Management of severe open tibial fractures

THE NEED FOR COMBINED ORTHOPAEDIC AND PLASTIC SURGICAL TREATMENT IN SPECIALIST CENTRES

S. B. Naique, M. Pearse, J. Nanchahal

From Department of Musculoskeletal Surgery, Imperial College School of Medicine, London, England

Although it is widely accepted that grade IIIB open tibial fractures require combined specialised orthopaedic and plastic surgery, the majority of patients in the UK initially present to local hospitals without access to specialised trauma facilities. The aim of this study was to compare the outcome of patients presenting directly to a specialist centre (primary group) with that of patients initially managed at local centres (tertiary group).

We reviewed 73 consecutive grade IIIB open tibial shaft fractures with a mean follow-up of 14 months (8 to 48). There were 26 fractures in the primary and 47 in the tertiary group. The initial skeletal fixation required revision in 22 (47%) of the tertiary patients. Although there was no statistically-significant relationship between flap timing and flap failure, all the failures (6 of 63; 9.5%) occurred in the tertiary group. The overall mean time to union of 28 weeks was not influenced by the type of skeletal fixation. Deep infection occurred in 8.5% of patients, but there were no persistently infected fractures. The infection rate was not increased in those patients debrided more than six hours after injury.

The limb salvage rate was 93%. The mean limb functional score was 74% of that of the normal limb. At review, 67% of patients had returned to employment, with a further 10% considering a return after rehabilitation. The times to union, infection rates and Enneking limb reconstruction scores were not statistically different between the primary and tertiary groups.

The increased complications and revision surgery encountered in the tertiary group suggest that severe open tibial fractures should be referred directly to specialist centres for simultaneous combined management by orthopaedic and plastic surgeons.

The open IIIB tibial fracture is almost invariably a high-energy fracture characterised by extensive soft-tissue damage or loss, bone exposure with periosteal stripping, and contamination. Early soft-tissue restoration has dramatically improved the outcome of these fractures. A better understanding of the cutaneous blood supply and advances in microsurgical techniques have led to reliable cover of traumatic musculocutaneous defects. Progressive refinement in the fixation of fractures and early bone grafting have resulted in a shorter time to union. The combined treatment of both the soft-tissue and skeletal components of severe open tibial fractures by dedicated teams has further improved outcomes and reduced morbidity.

Recognition of the importance of combined orthopaedic and plastic surgical treatment led to the publication of management guidelines by the British Orthopaedic Association (BOA) and British Association of Plastic Surgeons (BAPS). However, only 25% of acute hospitalisations in the UK have resident plastic surgery services, and the majority of open tibial fractures continue to present to district general hospitals without access to such facilities. The initial debridement and skeletal stabilisation are thus commonly undertaken at the presenting hospital, before transfer to a specialist centre for soft-tissue reconstruction. Inter-hospital transfer inevitably leads to delay in the definitive treatment of the open fracture, which may compromise the final outcome. The BOA/BAPS guidelines were developed to highlight the importance of a combined approach. However, recent studies suggest that the guidelines are still not being followed.

A combined orthopaedic and plastic surgery service was established at Charing Cross hospital for the management of severe limb injuries. Patients with open fractures either presented directly to our unit (primary group) or were transferred after initial treatment in a local hospital (tertiary group). The aim of our study was to assess the influence of the initial treat-
ment at another centre before transfer for definitive, combined orthopaedic and plastic surgical management.

Patients and Methods
A total of 100 fractures of the tibial shaft in 94 patients was managed in a combined orthopaedic and plastic surgical unit over a 4.5 year period. Using the classification of Gustilo and Anderson, there were four grade I, three grade II, 13 grade IIIA, 73 grade IIIB and seven grade IIIC injuries. Of these, only the 73 grade IIIB tibial injuries were included in the current study. Open fractures of the tibial plateau and ankle were excluded.

We reviewed the 73 grade IIIB fractures (72 patients) at a mean follow-up of 14 months (8 to 48). There were 12 women and 60 men. The mean age was 42 years (19 to 94) and the mean injury severity score was 15 (7 to 24). The methods of injury were road traffic accidents (70%), falls from heights (20%), sports (5%), industrial crush injuries (4%) and gunshot injuries (1%). Compartment syndrome was seen in seven patients (10%), peroneal nerve palsy in four (6%), and 12 patients (16%) had segmental fractures.

Outcome analysis. The patients’ records and radiographs were analysed and the following data collected: the mechanism of injury, time of initial presentation, timing of the first debridement and soft-tissue reconstruction, type of skeletal stabilisation, number and type of secondary procedures, time to union, and all complications encountered during treatment. Patients were invited to attend a review clinic or complete a telephone questionnaire.

The final limb function was assessed using the Enneking limb reconstruction scoring system, which records pain, functional activities and emotional acceptance. The reconstruction score is expressed as a proportion of the expected normal function for the patient.

The primary and tertiary groups were compared to assess the influence of the timing of debridement, soft-tissue reconstruction and the type of skeletal fixation on the final outcome. Results were analysed for statistical significance using Fisher’s exact test, with a p value of ≤ 0.05 considered significant.

Results
Two patients required primary amputation because of the severity of the injury. They were excluded from further analysis. There were three delayed amputations (two in the tertiary group, one in the primary group), these were included in the analysis. A diabetic patient with end-stage renal failure developed a large pressure sore on the heel at day 14. The second delayed amputation involved an acute fracture-site infection in a patient who declined free-flap surgery. The third late amputation was performed at 19 months because of a painful stiff foot. The overall limb-salvage rate was 93%.

There were 26 fractures in 25 patients (36%) in the primary group and 47 fractures in 47 patients (64%) in the tertiary group. A full clinical review was completed on 52 fractures (71%) and 19 patients (19 fractures) were contacted by telephone. None was lost to follow-up.

Timing of debridement. In the primary group, 20 fractures (80%) were debrided within six hours of injury compared with 28 (61%) in the tertiary group (2.5 to 12 hours in the primary group and 2 to 24 hours in the tertiary group). There was no significant difference in the incidence of deep infection between those debrided early and those debrided after six hours in either group (p = 0.406). However, the highest infection rate (3 of 19 fractures, 16%) was in the tertiary group debrided after six hours.

Soft-tissue reconstruction. Soft-tissue cover was obtained in 43 fractures (61%) within five days of injury; the remaining 28 fractures (39%) had delayed soft-tissue cover. Soft-tissue reconstruction included 63 flaps and eight split-skin grafts. Of the 63 flaps, there were 35 local fasciocutaneous flaps (13 distally-based and 22 proximally-based), two local muscle flaps (one gastrocnemius and one tibialis anterior) and 26 free muscle flaps (20 latissimus dorsi, five rectus abdominis and one serratus anterior).

Minor tip necrosis occurred in three local fasciocutaneous flaps (8.5%) and was treated by excision of the affected part and advancement of the flap. All healed uneventfully. There were six flap failures, four fasciocutaneous (11%) and two free flaps (8%). All failures occurred in the tertiary group, but this did not reach statistical significance (p = 0.08). Five of the six flaps which failed were created more than five days after the injury but comparison of those created within five days with those performed later failed to reach statistical significance (p = 0.076). The fasciocutaneous flaps which failed represented significant necrosis at the tip rather than total loss of the flap. These were salvaged using two gastrocnemius muscle flaps and two free latissimus dorsi flaps. One failure of a free flap was due to inadequate arterial flow in the vessels below the knee and was salvaged with a free rectus muscle flap anastomosed to the femoral vessels. The second latissimus dorsi flap was lost on the fourth day after anastomosis, because of an iliopoplantar deep-vein thrombosis in a patient with a contralateral traumatic above-knee amputation. The wound healed by secondary intention. All these patients went on to tibial union without infection.

Skeletal stabilisation and times to union. Skeletal stabilisation was achieved using Ilizarov external fixation in 36 fractures (51%), locked intramedullary nailing in 26 (36%), and unilateral biplanar external fixation in nine (13%).

The mean time to fracture union in patients treated with Ilizarov fixators was 29 weeks (16 to 42). Delayed union (union after 43 weeks) occurred in three of these cases (8%); two united after revision to reamed intramedullary nails, and the remaining fracture united spontaneously at 50 weeks. There were two nonunions (2.8%). One became infected after revision to a reamed nail and united at 76 weeks after further Ilizarov surgery. The patient subsequently requested amputation for a painful, stiff foot. The
Figure 1a – Radiograph of 25-year-old tree surgeon, who sustained a displaced diaphyseal tibial fracture. Presented directly to Charing Cross Hospital. Figure 1b – Clinical photograph of well-circumscribed anteromedial soft-tissue defect with minimal contamination. Treatment performed as urgent elective operation at 14 hours post-arrival by combined orthopaedic and plastic surgical team. Initial debridement followed by stabilisation with locked, reamed intramedullary nail and immediate soft-tissue cover by distally based fasciocutaneous flap. Figure 1c – Radiographs at six months showing union of the fracture. Figure 1d – Clinical photograph at eight months follow-up. Patient had returned to work and Enneking score was 97.
remaining fracture united at 135 weeks after re-application of an Ilizarov fixator.

The mean time to union in patients with reamed intramedullary nails was 29 weeks (16 to 68). Secondary procedures on 26 fractures included the removal of locking screws in five (19%) and fibular osteotomy in three (11.5%). Delayed union occurred in six (23%). Of these, four required exchange nailing, but the remaining two healed without further intervention.

Unilateral external fixation was used in nine fractures (12.7%). Two fractures were electively revised to a reamed intramedullary nail at 11 weeks because of lack of callus formation revealed by the radiographs. With the exception of a diabetic patient with terminal renal failure, who required a delayed amputation owing to a pressure sore on the heel, the remainder united at a mean of 26 weeks (15 to 34). Early revision of fixation was performed in 22 (48%) of the tertiary group. Indications for revision included incorrect implant selection, inadequate skeletal stability, or infection at presentation. The mean time to union was 29 weeks in the primary group and 26 weeks in the tertiary group.

Infection. Superficial infections in the form of cellulitis and minor skin graft loss occurred in seven of the 71 fractures (9%). Self-limiting superficial inflammation and discharge at the wire site was noted in most patients with Ilizarov external fixators. Significant pin-tract infections requiring a surgical procedure were seen in four of 45 fractures (7%) which had been stabilised with half pins and external fixators. One was subsequently fractured through an infected pin site after union and required further reconstruction.

Deep infection occurred in six of 71 fractures (8.5%), one in the primary group and five in the tertiary group (p = 0.41). There were two early and four late infections. One early fracture-site infection occurred in a patient in the tertiary group with a severe segmental tibial fracture who declined free-flap reconstruction, and a below-knee amputation was performed. One early intramedullary nail infection was managed by exchange nailing at ten weeks which was followed by infection-free union. Two late peri-implant nail infections occurred after fracture union. Both subsided with implant removal, over-reaming and lavage. Two late infections developed after revision of an external fixator to a reamed nail for delayed union. One responded to exchange nailing, and the other was managed with debridement and further Ilizarov fixation. Both united without any further infection. There was no case of a persistently infected fracture or chronic osteomyelitis.

Limb function and employment. The mean Enneking limb score in the primary group was 75 (17 to 97) and 74 (33 to 90) in the tertiary group (p = 0.8). The mean scores were unaffected by the method of fixation: 73 after nail fixation, 74 after Ilizarov fixation, and 75 in the unilateral external fixator group. All patients were independently ambulant at the time of final review. Almost half (49%) returned to their original employment, 13 (18%) returned to lighter duties, and three (4%) were unemployed before their injuries. Another seven patients (10%) were intending to return to work after rehabilitation and one died, leaving 12 (17%) who did not return to any form of employment.

Discussion

We were unable to demonstrate a relationship between the timing of the initial debridement and the subsequent development of infection or time to fracture union. Our results are similar to those of other studies, which suggest that the adequacy of the initial debridement, rather than timing, determines outcome. However, most of these studies focus largely on injuries receiving delayed definitive treatment in a tertiary care centre without earlier intervention at another hospital, which may be relevant to our observations. The nature of our patient group allowed us to analyse the effect of earlier intervention in addition to the delay in definitive treatment on the final result. The initial debridement in the tertiary group was characterised by a reluctance to aggressively excise dead and devitalised tissue, and was often performed without consultation with a plastic surgeon. The dictum of emergency debridement within six hours of injury, as prescribed by the BOA/BAPS guidelines, means that surgery may be performed in haste by surgeons lacking experience in the management of these severe injuries.

Two of our fractures had undergone an inappropriate debridement, which compromised local flap options so that free flaps were required. Early revision of skeletal fixation was necessary in almost half (48%) of the tertiary cases because of incorrect implant selection, inadequate skeletal stability, and contamination or infection at presentation. Furthermore, definitive skeletal stabilisation and soft-tissue cover were often delayed in the tertiary group because of the delay associated with patient transfer.

The timing of soft-tissue cover has been considered critical in determining the outcome of these injuries, in particular of flap survival. However, only 39% of patients in Godina’s study had underlying fractures, and both upper and lower limbs were included. In our study, the mean time to soft-tissue cover was 6.8 days and the incidence of deep infection was 8.5%. This is comparable with other studies performed with immediate soft-tissue reconstruction. Like Pollak, McCarthy and Burgess, we were unable to demonstrate a statistically-significant relationship between flap failure and timing. However, five of our six flap failures occurred in patients in whom soft-tissue reconstruction was deferred for more than five days, and all the failures were in the tertiary group. Delayed soft-tissue reconstruction is more difficult because of tissue oedema, peri-vascular fibrosis and the increased risk of venous thrombosis.

Three fasciocutaneous flaps (11.42%) failed in our series, and this is comparable with other studies. Few of our patients were suitable for gastrocnemius flaps (3%), and we have concerns that the use of soleus as a flap may compromise lower-limb function: soleus is important in...
Figure 2a – Clinical photograph showing early infection and devitalised bone. Figure 2b – Radiograph demonstrating failure of unilateral external fixation. Figure 2c – Intra-operative view of extensive post-debridement bone defect before a latissimus dorsi free muscle transfer was performed. Figure 2d – Radiograph taken after proximal corticotomy. Figure 2e – Final radiograph demonstrating union at the docking site after elective bone grafting. Figure 2f – Final clinical appearance. Patient had returned to full-time employment.
walking and as a peripheral venous pump. Our free-flap failure rate was 7%, and both occurred in the tertiary group. Although comparison of flap failure with the primary group did not reach statistical significance (p = 0.076), this may be a reflection of the small number of cases.

Several randomised trials have compared the results of open fractures treated either by external fixation or by reamed or unreamed intramedullary nailing. However, limited sample sizes, small numbers of grade IIIB injuries and wide confidence intervals have limited the power of the conclusions. Studies of open tibial fractures are further limited by the heterogeneity of these injuries and the lack of a reproducible classification. Injuries classified as Gustilo and Andersen IIIB may have significant differences in terms of the zone of injury, the size of the soft-tissue defect and the extent of bone loss, although they all require soft-tissue cover (Figs 1 and 2). Furthermore, the results of open injuries presenting directly to trauma centres with experienced multidisciplinary teams may not be comparable with the outcomes achieved in district general hospitals in the UK.

The method of skeletal fixation was determined in our patients according to the anatomy and configuration of the fracture, the extent of the soft-tissue defect and the degree of contamination. Intramedullary nailing was used in diaphyseal fractures associated with minimal contamination and mild comminution, provided that definitive soft-tissue cover could be achieved within 24 to 36 hours of skeletal fixation (Fig. 1). Indications for external fixation include severe wound contamination or infection at presentation, extensive soft-tissue injuries and bone loss (> 2 cm), fractures of the proximal and distal thirds of the tibia, early infection following intramedullary nailing, and delay in soft-tissue coverage (Fig. 2). A small number of injuries with relatively stable fracture configurations deemed unsuitable for nailing were managed with traditional unilateral external fixators. Most fractures requiring an Ilizarov frame were initially stabilised with a preliminary external fixator; these patients, as well as those requiring a corticotomy and bone transport for limb lengthening to restore lost bone, underwent further surgery at approximately two weeks (14% in our series), depending on soft-tissue status. Placement of the pins and wires was determined after direct discussion between consultant plastic and orthopaedic surgeons.

There was no significant difference in the mean time to union between the fixation methods. There was a higher incidence of deep infection (4 of 27, 15%) with nails than with the Ilizarov method (1 of 35, 3%), although this did not reach statistical significance (p = 0.1). The necessity for secondary procedures such as bone grafting (17%), fibular osteotomy (11%) and revision of the implant (9%) was lower in the Ilizarov group than in the nailing group.

In spite of earlier surgery and late definitive treatment of some fractures, the rate of fracture-site infection in our series (8.5%) is comparable with other studies. We believe this reflects the efficacy of combined orthopaedic and plastic surgical management in a dedicated trauma unit, and questions the need for emergency treatment of these severe injuries in peripheral centres. Even in specialised units, inadequate soft-tissue management leads to early infection, as demonstrated by the one patient who declined free-flap reconstruction. Two patients with secondary intramedullary nailing after initial external fixation developed deep infections, a complication which is well-recognised. Late infection after fracture union has been reported in open tibial fractures and occurred in two of our patients treated with reamed nails. Both patients presented one to two years after the original injury and were successfully treated by removal of the nail, lavage and medullary reaming. There were no persistent infections in our series.

The value of complex reconstructive surgery after severe open limb trauma can only be judged by satisfactory functional outcomes, as assessed by established measurement scales. We used the modified Enneking outcome scale, originally designed for evaluation of limb salvage after sarcoma surgery, as it reflected the magnitude of complex reconstruction needed in these severely-injured patients. The modified score evaluates joint movement, deformity, strength, pain, functional activity and emotional acceptance of the surgical reconstruction, and is expressed as a percentage of normal limb function. The mean Enneking limb score was 75 (17 to 97) in the primary and 74 (33 to 90) in the tertiary group. The scores were unaffected by the method of fixation. Of our patients, 48 (67%) returned to gainful employment, which compares well with previously reported re-employment rates.

Our results lend support to a number of published studies which have shown that emergency debridement and skeletal stabilisation of these difficult injuries is not necessary in order to prevent infection. These findings support the primary transfer of patients with severe limb injuries to the nearest hospital with emergency facilities for initial assessment and resuscitation. In the absence of plastic surgical support early onward transfer to a unit with such facilities may be more appropriate than an initial debridement and stabilisation, which may compromise later surgery. We now advocate radical debridement and stabilisation by senior members of the orthopaedic and plastic surgical teams as an urgent elective procedure rather than as an emergency operation. We would suggest that the BOA/BAPS guidelines be changed to reflect the evidence accumulating against the necessity for emergency debridement.

The similar final functional outcome in primary and tertiary groups, despite the difficulties encountered in the latter, emphasises the need for the simultaneous combined management of these severe injuries by dedicated ortho-
paedic and plastic surgical teams. The establishment of triage protocols and local trauma networks for patients with severe extremity injuries would ensure their optimal management in appropriate centres at an early stage.

References


