DISTAL METAPHYSEAL FRACTURES OF THE TIBIA WITH MINIMAL INVOLVEMENT OF THE ANKLE

CLASSIFICATION AND TREATMENT BY LOCKED INTRAMEDULLARY NAILING

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We reviewed 63 patients with fractures of the distal tibial metaphysis, with or without minimally displaced extension into the ankle joint. The fractures had been caused by two distinct mechanisms, either a direct bending force or a twisting injury. This influenced the pattern of the fracture and its time to union.

All fractures were managed by statically locked intramedullary nailing, with some modifications of the procedure used for diaphyseal fractures. There were few intra-operative complications. At a mean of 46 months, all but five patients had a satisfactory functional outcome. The poor outcomes were associated with either technical error or the presence of other injuries. We conclude that closed intramedullary nailing is a safe and effective method of managing these fractures.

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Most series of fractures of the tibia and tibial pilon contain a proportion of fractures in the distal metaphysis which are wholly extra-articular or with undisplaced extension into the ankle (Maale and Seligson 1980; Moller and Krebs 1982; Mast, Spiegel and Pappas 1988). There is evidence that the mechanism of injury and the prognosis of these fractures are different from those of pilon fractures (Ovadia and Beals 1986; Mast et al 1988), but their proximity to the ankle makes the primary treatment more complicated than that for fractures of the tibial diaphysis. This justifies a separate review of the epidemiology and prognosis of these injuries.

Closed, locked intramedullary nailing is now widely accepted as satisfactory treatment for tibial diaphyseal fractures (Bone and Johnson 1986; Court-Brown, Christie and McQueen 1990), but there are concerns about the use of this technique for fractures in the distal metaphysis. This is because of a theoretical increase in the risk of nail failure and the possibility of propagating an existing distal fracture into the ankle during instrumentation (Bostman and Hammenn 1982; Russell, Taylor and LaVelle 1991; Trafton 1992). Since 1986 in the Edinburgh Orthopaedic Trauma Unit, we have used an intramedullary nail for the primary treatment of these fractures. We have reviewed our results over a seven-year period.

PATIENTS AND METHODS

From August 1986 to May 1993, 63 consecutive distal tibial metaphyseal fractures were managed under the care of the senior authors by primary locked intramedullary nailing. In all of these, the centre of the fracture was in the distal metaphysis of the tibia (Fig. 1) and either entirely extra-articular (AO type 43A) or with minimally displaced extension into the ankle joint (AO types 43 C1 and 43 C2).

There were 39 men and 24 women with a mean age of 46 years (15 to 92). Six patients (9.5%) had multiple injuries. All fractures were classified by the AO system (Müller et al 1990), and the severity of the soft-tissue injury in the ten open fractures was recorded on the Gustilo system (Gustilo and Anderson 1976). The severity of the 53 closed fractures was recorded on the Tscherne system (Oestern and Tschernie 1984). Because we found two discrete groups of injuries with different mechanisms and fracture configurations, we considered them separately.

Type I. In 22 patients the fractures were either simple transverse or oblique (AO type 43 A1.3; Figs 2 and 3); in four of these there was either comminution or a metaphyseal wedge (AO type 43 A2 or A3). No type-I fracture extended into the ankle joint. The fibula was also fractured,
either transversely (18) or with comminution (4), above the tibiofibular syndesmosis at the same level as the tibial fracture.

**Type II.** In 41 patients the fracture was spiral, with little variation in the configuration of the major fragments. The inferior apex of the spiral was medial, extending superiorly to a posterolateral apex (Fig. 2). The distal fragment was always displaced laterally to a variable degree. The fibula was intact in five, but in the other 36 fractures there was either a short oblique or spiral fibular fracture at a different level from the tibial fracture. In 20 this was proximal at the level of the fibular neck, in six in the middle third and in eight in the distal fibula. Two patients had double fractures of the fibula.

In 20 type-II fractures there was an associated fracture into the ankle joint (Fig. 2). In this subgroup, we found no obvious difference in the pattern of the tibial fracture or the position of the fibular fracture. The articular fracture was either in the medial malleolus or the posterior malleolus (Fig. 2).

Type-II fractures were therefore subdivided into type-IIA (wholly extra-articular), type-IIB (associated medial malleolar fracture) or type-IIC (associated posterior malleolar fracture).

Eighteen of the 21 type-IIA fractures were AO type 43 A1.1 (Fig. 4); three showed either a wedge or comminution of the spiral fracture (AO 43 A2.3 or 43 A3.3). The seven type-IIB and the 13 type-IIC fractures were difficult to classify on the AO system, but most resembled AO 43 C1 fractures because both the articular and the metaphyseal fractures were simple and undisplaced. In type-IIB fractures the extension into the medial malleolus was always a continuation from the apex of the spiral fracture (Fig. 5). In type-IIC fractures the posterior malleolar fragment never appeared to communicate with the spiral fracture (Fig. 6).

**Operative technique.** Modifications were required to the basic nailing technique for shaft fractures (Court-Brown et al 1990). The position of the patient and the surgical approach to the medullary canal were the same. Accurate closed reduction of the fracture was confirmed with an image intensifier before insertion of a straight bulb-tipped guide wire into the distal tibial metaphysis, just short of the subchondral plate. Reduction was maintained using either a large reduction forceps or by manual pressure from the assistant during the reaming and nail insertion to prevent angulation at the fracture site.

The correct length of nail was selected when the measuring rod reached the distal subchondral plate. For fractures within 3 cm of the joint surface, to be able to lock the distal segment, we sawed off the distal 8 mm of the nail distal to the distal screw hole. This modification was to allow the use of two cross-screws and was required in five fractures. We used two cross-screws distally, because our initial
experience had shown that the fracture tended to tilt into recurvatum around a single screw. In many fractures the more proximal of the two cross-screws passed across the fracture site and exerted a lag-screw effect. Proximal cross-screws were required because of the tendency of these fractures to shorten if not statically locked. After insertion of the nail, any displaced fracture extension into the ankle joint was stabilised by supplementary cancellous screws. Associated fractures of the distal fibula were reduced and fixed only if severely displaced or causing disturbance of the ankle mortise.

Open fractures were treated before nailing by the methods which we have described for open diaphyseal fractures (Court-Brown et al 1991). All open injuries received flap cover within four days. We used routine monitoring of fascial compartment pressures after operation. Patients were allowed full weight-bearing after 48 hours; no casts or splints were used and early ankle mobilisation was encouraged under the supervision of a physiotherapist.

**Postoperative management and review.** Patients were reviewed at intervals of two to three weeks until union was confirmed by loss of pain at the fracture site on walking and definite radiological signs. We recorded malunion when there was over 1 cm of shortening or more than 5° of rotational or angular deformity. Our radiological assessment of the ankle included measurement of the talocrural angle, talar tilt and the medial clear space on mortise views. We recorded infection when there was a purulent discharge with laboratory isolation of pathogenic organisms.

Follow-up was for a mean of 46 months (12 to 82), with a minimum time from union of eight months. All operative and postoperative complications were recorded and a clinical assessment was made of functional disability. We made a specific assessment of ankle symptoms using the Olerud score (Olerud and Molander 1984), expressing the result as a percentage of the preinjury symptom score. Over 90% was recorded as an excellent result, 80% to 90% as satisfactory and less than 80% as unsatisfactory.
Table I. Severity of injury in two major groups of distal metaphyseal fractures of the tibia

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<th>Type I (n = 22)</th>
<th>Type II (n = 41)</th>
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<tr>
<td></td>
<td>Number</td>
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<td>Tscherné grade (closed injuries)</td>
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<td>C0</td>
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<td>C1</td>
<td>5</td>
<td>22.7</td>
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<tr>
<td>C2</td>
<td>6</td>
<td>27.3</td>
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<tr>
<td>C3</td>
<td>3</td>
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<td>Gustilo grade (open injuries)</td>
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<td>I</td>
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<tr>
<td>II</td>
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<tr>
<td>IIIa</td>
<td>4</td>
<td>18.2</td>
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RESULTS

Type-I fractures. The 22 fractures in this group were in patients with a mean age of 54 years (16 to 92), all of whom had had a direct bending force applied to the shin. These fractures were sustained in road-traffic accidents (11), football tackles (5) or domestic falls (6). Soft-tissue injury tended to be severe (Table I), with six open fractures (27.3%) and nine Tscherné type-2 or type-3 closed injuries (40.9%).

All 22 fractures were managed by the described nailing technique (Fig. 3), with static locking. Three early cases

Fig. 5a
Fig. 5b

A type-IIB fracture in a 43-year-old patient after a simple fall. There is an undisplaced spiral extension of the fracture into the ankle (arrows)(a). Radiographs at 14 weeks show union of the fracture with no secondary displacement of the medial malleolar segment (b).

Fig. 6a
Fig. 6b

A type-IIIc fracture in a 22-year-old patient, sustained at football (a). A posterior malleolar fracture (arrows) did not communicate with the metaphyseal fracture, and did not displace during nailing (b).
had only one distal locking screw. Fibular length was restored in all, with no important derangement of the ankle mortise, and no fibular fracture required fixation.

**Type-II fractures.** The 41 fractures were in patients with a mean age of 42 years (18 to 84) and were due to torsional injuries. They were caused by simple falls (25), twisting injuries at sport (10) and road-traffic accidents (6). Soft-tissue injuries tended to be less severe than in type-I fractures (Table I); there were four open fractures (9.7%) and ten Tscherne type-2 or type-3 closed injuries (24.4%).

All type-IIA fractures were initially treated by the standard nailing protocol; this did not cause propagation of a fracture into the ankle in any case. In type-IIB, three displaced medial malleolar fractures required reduction and screw fixation and in type-IIC, four posterior malleolar fractures were fixed. No undisplaced malleolar fractures became displaced during nailing. Fibular length was restored in all but three cases in which the fracture was located in the lateral malleolus. These required separate open reduction and fixation of the fibular fracture.

**Clinical results.** All the fractures united; the mean time to union was 16.2 weeks (10 to 50). In type-I fractures this was 22.1 weeks (16 to 50), longer than that for type-II fractures (Table II) at 13.9 weeks (10 to 31). The time to union was similar in the type-II subgroups (Table II), but was prolonged in the ten open fractures and the 19 closed fractures with Tscherne grade-C2 or grade-C3 soft-tissue injuries to 21 weeks and 18.2 weeks, respectively. Fractures with Tscherne grade-C0 or grade-C1 soft-tissue injuries united at a mean of 14.7 weeks.

The time to union was over 20 weeks in nine type-I fractures, but in only one type-II fracture. Six of these fractures had united by 25 weeks, only four required an exchange-nailing procedure. Three then united at 28, 30 and 32 weeks, but one later required open bone grafting and eventually healed at 50 weeks.

There were no deep infections; one patient had a superficial infection in the knee wound which required surgical debridement, and two had late infections related to the cross-screws which resolved after their removal.

Three patients developed transient common peroneal nerve palsy after nailing of type-II fractures. There were no obvious risk factors and all resolved within six weeks. One patient had dysesthesia in the saphenous nerve distribution after nailing which had improved at six months. Sixteen patients had nail removal after union.

Radiological review revealed that shortening of the limb of more than 1 cm had occurred in only one patient. This procedure was performed early in the series, before the importance of static locking had been appreciated and the proximal locking screw had not yet been inserted. Subsequently, shortening of 2 cm developed as the fracture collapsed with healing. There were no rotational deformities, but two patients had varus deformities of 10° and 15° respectively because of incomplete reduction of the fracture. One patient had a recurvatum deformity of 20° at the fracture site. Only one distal cross-screw had been inserted and the fracture had pivoted around the screw.

Six of the older patients had osteoarthritic changes in the ankle at presentation; no progression of these changes was seen during follow-up. All the intra-articular fracture extensions healed without displacement; radiographs showed no abnormal talocalcaneal angle.

One patient with a type-I fracture and two with type-II fractures had died from unrelated medical causes by the time of review; both had been free from complications of tibial fracture. In the other 60 patients, the mean time to resumption of full activities or return to employment was 12 weeks (4 to 32). Twenty patients (33.3%) had some anterior knee discomfort, but never enough to cause severe functional disability. Five patients (8.3%) had some ankle or hindfoot discomfort and one had pain related to a proximal cross-screw. Five patients (8.3%) lost ankle or subtalar movement: four lost less than 25%, but one patient with a crush injury of the foot in addition to her tibial fracture had marked restriction of ankle and subtalar movement.

The mean Olerud score of ankle symptoms was 89% of the prefracture level (35% to 100%). The mean Olerud score was lower for type-I fractures than type-II fractures, but only five achieved less than 80%. Two of these patients had shortening or angulation at the fracture due to technical error, one patient had ipsilateral hemiplegia from a head injury, one had a crush injury to the foot, and one had open bone grafting.

**DISCUSSION**

Müller et al (1990) defined the distal tibial metaphysis as the area included within a square the sides of which are the same length as the widest part of the distal articular surface (Fig. 1). Fractures in this area have not previously been distinguished clearly (Bauer, Edwards and Widmark 1962; Nicoll 1964; Vecsei, Scharf and Hertz 1980) and there is little information on their behaviour. Over the seven-year period of our review, we treated 619 fractures of the tibial diaphysis, 310 in the distal third, and 126 pilon fractures. Only 63 fractures of the distal metaphysis were treated, 14.5% of all fractures of the distal third of the tibia, excluding the malleolar segments.

Our new classification for these injuries resembles the system proposed for tibial diaphyseal fractures by Johner and Wruhs (1983), which has now become widely accepted
(Müller et al 1990). We found two distinct mechanisms of injury, bending and torsion. In the diaphysis torsional fractures are generally reported to be less common than transverse fractures (Burwell 1971; Johner and Wruhs 1983; Oni, Hui and Gregg 1988), but this is reversed in metaphyseal fractures. There is also a much lower incidence of wedge fragments and comminution in the distal metaphysis.

Type-I fractures which comprised one-third of the metaphyseal injuries, were due to a direct bending force. They were typically transverse, with a fibular fracture at the same level. They never involved the ankle joint, but often had a severe soft-tissue injury. Type-II fractures were produced by torsion; they were spiral, with an oblique or spiral fibular fracture at a different level. About half of the tibial fractures either extended into the medial malleolus (type IIB) or were associated with a separate posterior malleolar fracture (type IIC).

Maale and Seligson (1980) described our type-IIB fractures in a review of pilon fractures, and distinguished them from more severely comminuted intra-articular pilon fractures. None of our type-IIB fractures was produced by the vertical compression that typically produces a pilon fracture. They should also be distinguished from distal bifocal fractures of the tibia (Lonner, Jupiter and Healy 1993; Keating, Kuo and Court-Brown 1994), which are usually more severe with separate fractures of the tibia and the ankle.

In type-IIC fractures the posterior malleolar fragment was separate and never appeared to extend from the tibial fracture. This type accounted for 20.6% of all metaphyseal fractures and 31.7% of the spiral fractures. Bostman and Hanninen (1982) reported that 3% of fractures in the distal third of the tibia are associated with a posterior malleolar fracture and the likelihood of this pattern of injury therefore appears to be greater when the fracture is in the metaphysis.

The severity of the soft-tissue injuries in type-II fractures was less than in type-I fractures, but greater for both types than that reported for fractures in the diaphysis (Court-Brown et al 1990, 1991). This is probably due to the subcutaneous and relatively exposed position of the metaphysis despite the low energy of some injuries.

The conservative management of distal tibial fractures is known to lead to unacceptable deformity, with shortening or rotational malunion in up to 31% and ankle and subtalar stiffness (Digby, Holloway and Webb 1982; Haines et al 1984). Open reduction and plate fixation is associated with a high incidence of soft-tissue problems (Bourne 1989). Despite these problems, intramedullary nailing is rarely advised for fractures below the ischium, because of the risks of fracture into the ankle, and of nail failure (Bostman and Hanninen 1982; Trafton 1992). These complications, however, have not been seen in our experience and with careful modification of the basic nailing technique, it is apparent that closed nailing is a safe and effective treatment.

Our modifications to the standard technique for the diaphysis (Court-Brown et al 1990) were made as experience increased, and gave us an incidence of malunion or unacceptable shortening of 6.4%, which favourably compares with conservative management (Bostman and Hanninen 1982). Only fractures which are entirely extra-articular or with minimally displaced extension into the ankle are suitable; the method is not appropriate for distal, displaced intra-articular pilon fractures which require careful open reconstruction of the articular surface.

The functional outcome in our patients was excellent or satisfactory in 91.6%. The five with poor function either had technical errors at surgery or other severe injuries. Undisplaced extension of the fracture into the ankle did not appear to affect ankle function. The advantage of intramedullary nailing for diaphyseal fractures, in allowing immediate weight-bearing and early movement, is equally important as for fractures in the metaphysis. Anterior knee pain is a drawback, but this did not produce significant functional impairment in our series.

Distal tibial fractures in the metaphysis without significant articular involvement have more in common with diaphyseal fractures than with pilon fractures which have a poorer prognosis. Despite the soft-tissue injury being in general more severe than in diaphyseal fractures, the ultimate functional outcome after intramedullary nailing was satisfactory and the incidence of ankle problems was low. No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

REFERENCES


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