Nonunion of tibial fractures treated with external fixation

Contributing factors studied in 71 fractures

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We analyzed factors of importance for nonunion in a series of 39 closed and 32 open fractures of the tibia which were treated with external fixation. Factors analyzed included, age and sex of the patients, the mechanism of injury, the amount of soft tissue damage, the grade of comminution, the level at which the tibia was fractured, the presence of an intact fibula, the presence of multiple injuries, the type of external fixation used (Orthofix, STAR-90 or Hoffmann) and the need to supplement the stability of the reduction. We found that the type of open fracture, comminution of the fracture, extension the original wound for satisfactory reduction and fracture of the ipsilateral fibula, played a role in the development of nonunion.

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External fixation has been widely accepted for treatment of Type II and III open fractures of the tibia (Edge and Denham 1981, Behrens and Searls 1986, Gustillo et al. 1990). In addition, external fixation has also been applied in the treatment of closed fractures of the tibia (Evans et al. 1988) despite the fact that it may be associated with nonunion for unclear reasons (Rosso et al. 1989).

We retrospectively studied which factors contributed to the development of nonunion in closed and open tibial fractures treated with external fixation.

Patients and methods

From 1988–1995, 77 patients with 78 fractures of the diaphysis of the tibia were treated by reduction and external fixation using three systems: Orthofix, STAR-90 and Hoffmann. 71 patients (71 fractures) were available for follow-up. Patients were evaluated for factors which could effect the development of nonunion, including age and sex of the patient, mechanism of injury, type of fracture (open or closed), comminution, level of the fracture, presence of an intact fibula or other fractures in the same leg, presence of multiple injuries, use of interfragmental screws to supplement fixation and finally the time interval between injury and application of the external fixator.

Of the 71 fractures, 39 were closed (Group I) and 32 were open (Group II). The mean age for patients with closed fractures was 34 (16-68) years, while with open fractures it was 37 (15–68) years. Almost half the patients were younger than 30 years in both groups, with a man:women ratio of 3:1. Most of the fractures were the result of road traffic accidents: 23 of the 39 patients with closed fractures and 22 of the 32 patients with open fractures.

Fractures were classified according to the AO system into simple fractures, fractures with at least one butterfly fragment and comminuted or segmental fractures (Muller et al. 1990) (Table 1). Open fractures were classified into 3 types according to the mechanism of injury, the amount of soft tissue damage and the amount of contamination (Gustillo and Anderson 1976, Gustillo et al. 1984, Gustillo et al. 1987). 9 out of the 32 patients had type I open fractures, 12 had type II, 5 type IIIA, 4 type IIIB and 2 type IIIC.

6 of the closed fractures occurred in the proximal third of tibia, 17 in the middle and 16 in the distal third. 5 of the open fractures occurred in the proximal third, 14 in the middle and 13 in the distal third.

The fibula was intact in 14 and fractured in 25 of the patients with closed fractures, and was intact in 4 and fractured in 28 of the patients with open fractures. Additional fractures in the ipsilateral limb occurred in 4 patients of both groups, and approximately one-third of the patients in each group had multiple injuries.

The time between injury and operation averaged 3 days for the closed fractures and 1 day for the open

Table 1. Classification of the 71 tibial fractures

Fracture type	Closed	Open
Group A – simple fractures		
A 1 – spiral	10	4
A 2 – oblique	7	3
A 3 – transverse	10	8
Group B – fracture with butterfly		
B 1 – one fragment (torsion)	5	3
Group C – comminuted or segmental fractures		
C 1 – comminuted	4	13
C 2 – segmental	3	1
Total	39	22

There were no type B 2, B 3 or C 3 fractures

fractures. In closed fractures, Orthofix was used in 20 patients, STAR-90 in 14 and Hoffmann in 5. For open fractures, 12 Orthofix, 12 STAR-90 and 8 Hoffmann were used.

All closed fractures were reduced under radiographic control. Extension of the wound was required for reduction of the fracture segments in 19 open fractures. Reduction was satisfactory for both closed and open fractures. Interfragmentary screws were used for additional stability of the reduction in 3 patients with open fractures. Postoperative management depended upon the type of injury and whether the patient had additional injuries. Most patients were walking with partial weight bearing 6 weeks after injury.

Results

All closed fractures healed on average 5 (3–8) months after the injury. Only one delayed union was observed which was attributed to a displacement of the fracture in a patient with neurological disease. As a result of the delayed union, the external fixator was exchanged for a functional brace 4 months after injury.

Of the 32 patients with open fractures, nonunion was observed in 12, while 20 fractures united after average 6 (4–8) months. Nonunion occurred in 1 of 9 patients with type I fractures, in 4 of 12 type II fractures and in 7 of 11 type III fractures and in both cases with type IIIC open fractures. All nonunions were bone grafted with the external fixator in place.

Of the 8 transverse fractures there was 1 nonunion, none in the 3 oblique fractures, 1 in 4 spiral fractures, 2 in 3 fractures with a butterfly segment and 8 in 13 comminuted fractures. According to the level of the fracture, 2 nonunions were seen in the 5 fractures of the proximal third of the tibia, 5 in 14 fractures of the middle third and 5 in 13 fractures of the distal third.

Only 1 nonunion was seen among 4 open fractures

Table 2. Factors associated with nonunion of tibial fractures

Parameter	Total	Nonunions
Open fracture type		
I	9	1
II	12	4
III	11	7
Fracture type		
A 1 - spiral	4	1
A 2 - oblique	3	0
A 3 - transver	8	1
B 1 - one fragment (torsion)	3	2
C 1 - comminuted	13	8
C 2 - segmental	1	0
Level of fracture		
proximal third	5	2
middle third	14	5
distal third	13	5
Intact fibula	4	1
Fractured fibula	28	11
Reduced without wound extension	13	2
Reduced with wound extension	19	10
Ipsilateral fractures	4	2
Multiple injuries	11	4

with an intact fibula, while 11 nonunions were found in 28 patients with also a fractured fibula. Of the 13 patients with no extension of the original wound 2 open fractures (1 type I and 1 type II) developed nonunion. In contrast, 10 of the 19 open fractures which developed nonunion (3 type II and 7tType III) had had the wound extended to obtain satisfactory reduction.

Nonunion was observed with all types of external fixation systems. 6 of 30 patients treated with Orthofix fixator, 3 of 26 with STAR-90 and 3 of 11 with Hoffmann developed nonunion. 4 patients who developed nonunion had an additional fracture in the same leg, as well as multiple injuries, while only 2 out of the remaining 9 patients with multiple injuries developed nonunion (Table 2).

Aseptic loosening of the pins was observed in only 1 patient with an open fracture which proceeded to nonunion, and mild pin tract infection was observed in 2 patients with closed fractures and in 3 patients with open fractures. Only 1 of the latter developed nonunion. No patient developed osteomyelitis or deep pin-tract infection, but 2 patients with type III open fractures developed a staphylococcal infection of the soft tissues, resulting in nonunion of the fractures.

Discussion

Nonunion of a diaphyseal fracture of the tibia may be related either to the severity of the fracture itself or to

the method of treatment (Waddell and Reaedon 1983). It is not uncommon after external fixation (Rosso et al. 1989). We found a notable difference in the nonunion rate between closed and open fractures. Only 2 delayed unions occurred in 39 closed fractures, whereas 12 nonunions occurred in 32 patients with open fractures. The importance of soft tissue damage is well known (Evans et al. 1988, Green et al. 1988). However, Court-Brown and Hughes (1985) in their study of 48 diaphyseal fractures of the tibia treated by external fixation observed better results in open Type II and III fractures than in closed or Type I open fractures. The authors considered a good initial reduction as playing a primary role.

We used 3 types of external fixator with the same nonunion rate supporting previous findings that nonunions occur irrespective of the type of fixator (Behrens and Searl 1986). We found that comminution in open fractures was another important factor for nonunion.

Heppenstall et al. (1984) proposed that fractures of the distal third of the tibia are more prone to nonunion (Heppenstall et al. 1984). In our series, however, nonunion equally common at all levels of open tibial fractures. Some studies indicate that an intact fibula contributes to the development of nonunion (Teitz et al. 1980, Hooper et al. 1981, Leffers and Chandler 1985), however, our findings and those of others (Werken et al 1993) does not support this.

We observed a greater number of nonunions in open fractures that required an extension of the original wound than in those that did not. Such a reduction is perhaps better referred to as an open reduction. These observations are compatible with a previous study which found a high number of nonunions whenever an open reduction was required, either for closed or open fractures.

Only 2 out of our 32 patients with open fracture had infections. In other series, wound infection occurred in 2–25% according to the type of the fracture (Gustilo and Anderson 1976, Delinger et al. 1988). Although pin tract or wound infection was rare in our study, the latter complication was always associated with nonunion.

As has been previously shown, nonunion is common in type III open fractures (Lange et al. 1985, Caudle and Stern 1987) In our series, more than half the type III open fractures, did not unite.

In conclusion, the extent of soft tissue damage in open fractures, comminution of the fracture, surgical extension of the wound, and fracture of the ipsilateral fibula were found to play an important role in the development of nonunion of tibial fractures treated with external fixation.

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