TRIPLANE FRACTURE OF THE DISTAL TIBIA
A VARIANT IN CASES WITH AN OPEN GROWTH PLATE

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We have reviewed 15 cases of triplane fracture of the distal tibia. The mechanism of injury is lateral rotation and the anatomical pattern of the fracture depends on the state of the growth plate at the time of injury. In seven of our cases the anteromedial part of the growth plate was fused, but in eight children the plate was completely open. In six of these eight children there was a hump or projection of the medial growth plate.

It is suggested that this hump stabilises the anteromedial part of the epiphysis in a manner similar to the partial anteromedial fusion seen in older children, and that this accounts for the occurrence of triplane fracture in the presence of an open growth plate.

Most epiphyseal injuries can be classified according to Salter and Harris (1963), but some are too complex to fit into this scheme. One such injury is the triplane fracture of the distal tibia, first described by Marmor in 1970. The fracture is in three planes:
1. Coronal, through the posterior tibial metaphysis and seen either as a Salter–Harris Type II or Type IV injury on the lateral radiograph.
2. Transverse, through the growth plate.
3. Sagittal, through the distal tibial epiphysis and seen as a Salter–Harris Type III injury on the anteroposterior radiograph.

Other workers have investigated these fractures using conventional tomography and computed tomography. The injury may result in two main fragments (Cooperman, Spiegel and Laros 1978; Pieró et al. 1981; von Laer 1985), three main fragments (Marmor 1970; Lynn 1972; Kårholm, Hansson and Laurin 1981; Dias and Giegerich 1983; von Laer 1985) or four main fragments (Kårholm et al. 1981). This variety of pattern has previously been attributed to differing mechanisms of injury, but von Laer (1985) considered that they were always caused by lateral rotation and eversion, and that the pattern of fracture depended on the state of fusion of the distal tibial growth plate.

We report a series of 15 children with triplane fractures, treated at the Nottingham University Hospital and the Derbyshire Children’s Hospital, Derby. Our aim was to assess the pattern of fractures in relation to the maturity of the growth plate.

PATIENTS

The patients were located from case records. In all cases the initial diagnosis had been made by finding the typical appearance of a Salter–Harris Type III injury on the anteroposterior radiograph and either a Type II or a Type IV injury on the lateral radiograph (Figs 1 and 2). Two patients had also had conventional tomography and CT scanning.

One patient had been injured before 1983, but the other 14 children sustained their fractures during 1983, 1984 and 1985. All but one of the patients attended for Fig. 1
A typical triplane fracture. The appearance is that of a Salter–Harris Type II injury on the lateral film and a Type III injury on the anteroposterior radiograph.

Fig. 2

Requests for reprints should be sent to Mr P. H. Worlock.
Table 1. Growth-plate fusion related to age and the presence of hump in the medial growth plate

<table>
<thead>
<tr>
<th>Growth plate</th>
<th>Fused medially</th>
<th>Completely open</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of children</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Mean age</td>
<td>14 years 6 months</td>
<td>13 years 1 month*</td>
</tr>
<tr>
<td>Hump present in medial growth plate</td>
<td>1</td>
<td>6†</td>
</tr>
</tbody>
</table>

* p < 0.05, Student's t-test
† p < 0.02, Fisher's exact probability test

review; the other had moved away, but was able to return a questionnaire on current symptoms.

There were seven boys and eight girls, with 10 fractures of the right ankle and five of the left. All 15 children gave a history of a twisting injury. The mean age at the time of injury was 13 years 8 months (range, 11 years 11 months to 16 years 4 months). The average period of follow-up was 19 months (range, 8 months to over three years).

Radiography. Condition of the growth plate. The state of fusion of the growth plate was assessed on the initial radiographs. In eight cases the growth plate had been completely open (Table 1), and these eight children were significantly younger (p < 0.05) than the seven children with fusion of the medial part of the plate.

In six of the eight children (75%) with completely open growth plates, a hump was seen in the medial part of the growth plate on the anteroposterior radiograph (Fig. 3). The sagittal or epiphyseal part of the fracture was medially placed and appeared to be related to the hump. There was evidence of such a hump seen in only one of the seven children (14%) with medial fusion of the growth plate. This difference in prevalence of the medial hump was also statistically significant (p < 0.02, Fisher's exact probability test).

Anatomy of the fracture. The radiographs of 12 children showed a typical two-part fracture, with a Type II lesion visible on the lateral film and a Type III lesion on the anteroposterior film (Cooperman et al. 1978).

Three children showed a Salter–Harris Type IV lesion on the lateral radiograph. This has been previously reported to be suggestive of a three-part fracture (Spiegel et al. 1984). In one of these children the growth plate was fused medially and in the other two it was completely open with a medial hump. The fracture was undisplaced in one of these three children and further radiography was not justified; the other two patients had conventional tomography and CT scanning (Figs 4 to 7).

Both of these children showed similar three-part fractures (Fig. 8); the three fragments were:
1. The anterior tibial metaphysis with the attached anteromedial part of the epiphysis.
2. A separate anterolateral epiphyseal fragment.
3. The posterior tibial metaphysis with the attached part of the posterior epiphysis.

A triplane fracture with an open growth plate. There is a medial epiphyseal hump and the sagittal fracture is placed medially, close to the hump.

Conventional tomography of a three-part triplane fracture. A Salter–Harris Type IV injury is seen in the lateral view, and a Type III injury on the anteroposterior view. The anteromedial part of the epiphysis is fused to the tibial shaft.

CT scans of a three-part triplane fracture. Figure 6 - The cut through the distal tibial epiphysis shows the anterolateral fragment with the sagittal part of the fracture anteriorly and the posterior epiphyseal fragment separated from the medial malleolus. Figure 7 - At the level of the tibial metaphysis the coronal fracture is seen. The anteromedial epiphyseal fragment remains attached to the tibial shaft.
Treatment. The nine undisplaced fractures were treated in a below-knee plaster for four to six weeks until united. Displaced fractures were treated by closed manipulation. This was successful in four patients who were then treated in plaster. Open reduction and internal fixation was necessary in two cases.

RESULTS
At review 10 patients had no symptoms and four complained of occasional discomfort or swelling of the ankle after exercise. The remaining patient, who did not attend for review, reported no significant symptoms. In all cases there were no clinical deformities and leg length was equal. The range of ankle movement was full in 11 children, with restriction of dorsiflexion of less than 5° in the other three. All fractures had united with normal fusion of the growth plate and with no evidence of joint incongruity. There were no complications.

DISCUSSION
There is a characteristic pattern of fusion of the growth plate of the distal tibia. This begins in the middle and spreads first anteromedially, then posterolaterally (Kleiger and Mankin 1964; Mac Nealy et al. 1982). This process takes about 18 months and it is during this period that triplane fractures have been said to occur (Spiegel et al. 1984). The pattern of fusion explains the pattern of the triplane fracture; this occurs around the fused anteromedial part of the epiphysis, which itself remains attached to the shaft (Cooperman et al. 1978).

However, von Laer (1985) reported that triplane fractures could occur when the growth plate is still fully open. Kleiger and Mankin (1964) described an elevation or hump in the growth plate, about 1 cm from its medial edge, in 40% of adolescents between the ages of 12 and 20 years. In our series, eight children had a triplane fracture in the presence of a completely open growth plate; six of these children had such a medial hump. Kleiger and Mankin (1964) suggested that the medial hump might prevent displacement of the medial part of the epiphysis by a rotary force. Our findings support this hypothesis; we suggest that the medial hump may stabilise the anteromedial part of the epiphysis in the same way as fusion of the medial part of the plate in older children.

Dias and Giegerich (1983) suggested that two grades of injury can result from a lateral rotation force applied to the distal tibia during the period of growth plate fusion. In a Grade I injury the anterior tibiofibular ligament avulses the anterolateral corner of the distal tibial epiphysis (the juvenile Tillaux fracture, Fig. 9). The Tillaux fracture fragment is virtually identical to the anterolateral epiphyseal fragment in a triplane fracture. If there is further lateral rotation, the remainder of the distal tibial epiphysis separates through the growth plate, taking with it an attached posteromedial metaphyseal fragment (Fig. 10) and producing a (Grade II) three-part triplane fracture.

The three-part fractures seen in our series had a different configuration from that described by Dias and Giegerich. The anteromedial epiphyseal fragment remained attached to the metaphysis and the detached two fragments were an anterolateral (Tillaux) fragment and a posterior epiphyseal-metaphyseal fragment (Fig. 5).
This represents an extension of the two-part fracture described by Cooperman et al. (1978) in which the anterolateral part of the epiphysis remained attached to the posterior fragment; they also considered that this fracture was caused by lateral rotation.

Our findings support previous observations that the pattern of fracture seems to depend on the anatomy of the growth plate at the time of injury (Kärrholm et al. 1981; Dias and Giegerich 1983; von Laer 1985) and that the mechanism of injury is one of lateral rotation. We consider that stabilisation of the anteromedial epiphysis, either by local fusion of the growth plate or by the presence of a medial hump, is the key factor in the pattern of these injuries.

It is generally agreed that growth-plate disturbance and resultant deformity are unlikely to be a problem when the fracture occurs near to the time of fusion of the growth plate. We observed no disturbance of growth or deformity in the patients who still had an open growth plate and can confirm that, with accurate reduction, a good result can be confidently expected.

Tomography and CT scanning can define the anatomy of the fracture more clearly, but this is important only if a displaced fracture cannot be reduced by closed means. Residual displacement of more than 2 mm is an indication for open reduction (Cooperman et al. 1978; von Laer 1985). An undisplaced fracture can be treated in plaster with certainty of a good result.

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REFERENCES


