THE HEALING OF CLOSED TIBIAL SHAFT FRACTURES

THE NATURAL HISTORY OF UNION WITH CLOSED TREATMENT

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One hundred consecutive closed fractures of the adult tibial shaft treated by closed methods were surveyed prospectively in order to observe their natural history. The fractures were analysed with regards to speed of healing and the influence of age, sex, causal force, radiological morphology and concurrent fibular fracture. At 20 weeks 19 fractures had not yet united, but 15 of these had united by 30 weeks with conservative treatment alone. The remaining four cases were operated upon because no further progress in healing was anticipated. These findings suggest that, with regard to healing, open reduction and internal fixation is rarely justified in closed adult tibial shaft fractures.

Tibial shaft fractures probably enjoy the worst reputation of all adult diaphyseal fractures because of the problems arising from their treatment (Charnley 1961; Wilson 1982; Leach 1984). Delayed union is common with a reported incidence of between one and 17% (Dehne et al. 1961; Nicoll 1964; Weissman, Herold and Engelberg 1966; Sarmiento 1970). A review of the relevant literature suggests that no type of tibial fracture is immune from this complication (Charnley 1961; Editorial BMJ 1975). However, although many reports seek to justify open reduction and internal fixation for this reason (Müller 1963; Ruedi, Webb and Allgöwer 1976; Johner and Wruhs 1983), we could find no precise information in the recent English literature concerning the natural history of closed adult tibial shaft fractures treated by closed methods. Most relevant studies are retrospective or concerned with a mixed population of fractures and treatments (Allum and Mowbray 1980; Johner and Wruhs 1983). It would be valuable to know what proportion of such fractures which had not united by 20 weeks, when most surgeons might be tempted to operate (Souter 1969), eventually go on to nonunion.

The reasons for the susceptibility of adult tibial shaft fractures to delayed union are unclear. Factors which may influence the outcome include soft tissue damage (Ellis 1958; Bauer, Edwards and Widmark

1962), the morphology of the fracture (Jackson and Macnab 1959; Nicoll 1964; Allum and Mowbray 1980) and an intact fibula (Hoaglund and States 1967). There is no agreement as to which of these is the most important and different authors stress different factors (Austin 1977; Keller 1983); this may be due to differences in the population of fractures studied.

The present survey was undertaken in order to examine the natural history of unilateral closed adult tibial shaft fractures treated by closed means; several of the so-called prognostic factors were examined in order to discover their clinical relevance.

PATIENTS AND METHODS

One hundred consecutive adult patients who, between 1 August 1985 and 31 July 1987, had sustained a closed unilateral fracture of the tibial shaft and were treated by closed methods, were studied prospectively at the Leicester Royal Infirmary. The standard initial treatment was closed reduction where required, followed by immobilisation in a groin-to-toe plaster cast. This was changed to a patellar tendon-bearing cast after four to six weeks. Some fractures were treated with an orthoplast brace after the plaster cast had been removed. Each patient was seen fortnightly in a special clinic, though they remained under the care of one of 10 consultants each of whom was entirely responsible for all decisions concerning treatment.

Detailed clinical information was recorded for each patient with particular reference to age, sex and aetiology of trauma. The severity of the injury was estimated and classified as high or low energy violence (Bauer et al. 1962). High energy violence included all accidents in which a motor vehicle or motorcycle was

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0301-620X/88/5155 \$2.00
J Bone Joint Surg [Br] 1988;70-B:787-90.

involved, falls from a height of more than six feet and blows from heavy objects. Low energy violence included falls at ground level or from a low level, injuries from sport and push-bicycle accidents in which motor vehicles or motorcycles were not involved.

A fracture was regarded as healed when all immobilisation aids had been discarded and unrestricted weight-bearing was allowed. Normal union was defined as union occurring within 20 weeks and delayed union as lack of union after 20 weeks (Ellis 1958; Nicoll 1964).

The initial radiograph was classified according to the morphology and location of the fracture. For ease of reference, the fractures were labelled thus: Type I - transverse; Type II - spiral; Type III - oblique and Type IV - comminuted supramalleolar.

The shaft was defined as being between the level of the tibial tuberosity and 2.5 cm above the horizontal articular surface of the ankle. It was divided longitudinally into equal thirds and the location of the fracture was determined by its lowest boundary.

The differences between fractures with delayed union and those healing at normal speed were analysed with respect to age, sex, causal violence, location of fracture on the shaft, fracture morphology and the presence or absence of an intact fibula; chi-squared tests were used (Swinscow 1983) and the data also subjected to discriminant analysis using the SPSS package, in order to establish whether single factors or linear combinations of factors could be used to separate normal from delayed union (Norusis 1983). To this end, half the data were used to generate the discriminant functions and the other half to test the results independently.

RESULTS

The age range was from 16 to 89 years (mean $\pm$ 1 s.d., 34.7 ± 18.9) and there were 72 males and 28 females; 71 fractures were caused by low energy violence, commonly sports injuries, and 29 by high energy violence, commonly road traffic accidents.

Eighty-one fractures were united at 20 weeks; 19 had delayed union. Four of the 28 females (14.3%) and 15 of the 72 males (20.8%) had delayed union. The average age of patients with normal union was 34.8 years (± 19.9) and that of patients with delayed union was 34.4 years (± 14.6). Of the 19 patients whose fractures were not united at 20 weeks, conservative treatment was continued in all but four cases who were operated upon because their surgeons anticipated no further progress in healing.

The influence of the causal violence on the speed of healing is shown in Table I. Ten of the 29 fractures associated with high energy violence developed delayed union compared with 9 of the 71 associated with low energy violence; this difference is significant ($0.02 > p > 0.01$). The influence of the location of the fracture in the shaft on the speed of healing is shown in Table II. Seven fractures in the middle third and 11 in the

Table I. Influence of the severity of the injury on the speed of healing as number and percentage of cases

	Total	Normal union	Delayed union
High energy violence	29	19 65.5	10 34.5
Low energy violence	71	62 87.3	9 12.7
		81 81.0	19 19.0
Chi-squared = 6.36, DF = 1, $0.02 > p > 0.01$			

Table II. Influence of the location of the fracture in the shaft on the speed of healing as number and percentage of cases

	Total	Normal union	Delayed union
Upper third	3	2	1
Middle third	39	32 82.1	7 17.9
Lower third	58	47 81.0	11 19.0
		81 81.0	19 19.0

Table III. Influence of the radiological morphology of the fracture on the speed of healing as number and percentage of cases

	Total	Normal union	Delayed union
Type I	39	32 82.1	7 17.9
Type II	28	22 78.6	6 21.4
Type III	25	19 76.0	6 24.0
Type IV	8	8	0
		81 81.0	19 19.0

Table IV. Influence of an intact fibula on the speed of healing as number and percentage of cases

	Total	Normal union	Delayed union
Intact fibula	29	28 96.6	1 3.4
Fractured fibula	71	53 74.6	18 25.4
		81 81.0	19 19.0
Chi squared = 6.42, DF = 1, $0.02 > p > 0.01$			

lower third developed delayed union, compared with 1 of 3 upper third fractures; these differences are not statistically significant.

The influence of the morphology of the fracture on the speed of healing is shown in Table III. Seven of 39 Type I fractures (transverse) developed delayed union compared with six of 28 Type II (spiral) and six of 25 Type III (oblique) fractures. No Type IV fracture (comminuted supramalleolar) developed delayed union. Four of the Type II fractures classified as developing

delayed union were recorded in the notes as being clinically and radiologically united, but the patients, who were elderly and frail, were still being treated in a tibial brace at the end of the 20-week period. There was no statistically significant difference between the two healing groups with regard to their relationship with the fracture morphology. The influence of the intact fibula on the speed of healing is shown in Table IV. Only one patient with an intact fibula developed delayed union and the presence of an intact fibula is probably significant ($0.02 > p > 0.01$) in that it is not associated with delayed healing.

Discriminant analysis (Norusis 1983) of the data yielded no individual factor or linear combination of factors which could be used to separate normal from delayed union.

The basic characteristics of the fracture population were not unusual. More fractures were sustained in the lower third of the tibia (58%) than anywhere else. Only 11 of 39 middle third (28.2%) and 16 of 58 lower third fractures (27.6%) were associated with high energy violence compared with two of the three upper third fractures. The severity of the injury was related to the radiological morphology of the fracture ($0.01 > p > 0.001$), as reported by others (Ellis 1958; Bauer et al. 1962; Allum and Mowbray 1980). Thirty-nine of the 100 fractures were Type I, 28 were Type II, 25 were Type III and only eight were Type IV. High energy violence was associated predominantly with Types I (41.4%) and III fractures (44.8%). By contrast, low energy violence was associated with predominantly Types I (38%) and II (36.6%) fractures. In addition, 92.9% of Type II and 75% of Type IV fractures were associated with low energy violence. The severity of trauma probably determined whether or not the fibula also was fractured ($0.10 > p > 0.05$). It was intact in 29% of cases and 24 of the 29 cases (82.8%) were associated with low energy violence compared with 47 of 71 (66.2%) of those with a fibular fracture.

Residual valgus or varus deformity was less than 5° in 78.9% of patients, 6 to 10° in 18.4% and more than 10° in 2.6%. Anteroposterior angulation was less than 5° in 86.8% of patients, 6 to 10° in 9.2% and more than 10° in 3.9%. Shortening was less than 1 cm in 94.7% between 1.1 and 2 cm in 5.3% and no case had more than 2 cm of shortening. Between three months and two years after the injury, 43% of the patients had either objective or subjective restriction of ankle or subtalar movement. Only 20% were off work for more than 20 weeks after the fracture.

DISCUSSION

This prospective survey has shown that the prevalence of delayed union, as defined, in a series of closed adult tibial shaft fractures treated by closed means, was 19% at 20

weeks. There were no other complications worthy of note. The only clinical factor which related to delayed union was high energy violence, which had a much higher incidence of delay than low energy violence. This difference could not, however, be used to predict the outcome of any individual fracture, probably because classification into high or low energy is an oversimplification.

Some authors have reported that the location of the fracture in the shaft plays a significant role with regards to the speed of union (Ellis 1958; Allum and Mowbray 1980). In our series there was little difference between fractures in the lowest third and those in the middle third (upper third fractures were too few for meaningful conclusions). Similar findings have been reported by Nicoll (1964) and by Sarmiento (1970), whose series included both open and closed fractures. Nor could we confirm the often expressed opinion that transverse fractures take the longest to unite (Charnley 1961; Johner and Wruhs 1983); our delayed union rate was similar in Types I, II and III fractures which were through the hard compact bone of the diaphysis. Differences between transverse and spiral fractures which others have observed may be due to the fact that they included open fractures.

We also found no evidence that an intact fibula delays healing, as claimed by Jackson and Macnab (1959). Burwell (1971) considered displaced isolated tibial shaft fractures an absolute indication for open reduction and internal fixation, but only 3.4% of our fractures with an intact fibula developed delayed union compared with 25.4% in the group with fibular fractures ($0.02 > p > 0.01$). Our findings are similar to those reported by Allum and Mowbray (1980) and by Hooper, Buxton and Gillespie (1981).

This study has also demonstrated the natural history of slowly healing closed adult tibial shaft fractures treated by closed methods. Of the 19 fractures which had not united by 20 weeks, conservative treatment was continued successfully in 15, all of whose fractures healed within the next 10 weeks. Thus, if such a fracture is not united at 20 weeks the chances of union at the end of 30 weeks are better than five to one.

These results contradict those of Lucas and Todd (1973), who reported 12% delayed union at 32 weeks in a series of closed tibial shaft fractures. Our results suggest that, with regards to healing, open reduction and internal fixation is rarely justified in closed adult tibial shaft fractures.

The authors wish to thank all the consultant orthopaedic surgeons at the Leicester Royal Infirmary for allowing us to study their patients. They also thank John Beckett of the Computer Centre, University of Leicester for his advice on the statistical techniques.

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.

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