Reamed nailing of Gustilo grade-IIIB tibial fractures

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Reamed intramedullary nailing was carried out on 57 Gustilo grade-IIIB tibial fractures in 55 patients. After debridement, there was substantial bone loss in 28 fractures (49%). The mean time to union was 43 weeks (14 to 94). When there was no bone loss, the mean time to union was 32 weeks; it was 45 weeks if there was bone loss. Fractures complicated by infection took a mean of 53 weeks to heal. Revision nailing was necessary in 13 fractures (23%) and bone grafting in 15 (26%). In ten fractures (17.5%) infection developed, in four within six weeks of injury and in six more than four months later. Of these, nine were treated successfully, but one patient required an amputation because of osteomyelitis.

Our results indicate that reamed intramedullary nailing is a satisfactory treatment for Gustilo grade-III tibial fractures.

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Patients and Methods

We undertook a retrospective analysis of 57 Gustilo grade-IIIB tibial fractures presenting at a British and at a Canadian trauma centre between 1987 and 1994. There were 55 patients (48 men and seven women) with a mean age of 36 years (15 to 78). Road-traffic accidents had caused the injuries in 45 patients (82%), 24 (53%) of whom were pedestrians, 13 (20%) motorcyclists and eight (18%) occupants of cars. Seven patients (13%) had been injured at work and three (5%) while playing sports. The injury severity score was over 16 in 25 patients (45%) with multiple injuries. Table I shows the number of fractures as described by the AO classification: of these, there were eight type-A fractures (14%), 22 type-B (38%) and 27 type-C (47%).

Both trauma centres used identical definitions and management protocols. The criteria of Gustilo, Mendoza and Williams were used to define the fractures. In all cases there was extensive soft-tissue damage, contamination with significant bony comminution, or contamination with periostal stripping. After initial assessment, all patients had wound excision and debridement. In all fractures a statically-locked reamed Grosse-Kempf intramedullary nail (Howmedica, East Rutherford, New Jersey) was used. There was substantial bone loss (more than 2 cm, involving more than 50% of the tibial circumference) in 28 fractures (49%) after debridement and stabilisation. In all cases there was extensive soft-tissue damage, contamination with significant bony comminution, or contamination with periostal stripping. After initial assessment, all patients had wound excision and debridement. In all fractures a statically-locked reamed Grosse-Kempf intramedullary nail (Howmedica, East Rutherford, New Jersey) was used. There was substantial bone loss (more than 2 cm, involving more than 50% of the tibial circumference) in 28 fractures (49%) after debridement and stabilisation. In all cases, a consultant orthopaedic trauma surgeon either carried out or supervised the operation. The patients received intravenous gentamicin combined with either cefazolin or cefuroxime for 72 hours after operation. All wounds were left open and

<table>
<thead>
<tr>
<th>AO classification</th>
<th>Number (%)</th>
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<tbody>
<tr>
<td>A2</td>
<td>3 (5)</td>
</tr>
<tr>
<td>A3</td>
<td>5 (9)</td>
</tr>
<tr>
<td>B1</td>
<td>2 (3)</td>
</tr>
<tr>
<td>B2</td>
<td>11 (19)</td>
</tr>
<tr>
<td>B3</td>
<td>9 (16)</td>
</tr>
<tr>
<td>C2</td>
<td>10 (17)</td>
</tr>
<tr>
<td>C3</td>
<td>17 (30)</td>
</tr>
<tr>
<td>Total</td>
<td>57</td>
</tr>
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</table>
a ‘relook’ procedure was carried out within 48 hours. Soft-tissue cover was undertaken at the time of the ‘relook’ or as soon afterwards as possible. The mean time to soft-tissue cover was four days. Split-skin grafting was used for 11 fractures (19%) and flap cover in 44 (77%). There were 12 free flaps (seven latissimus dorsi and five rectus abdominis), 15 fasciocutaneous flaps and 17 soleus or gastrocnemius muscle flaps.

After operation, patients with isolated tibial fractures were mobilised on crutches and allowed to bear weight as tolerated. Those with multiple injuries were mobilised as rapidly as their other injuries allowed. Four patients were lost to follow-up. They were not demographically different from the remaining 51 who were followed up for a mean of 41 months (12 to 79).

We considered union to have occurred when anteroposterior and lateral radiographs showed bridging of three of the four bony cortices. We defined malunion as angulation or rotation of more than 5° or shortening of more than 1 cm. Soft-tissue infection was diagnosed if there were clinical signs of infection and positive bacteriological cultures. Deep infection involving bone was diagnosed if a purulent discharge necessitated further bony debridement.

We measured the ranges of knee, ankle and subtalar movement at the final follow-up and compared the occupations and levels of recreational activity of the patients before injury and after treatment.

Statistical evaluation was carried out using analysis of variance.

Results

In three patients (5%), the severity of the associated soft-tissue damage was such as to require below-knee amputation within a week of injury. Using the techniques for compartment monitoring described by McQueen, Christie and Court-Brown, we diagnosed a compartment syndrome in three patients (5%), subsequently treated by four-compartment fasciotomy. At final follow-up, there were no sequelae directly related to the compartment syndrome.

The mean time to union was 43 weeks (14 to 94). Fractures with little or no bone loss healed in a mean of 32 weeks. The mean time to union was 45 weeks when there was substantial bone loss and 53 weeks when the fracture had been complicated by infection. These differences were significant (p = 0.05). Aseptic nonunion developed in 24 fractures (42%), 15 (62.5%) of which had substantial bone loss. One patient was wheelchair-bound and declined further treatment. Of the remaining 21 fractures, 13 (56.5%) required exchange intramedullary nailing and eight healed without further surgery in a mean of 20 weeks. Bone grafting was required in 15 fractures, ten of which had prophylactic grafting eight to 12 weeks after injury. There were four cases of malunion (7%). At final follow-up, three fractures had united with 5° to 10° of valgus and one patient had 10° of varus.

Ten fractures (17.5%) had infective complications, which occurred within six weeks of injury in four. One of these was a superficial partial necrosis of a fasciocutaneous flap which resolved with local treatment. The other three were deep infections, two of which developed in patients in whom flap cover was delayed by more than a week. Two of the fractures united, but one patient required a below-knee amputation for chronic osteomyelitis. The other six infections presented more than four months later. Two were abscesses beneath flaps which did not involve bone. Both were drained and the fractures subsequently united. Union was already advanced in three of the four bony infections which presented late. We undertook debridement, sequestrectomy and removal of the nail. Refracture occurred in two cases, necessitating secondary nailing. Both fractures went on to heal without further infection. We carried out debridement, sequestrectomy and reimplantation of the remaining case of late infection, but the fracture did not unite until it was bone grafted three months later.

We undertook a retrospective functional assessment of 47 patients (49 fractures), eight either having been lost to follow-up or undergone below-knee amputation. Telephone interviews were held with 12 patients who declined to return for functional assessment. Five patients had retired before their injury occurred. Of the remaining 42, 24 (57%) had resumed their original occupation and two (4.8%) had taken up different work or had been obliged to retrain. The remaining 16 patients (38%) were unemployed with no likelihood of returning to work. Eight patients (17%) had regained their former level of recreational activity, 28
(59.6%) engaged in a lower level of leisure pursuits and 11 (23.4%) considered themselves to be too disabled for recreational activity.

We examined 35 patients (37 fractures) and found residual joint stiffness in six knees (16%), 22 ankles (60%) and 18 subtalar joints (49%). Pain at the site of the fracture persisted in 21 patients (44.7%).

Discussion

About 23% of all tibial fractures are open and most of these are Gustilo grade III.\textsuperscript{1,2,13} Grade-IIIIB fractures comprise about 28% of all open tibial fractures. A general hospital serving a population of about 250,000 can expect to admit three or four patients with grade-IIIIB tibial fractures per year.

Although the numbers of patients in previous studies have been small, the differences in outcome have been considerable. Some surgeons advocate external fixation and others prefer reamed or unreamed intramedullary nailing. There is consensus about the need for early soft-tissue cover,\textsuperscript{15} but there are no generally accepted guidelines for the management of the most common complications, infection and nonunion.

The reported mean times to union for grade-IIIIB tibial fractures treated by intramedullary nailing vary from 31 to 50 weeks.\textsuperscript{3-6,8,14} Uncomplicated grade-IIIIB tibial fractures unite sooner than those in which there is bone loss or infection. The mean time to union has decreased during the last decade. Court-Brown et al\textsuperscript{3} noted a mean time to union of 38 weeks for uncomplicated grade-IIIIB fractures and 78 weeks for fractures complicated by substantial bone loss. A later review by Rose and Court-Brown\textsuperscript{16} showed that the mean time to union had decreased to 56 weeks. In our study, the mean time to union in fractures complicated by substantial bone loss was 45 weeks. The improved results may reflect an increased use of exchange nailing and bone grafting in the treatment of nonunion and better detection and treatment of osteomyelitis.

When there is little or no bone loss, nonunion can be managed by exchange nailing, but this should not be carried out when it involves reaming infected bone or bone which is healed autogenous corticocancellous graft.\textsuperscript{17} In cases of hypertrophic or atrophic nonunion, exchange nailing should be undertaken 20 to 25 weeks after primary treatment. It will usually lead to union in cases of hypertrophic nonunion, and in many cases of atrophic nonunion it may produce a periostal and osseous reaction. When this occurs, we suggest a second exchange-nailing procedure be carried out after a further ten to 12 weeks. If there is no such reaction after exchange nailing, we advocate bone grafting. We believe that fractures with substantial bone loss should be treated by bone grafting, best undertaken six to eight weeks after primary surgery. We advise against

\begin{itemize}
\item Soft tissue
\item Debridement and exchange nailing (further flap if required)
\item Bone
\item Drainage
\item Vascular bone
\item Avascular bone
\item Bone resection
\item Bone graft
\item Union
\item Exchange nailing (if required)
\item Local treatment or second flap
\item Flap necrosis
\item Subflap abscess
\item Infection
\end{itemize}

Fig. 2

Algorithm for the management of infection in Gustilo grade-IIIIB fractures treated by reamed intramedullary nailing.
immediate bone grafting in case there is early infection. A second bone graft may be required if the fracture does not unite. Figure 1 shows our algorithm for the management of nonunion.

The overall rate of infection was 17.5%. We believe that it is important to distinguish between soft-tissue and bone infection. In three cases, infection was confined to the flap and did not affect union. The remaining seven infections apparently arose in bone, giving an incidence of osteomyelitis of 12.7%. All soft-tissue infections clearly require urgent treatment, but they do not necessarily affect bony union. Over the last decade we have encountered several abscesses beneath flaps. They are generally well localised and union proceeds uneventfully after drainage. If detected early, infection of bone can usually be treated successfully, although union may be delayed. Osteomyelitis proved refractory to treatment in only one case. Court-Brown, Keating and McQueen drew up an algorithm to deal with infection of bone after intramedullary nailing of the tibia. Figure 2 is an updated algorithm for the management of bone infection in grade-IIIB tibial fractures. In the treatment of both nonunion and infection, exchange nailing and bone grafting are the key procedures. If primary infection occurs around the intramedullary nail, exchange nailing is indicated. Any avascular segment of bone associated with the infection should be resected and the defect filled with bone graft. If there is no avascular bone, further exchange nailing will be required if the fracture does not unite.

Alternatives toreamed intramedullary nailing are unreamed nailing and external fixation. The results of unreamed and reamed nailing of grade-IIIB fractures are similar. Most of the apparent differences relate to methodology and definitions. Keating et al. found that the only difference between reamed and unreamed nailing was the incidence of breakage of the implant. Comparing unreamed nailing with external fixation, Schandelmaier et al. and Tornetta et al. found that with intramedullary nailing the time to union was shortened and the functional outcome improved. Schandelmaier et al. reported no difference in the rate of infection, the need for secondary surgery or malunion.

Circular external fixators such as the Ilizarov frame may be a satisfactory alternative to intramedullary nailing in treating complex open tibial fractures. Studies to date, however, have focused on the use of circular frames in the management of fractures complicated by infection, and information on their use in the primary treatment of tibial fractures is limited.

Our results indicate that intramedullary nailing is a satisfactory way of managing Gustilo grade-IIIB tibial fractures. Surgeons may encounter both nonunion and infection, but if managed appropriately the effects of these complications can be minimised. Nevertheless, patients should be warned that they may not be able to resume their previous occupations or levels of physical activity. 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