SPIRAL FRACTURES OF THE SHAFT OF THE TIBIA

INITIAL DISPLACEMENT AND STABILITY OF REDUCTION

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We have analysed the initial displacement and the retention of position after reduction of 192 spiral fractures of the tibial shaft. In fractures with an initial lateral displacement of one half the width of the shaft or more, successful retention of position after the primary closed reduction was achieved in only 18%. The direction of displacement between the tibial fragments showed little variation; the proximal fragment was always medial and anterior to the distal. This resulted in an increased space between the proximal tibial fragment and the shaft of the fibula in the plane of the interosseous membrane.

There was a strong correlation between the initial displacement and the initial shortening. No evidence of a posterior soft-tissue hinge, able to facilitate closed reduction, could be found. Consequently, in treating severely displaced spiral fractures, open reduction and internal fixation or a few weeks' initial calcaneal traction seem to be the rational alternatives.

When scrutinising the accumulated knowledge of fractures of the shaft of the tibia one cannot escape thinking that the challenging nature of direct impact fractures (with their overt lesions of the skin and other soft tissues) may have overshadowed the problems associated with the more "benign" fractures caused by indirect violence. Every skeletal injury, however, also involves neighbouring musculoligamentous structures.

In the leg an important stabilising role has been attributed to integrity of the interosseous membrane and the periosteum (Charnley 1963). Tearing of the interosseous membrane has been experimentally produced by axial loading of specimens with osteotomies of the tibial and fibular shafts made at different levels from each other (Sarmiento *et al.* 1974). This is the pattern in patients with rotational tibial shaft fractures; typically, the tibia is fractured at the junction of the middle and distal thirds while the fibular fracture is just below the head or through the malleolus (Ender, Krotscheck and Jahna 1957; Böstman, Vainionpää and Saikku 1984).

The purpose of this clinical study was to analyse the natural variation and characteristics of the initial displacement of spiral fractures of the adult tibial shaft and to examine the stability of reduction.

Figures 1 and 2—Anteroposterior and lateral radiographs of a typical spiral lateral-rotation fracture of the tibial shaft with an associated high fibular fracture. Partial disruption of the interosseous membrane can be suspected on the basis of the displacement pattern.

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Fig. 1

Fig. 2

PATIENTS AND METHODS

The series comprised 192 consecutive patients over 18 years of age with rotational fractures of the tibial shaft who presented at the Department of Orthopaedics and Traumatology, Helsinki University Central Hospital, during the years 1976 to 1983. All the fractures were in the infra-isthmal section of the tibial shaft, defined as that portion between 60% and 85% distal along the tibial length—that is, the area where the polar moment of inertia of the tibia reaches its minimum and the bone is weakest when subjected to torsional loading (Minns, Bremble and Campbell 1975). To standardise our material, only fractures without a butterfly fragment and having the associated fibular fracture at a different level from that in the tibia were included (Figs 1 and 2). These amounted to 79% of all tibial shaft fractures with a helical configuration during the period under review. The mean age of the patients was 38.3 years.

All radiographs were examined for the initial lateral displacement in the coronal plane measured on the anteroposterior film, and in the sagittal plane measured on the lateral film; from these measurements the magnitude and direction of the true displacement between the tibial fragments were calculated (Fig. 3). In addition, the initial radiographic shortening and the site of the associated fibular fracture were recorded.

Management was initially conservative; unless the

position of the fragments was acceptable, this consisted of closed reduction under anaesthesia as an emergency procedure on an orthopaedic table, using temporary cal-caneal traction and an image intensifier. A padded long-leg plaster cast was applied. From the next day the patient was encouraged to move around on crutches without weight-bearing. Three or four days later, radiographs were taken to check the position of the fracture. The position of the tibial fragments was considered acceptable if there was lateral displacement of not more than one half of the diaphyseal diameter in both views, angulation not exceeding 5°, shortening of no more than 10 mm and no noticeable rotatory malposition (Slätis and Rokkanen 1967; van der Linden and Larsson 1979; Johner and Wruhs 1983). If the position of the fracture had changed, open reduction and internal fixation were considered. Simple angulations, however, were corrected by axial wedging of the cast. During the early years of the study a second attempt at closed reduction was made before operating on the fracture.

RESULTS

Initial displacement. The initial lateral displacement, using the diaphyseal diameter as a measuring unit, was 0.38 ± 0.21 (mean and standard deviation) in the coronal plane (range 0.05 to 1.05) and 0.23 ± 0.14 in the sagittal plane (range 0.05 to 0.85). There was a strong correlation

Fig. 3

The magnitude (D_T) and direction (angle A) of the true displacement were calculated with the aid of the coronal (D_C) and sagittal plane (D_S) displacements measured from routine anteroposterior and lateral radiographs respectively:

$$D_T = \sqrt{D_C^2 + D_S^2}; \quad \tan A = \frac{D_S}{D_C}$$

Fig. 4

Measured displacements of 192 tibial shaft fractures showing the regression line relating displacement in the coronal versus the sagittal plane ($r = 0.794$).

between these two (Fig. 4). Consequently the direction of the true displacement, 0.44 ± 0.25 in magnitude, showed little variation, the mean value for the angle between the direction of the displacement and the coronal plane being 31° . The proximal tibial fragment in all cases was medial and anterior to the distal (Figs 5, 6 and 7). The initial radiographic shortening was 8.7 ± 3.2 mm, its correlation with the magnitude of the true displacement being very strong ($r = 0.882$).

Associated fibular fracture. The site of the fibular fracture was just distal to the head in 78, high diaphyseal in 48, just proximal to the tibiofibular syndesmosis in 19 and malleolar in 29 patients. In 18 cases there was a double fibular fracture. The severity of the initial lateral displacement of the tibial fracture was not influenced by the site of the associated fibular fracture.

Stability after reduction. In 73 patients (38% of the total) the initial position of the fragments was acceptable and no reduction was required. In 119 patients a total of 159 closed reductions (excluding axial wedgings) were performed, and in 52 of these (27% of the total) open reduction and internal fixation eventually had to be undertaken (Fig. 8). The overall rate of successful retention of the fracture position after the primary closed reduction was 42%. In fractures with an initial coronal displacement of one half of the shaft width or more, the rate of successful retention was only 18%; whereas in those with less displacement requiring closed reduction

merely for angulation, shortening or malrotation, it was 90% (Table I). In three patients an initially acceptable lateral displacement was, on the next check radiographs, seen to exceed one half of the shaft width.

DISCUSSION

As long as an anatomical result fulfilling certain criteria is recognised as a prerequisite for an acceptable functional recovery after fracture of the tibial shaft, the factors which determine success and failure in controlling the position of the fragments are of interest. Repeated closed reductions of fractures of the shaft of the tibia

Table I. Initial displacement and stability after reduction in 192 patients

Stability	Initial displacement in the coronal plane*			Total
	<0.50	0.50—0.75	>0.75	
Initial position acceptable	73	—	—	73
Successful retention of position after primary reduction	36	14	—	50
Failure of retention after primary reduction	4	39	26	69
Total	113	53	26	192

* Diaphyseal diameter as the measuring unit

Figure 5—Anteroposterior radiograph of a severely displaced spiral tibial shaft fracture showing coronal displacement. Figure 6—Lateral radiograph shows the displacement in the sagittal plane. The true displacement was 0.82 using the diaphyseal diameter as a measuring unit. Figure 7—In this patient serial computerised tomography was obtained at the levels indicated on the plain radiographs. The intact leg is included for comparison. The direction of the true displacement between the fragments is seen to be close to the plane of the interosseous membrane. The space between the proximal tibial fragment and the fibular shaft has markedly increased, indicating rupture of the interosseous membrane, whereas the relationship between the distal tibial fragment and the fibula is similar to that in the uninjured leg.

Fig. 8

Management of the fractures. The methods of internal fixation included plating, compression screwing and intramedullary nailing.

seem to be associated with an increased risk of delayed union and refracture (Watson-Jones and Coltart 1943; Hedenberg and Pompeius 1960; Böstman 1983). So fractures that probably will not retain an acceptable position within the cast would benefit from being identified early, to allow rational planning of management.

As for the stability after reduction, the best predictive factor was, not unexpectedly, the magnitude of the initial lateral displacement. More surprising was the constant direction of the true displacement of the proximal tibial fragment in relation to the distal one; it was always medial and anterior. Thus the resulting increased space between the proximal tibial fragment and the shaft of the fibula occurred close to the plane of the interosseous membrane, which obviously must tear or be avulsed to allow such displacement. Consequently, the basic determinant of stability of rotational tibial shaft fractures seems to be the amount of injury to the interosseous membrane. An analogous situation has been recently presented for fractures of the distal ulna (Dymond 1984). Noteworthy is the fact that during the first few days after reduction the lateral displacement increased further in a few patients, perhaps because of inadvertent loading of the limb while in the cast, indicating progressive tearing of the interosseous membrane.

In contrast to the ideas of Alms (1961), no evidence of a posterior soft-tissue hinge, facilitating the reduction of these fractures, emerged in this study. A marked initial lateral displacement was accompanied by considerable shortening and overriding of the fragments. Hence a simple rotatory correction of the position of the distal

fragment cannot control the displacement and reduce the fracture. For severely displaced rotational fractures of the shaft of the tibia, open reduction and internal fixation, or a few weeks' initial calcaneal traction, appear to be the rational alternative methods of treatment.

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