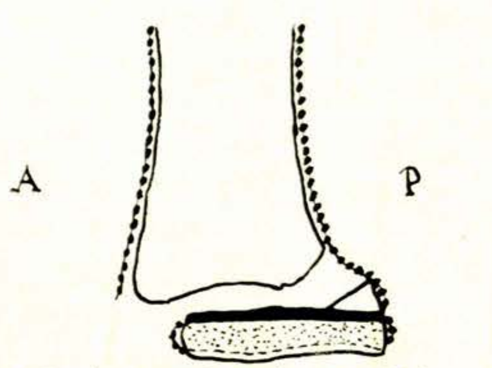

Fig. 5. Eversion external rotation type of injury.

Fig. 6. Vertical fracture with minimal displacement.

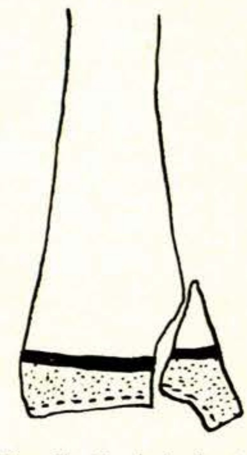

Fig. 7. Vertical fracture with severe displacement.

Type III

Crush injuries of the distal tibial epiphysis are very uncommon. McFarland[5] first described this injury affecting the medial portion of the epiphysis in 1931. He attributed this injury to a forcible internal rotation and adduction at the ankle. In McFarland's cases the injury occurred when the patient's foot became caught between two iron railings. Consequently this injury has become known as the 'railing fracture'. As a result of injury premature fusion of the medial portion of the epiphysis occurred. This was followed by shortening of the affected limb and a varus deformity at the ankle.

A case recently admitted to Baragwanath Hospital appears to be unique in that the lateral part of the epiphysis was crushed and not the medial part as in McFarland's series. A search of the literature has failed to reveal a similar case reported.

CASE REPORT

A 4-year-old male child was admitted to the Orthopaedic Service because its mother had noticed that it had a deformity of the right foot. Eighteen months previously, while holidaying with his grandmother in a country area, the child had caught its right foot in the spokes of a tricycle wheel. He received treatment in a hospital in the country town but no details were obtainable from the hospital.

On examination the abnormal findings were confined to the right ankle region. There was no shortening of the leg as a whole. Clinically the patient had approximately a 30° valgus deformity of the ankle. X-ray showed a crush fracture of the lateral side of the distal tibial epiphysis. On X-ray there was 12° of valgus deformity at the ankle. The epiphysis had not fused (Fig. 8).

Although no details of the mechanism of injury were available, it is likely that it resulted from an external rotation abduction force. Because the valgus deformity, on X-ray, was only 12 degrees it was proposed to treat the child in an above-knee plaster cast for 12 months. During this time he was to be discouraged from bearing weight on the affected side. If at the end of 12 months the deformity has remained stationary or has progressed, a wedge osteotomy on the lateral side of the tibia and fibula will be performed.

Discussion of Type II and III Fractures

Following a crush, vertical or oblique fracture the

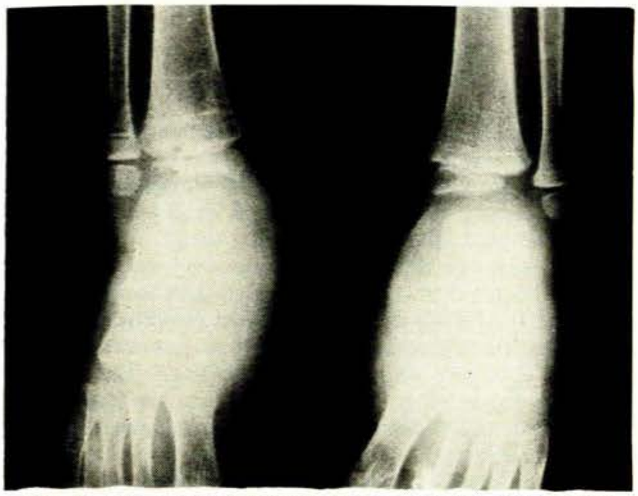

Fig. 8. The crushed lateral portion of the distal tibial epiphysis is on the right. The normal side, for comparison, is on the left.

damaged portion of the epiphysis may fuse prematurely or grow at a slower rate than the undamaged portion. Sometimes the undamaged portion of the epiphysis may also fuse. The reason for this is not clear, but the sequelae of this injury may be a progressive varus or valgus deformity at the ankle, depending on which side the epiphysis is damaged, or a progressive shortening of the limb if the whole epiphysis fuses prematurely.

The varus or valgus deformity at the ankle is due to the growth of one portion of the epiphysis while the other has ceased growing. The shortening of the whole limb is due to a premature fusion of the whole epiphysis. To prevent this premature fusion, repeated wedge osteotomies of the shaft of the tibia, on the damaged side, are performed. The osteotomy must be designed to overcorrect the deformity so that the inevitable recurrence is delayed as long as possible. Growth of the lower end of the fibula will also contribute to the varus deformity if the medial portion of the distal tibial epiphysis is damaged. It is not certain what the role of the fibula in the reported case will be, as there has not been a similar case reported in the literature. For this reason it is proposed to observe the child for 12 months. At 3-monthly intervals a clinical and a radiological assessment will be made. The findings will be reported in a follow-up article.

Clinical Features of Injuries to the Distal Tibial Epiphysis

This type of injury must be suspected when a child presents with a history of injury to the ankle region. Pain, swelling, limitation of movement and deformity may be present. A compound fracture is obvious. The diagnosis must differentiate between acute osteomyelitis and septic arthritis.

Anteroposterior, lateral and oblique X-ray views of the ankle and lower tibia should be taken and as the appearance of epiphyses is variable in different individuals the opposite limb must be X-rayed for comparison.

TREATMENT

Type I

Reduction should be achieved under general anaesthesia on the day of injury. This procedure should be performed gently to avoid further damage to the epiphysis and to its blood supply. Delay in reduction makes the procedure more difficult, as healing occurs rapidly. The longer the delay, the greater the force required to achieve reduction. If force is used, further damage to the epiphysis and its blood supply may occur. If a fracture of this type which is several days old cannot be reduced by gentle manipulation, it should be allowed to malunite. The effects of this malunion are corrected 3 months later by an osteotomy of the shaft.

Following reduction of a type I fracture, the limb is immobilized in an above-knee plaster cast for 8 weeks. During this time weight-bearing on the affected limb is forbidden. The parents must be warned about the possibility of a subsequent growth disturbance, although this is uncommon in this type of fracture. The involved tibia, ankle joint and the corresponding structures of the normal limb are X-rayed 6-monthly for 3 years or until the epiphysis fuses, whichever comes first.

Type II

If displacement is present, as shown in Fig. 6, there must be an intra-articular fracture in addition to an epiphyseal injury. An open reduction will be essential and the fragments must be accurately aligned. This is necessary to restore an accurate alignment of the articular cartilage and of the epiphyseal plate. This procedure may prevent the premature fusion of the damaged portion of the epiphysis. Reduction is maintained by 2 crossed Kirschner wires. The wires may be allowed to cross the epiphyseal plate but must be removed within 8 weeks. Postoperatively, the limb is immobilized as in type I fracture and the follow-up is the same.

If there is no displacement, as in Fig. 7, the limb is put into an above-knee plaster cast for 8 weeks. Weight-bearing on the affected side is forbidden during that time.

With this type of fracture the parents are given a guarded prognosis and told that subsequent growth disturbance is highly likely.

Type III

The fracture is treated initially by plaster-cast immobilization and non-weight-bearing for 12 months. This is done in the hope that some recovery may occur. The subsequent treatment and prognosis have been discussed in the case report.

SUMMARY

The various forms of injury to the distal tibial epiphysis and their mechanism, prognosis and treatment are discussed. A unique case of crush fracture of the distal tibial epiphysis is reported.

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