Outcomes of infected grade IIIB open tibial fractures

Nazri Mohd Yusof[1], MBBS, MMed, *Ahmad Sukari Halim*[2], MD, FCCP

INTRODUCTION Infection following grade IIIB open tibial fracture is common. The primary aim of managing this condition is to achieve control of infection before the bone reconstruction procedure is performed. The outcomes for such patients have not been evaluated in the literature. This study was conducted to examine the outcome of a multi-stage procedure for the treatment of infected grade IIIB open tibial fractures.

METHODS Between 2004 and 2008, we treated 11 patients with infected grade IIIB open tibial fractures in our unit. The management of infected grade IIIB open tibial fracture comprised three stages, which included serial debridement, wound closure by local flap surgery and bone reconstruction. The margin of resection and the type of bone reconstruction depended on the anatomical location of the disease, the extent of osteomyelitis and patient preference regarding treatment options. Bone reconstruction procedures included bone grafting, plating, interlocking nail, hybrid and monolateral external fixator, and Ilizarov bone transport.

RESULTS Gram-negative organisms were isolated from all patients. *Pseudomonas aeruginosa* (*P. aeruginosa*) (44%) was the most common organism cultured. Infection was resolved in all patients. Nine fractures achieved union, with a mean union time of 15 months. Two patients with *P. aeruginosa* infection developed non-union of the fracture and refused additional surgery after three years of treatment.

CONCLUSION The multi-stage management approach is well-accepted and effective in controlling infection in infected grade IIIB open tibial fractures.

Keywords: severe open fracture, wound infection
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INTRODUCTION

The outcomes for open fractures have improved over the years with the use of prophylactic antibiotics, radical debridement and early soft tissue coverage. Despite encouraging developments in the management of open fractures, the infection rate in grade IIIB open fractures, especially in the tibia, is still high.[1-3] Once infection has occurred, treatment becomes complex, prolonged and socially demanding for the patient.[4] Although the infection rate following open grade IIIB tibial fractures is high, outcomes for these patients have not been evaluated in the literature. Johnson et al looked at the infectious complications of severe open tibial fracture caused by military injuries.[3] However, the mechanism and treatment of military injuries are different from those of civilian injuries. To the best of our knowledge, no studies have assessed the outcomes of infections following open tibial fractures caused by civilian injuries. This study presents the results of 11 patients with infected grade IIIB open tibial fractures that were managed in stages, with the aim of first controlling the infection before bone reconstruction was performed to achieve bone union.

METHODS

This was a prospective study conducted in 11 patients (9 male, 2 female) treated for infected grade IIIB open tibial fractures at the Advanced Trauma and Limb Reconstruction Unit, Hospital Tengku Ampuan Afzan, Pahang, Malaysia from 2004 to 2008. The mean age of the patients was 39 (range 22–82) years. Infection was diagnosed when there was evidence of purulent discharge, signs of inflammation (pain, swelling, redness and warmth) and on confirmation from bacteriological tests. Ten injuries were due to road traffic accidents and one was an industrial injury. The mean injury severity score was 12 (range 9–16). The time lapse from injury to treatment of infection ranged from one week to two years. Reasons for the delay in treatment included late referral or patients seeking alternative treatment from traditional bone setters. Four injuries were proximal tibial fractures, five were mid-shaft and two were distal. The wound sizes ranged from 2 cm × 2 cm to 7 cm × 4 cm. The mean size of the bone defect was 2 cm (range no defect to 4 cm) (Table I).

The infected open fractures were treated in three stages, as described by Patzakis and Zalavras.[4] Stage one consisted of debridement, skeletal stabilisation with an external fixator, and antibiotics. Stage two involved durable wound coverage with a local flap, while stage three entailed management of bone defects and non-united fractures (Figs. 1a–e). Depending on the location of the disease, the extent of osteomyelitis and the patient's treatment preference, a decision was made regarding the kind of surgical intervention. Margins of resection were divided into wide (> 5 mm) or marginal (< 5 mm) resections. Wide resection usually resulted in the removal of a bone segment and sometimes required bone reconstruction with an Ilizarov bone

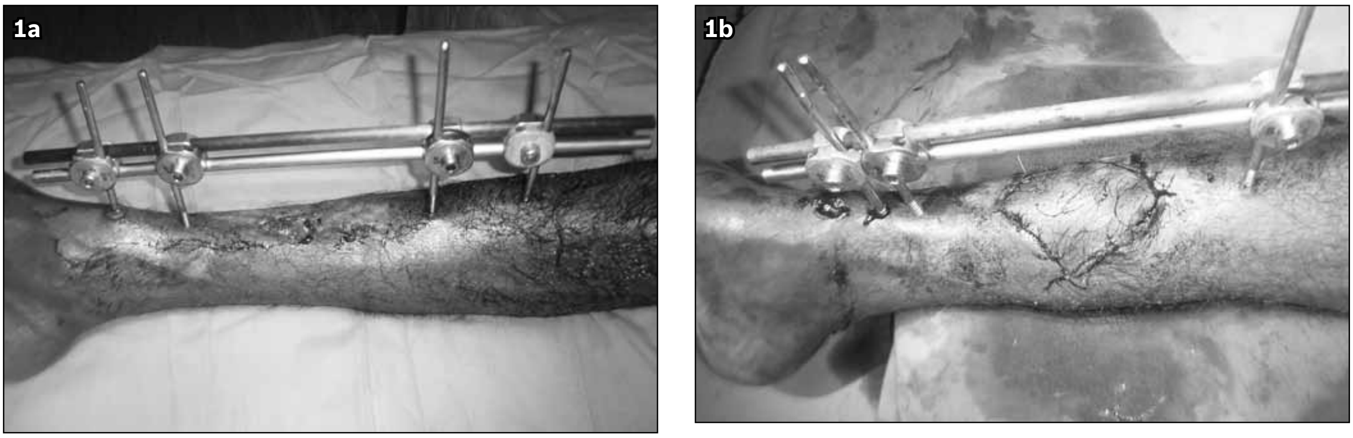
[1]Department of Orthopaedics, Traumatology and Rehabilitation, Kulliyyah of Medicine, International Islamic University of Malaysia, Kuantan, [2]Reconstructive Sciences Unit, School of Medical Science, Universiti Sains Malaysia, Kubang Kerian, Malaysia

Correspondence: A/Prof Nazri Mohd Yusof, Associate Professor, Department of Orthopaedics, Traumatology and Rehabilitation, Kulliyyah of Medicine, International Islamic University Malaysia, Jalan Hospital, Kuantan 25150, Malaysia. nazrimy2000@yahoo.com

Table I. Patient characteristics.

Patient No.	Age (yrs)/ gender	AO-OTA	Time from injury	Wound size (cm)	Bone defect size (cm)	CM	Medical problem	Organism
1	82/F	41A3	3 wks	2 × 2	None	IVA	None	*Enterobacter cloacae*
2	37/M	41C3	1 wk	2 × 2	2	IVB	Hep B+C, HIV	MRSA, *P. aeruginosa*
3	38/M	42A3	4 mths	5 × 3	4	IVA	None	*P. aeruginosa*
4	45/M	42B3	4 mths	2 × 2	2	IVA	None	*P. aeruginosa*
5	31/M	42B3	3 wks	2 × 5	4	IVA	None	*A. baumannii, K. pneumoniae*
6	23/M	42C3	1 wk	3 × 7	4	IVA	None	*A. baumannii*
7	47/M	43A2	1 wk	3 × 3	None	IVA	None	*P.* spp.
8	37/M	41C3	2 wks	4 × 2	4	IVA	Schizophrenia	*P. aeruginosa*
9	41/F	42A2	1 wk	2 × 2	None	IVB	NIDDM	*P. aeruginosa*, MRSA
10	22/M	41C2	2 yrs	7 × 4	4	IVA	None	*P. aeruginosa, E. coli, Enterobacter* spp.
11	29/M	43C3	6 mths	2 × 5	2	IVA	None	*P. aeruginosa*

AO-OTA: Orthopaedic Trauma Association classification; CM: Cierny-Mader classification; F: female; M: male; Hep: hepatitis; HIV: human immunodeficiency virus; MRSA: methicillin-resistant *Staphylococcus aureus*; *P.*: *Pseudomonas*; *A.*: *Acinetobacter*; *K.*: *Klebsiella*; NIDDM: non-insulin dependent diabetes mellitus; *E.*: *Escherichia*; IVA: diffuse infection in a healthy host; IVB: diffuse infection in an immunocompromised host



transport. Marginal resection involved only the removal of the infected and necrotic bone without segmental resection of the bone.[5]

The wound was managed with an open method using normal saline dressing. After one week, it was inspected for signs of infection, and a decision was made regarding whether it was ready for wound closure or required repeated debridement. The average number of debridements required to achieve control of the infection was 2.4 (range 2–4). The average number of debridements for acute infection (within two weeks of injury) was 2.8, while that for delayed infection (more than two weeks after injury) was 2. The most common organism isolated was *Pseudomonas* (*P.*) *aeruginosa* (44%), followed by methicillin-resistant *Staphylococcus* (*S.*) *aureus* (12.5%) and *Acinetobacter baumannii* (12.5%) (Table I). The choice of wound coverage was based on the location and size of the wound and the flap availability. A gastrocnemius flap was used for the proximal tibia. A soleus and tibialis anterior flap was used for the middle third of the tibia, and sural flap was used for the distal third of the leg. A gastrocnemius myocutaneous flap or a combination of flaps was used for large wounds.

During this period, the fracture was stabilised by external fixator. Antibiotics were given for six weeks depending on the sensitivity and culture results. They were administered intravenously and changed to oral forms after the wound had healed and the condition of the patient had improved. The bone

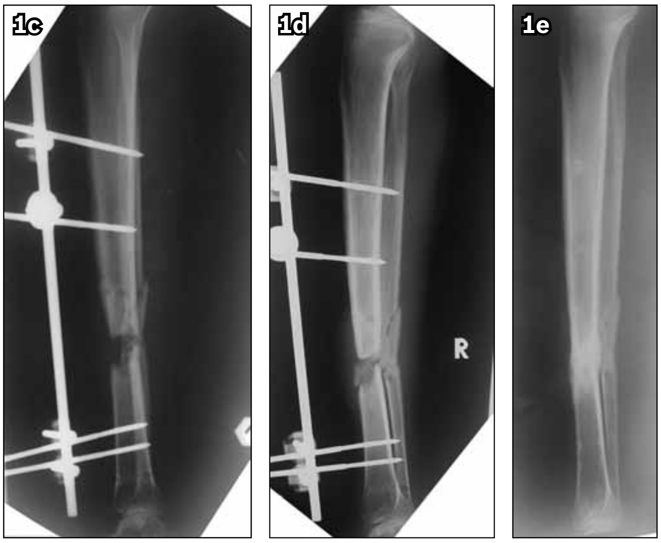


Fig. 1 Photographs of the leg show (a) sinus surrounded by scar tissue in the midshaft of the tibia; and (b) sural flap that covers the wound defect following resection of the scar tissue and infected bone. Lateral plain radiographs show (c) the diaphyseal defect following marginal resection; (d) the tricortical iliac bone graft to bridge the bone defect; and (e) consolidation of the fracture eight months post bone grafting.

Table II. Surgical outcomes of the patients.

Patient No.	Surgical margin	No. of debridements	No. of surgeries	Local flap	Bone reconstruction procedure	Union time (mths)
1	Marginal	2	2	Gastrocnemius flap	None	4
2	Marginal	4	5	Gastrocnemius flap	Ilizarov fixator and bone graft	7
3	Wide	2	4	Gastrocnemius, soleus and fasciocutaneous flap	Ilizarov bone transport	12
4	Marginal	2	7	Soleus flap	ILN and bone graft	Non-union
5	Marginal	2	4	Gastrocnemius and soleus muscle flap	Locking plate and bone graft	10
6	Wide	3	4	Gastrocnemius and fasciocutaneous flap	Ilizarov bone transport	18
7	Marginal	2	3	Sural flap	Hybrid external fixator	6
8	Marginal	3	7	Gastrocnemius flap	Ilizarov bone transport	Non-union at docking site
9	Marginal	2	4	Tibialis anterior flap	ILN	9
10	Wide	2	5	Medial gastrocnemius myocutaneous flap	Ilizarov bone transport	9
11	Marginal	2	3	Sural flap	Tricortical bone graft	8

Note: Infection was resolved in all 11 patients.
ILN: interlocking nail

reconstruction procedure was performed approximately 4–6 weeks after wound closure. Decision on the type of procedure to perform was made based on the location and size of the bone defect, the patient acceptance of and capacity to comply with the postoperative instructions and rehabilitation programme post procedure. Surgeries performed to reconstruct bone defects and to facilitate union included bone grafting, interlocking nail, plating, external fixator (hybrid, monolateral and Ilizarov) and Ilizarov bone transport. Simpler surgeries were preferred to complex and tedious reconstruction procedures unless there was a large bone defect, or the soft tissue was in poor condition. Each patient underwent an average of four operations (range 2–7) until treatment was completed (Table II). All patients were followed up at the Advanced Trauma and Limb Reconstruction Unit for a minimum period of two years, where wound healing, fracture union and infection were monitored by clinical, radiological and haematological investigations. Union time was measured from the time of the bone reconstruction procedure to the time of bone union.

RESULTS

At the end of the follow-up period, all infections were resolved. Nine patients achieved union, with a mean union time of nine (range 4–18) months. Fractures in patients with large bone defects took a longer time to consolidate. Two patients had non-union and refused further surgical intervention after three years of treatment (Table II). One patient (Patient 4) had a relapse of infection after interlocking nail and bone grafting, which was performed 11 months after the injury. The infection was controlled after nail removal, but the fracture remained non-united. He was ambulating without support but with an antalgic gait at the time of this writing. The other case (Patient 8) had non-union at the docking site after bone transport with an Ilizarov fixator. He also had an infected non-union of the femur at the same site. He was ambulating with a wheelchair at home at the time of this writing.

DISCUSSION

The rate of infection from grade IIIB open tibial fractures has been reported to be as high as 50%, while the success rate for treatment of diffuse post-traumatic osteomyelitis is only 56%.[6,7] Failure of treatment may lead to amputation or permanent disability. Many studies have assessed the outcomes of open fractures but have not explored in detail the management and outcomes of infected open fractures.[8,9] Other studies have combined cases of infected open fractures with those of infection following internal fixation of a closed fracture.[7,10] Johnson et al examined infectious complications from severe open tibial fractures caused by military injuries.[3] Military injuries differ from civilian injuries in terms of their cause and treatment protocol. Civilian injuries are characterised by high-velocity blunt injuries, while military ones are characterised by high-velocity explosive injuries. In civilian injuries, patients are sent directly to the hospital for definitive surgeries, whereas in military injuries, patients are usually transferred to a military hospital at the combat zone before being transferred to the tertiary centre for definitive treatment.[3]

We found that patients who presented with acute infections tended to have more debridement compared to those who presented with late infection. Swelling and inflammation make it difficult to determine the margins of debridement in acute infection. In delayed infections, the borders between infected and healthy tissue are more apparent, making it easier to decide on the margins of resection. We delayed the wound coverage to allow for a second look and, if necessary, to repeat debridement of the residual necrotic bone or tissue, which are the sources of persistent infection. This multi-stage procedure was found to have a higher success rate than a single-stage procedure for the treatment of osteomyelitis.[10]

Infections following grade IIIB open tibial fractures in our patients were caused mainly by Gram-negative organisms, a finding that is similar to that reported by Johnson et al.[3] Interestingly, two patients whose fractures failed to unite had *P. aeruginosa* infection, while in Johnson et al's series, persistent infection was due to staphylococci. Tice et al noted that *P. aeruginosa* infection was associated with a greater than two-fold increased risk of recurrence compared with *S. aureus* infection.[11] Simpson et al found that marginal resection was associated with recurrence in Cierny-Mader group B hosts (immunocompromised) compared to group A (healthy) hosts.[5] We did not find any difference in recurrence for both in terms of the margin of resection.

Although some authors have claimed that local flaps have higher complications, such complications did not occur in our patients.[12] We found that local flaps were reliable for wound coverage. A gastrocnemius myocutaneous flap or a combination of two or three local flaps successfully covered large wounds. We noted only one instance in which advancement of a gastrocnemius flap was performed to cover a wound that developed a persistent infection. Additionally, we observed no complications such as tip necrosis for our distal-base sural flap patient. Fodor et al observed tip necrosis of the sural flap in two subjects in their series of nine cases of osteomyelitis treated with this type of flap.[13]

Different procedures were performed for bone reconstruction, depending on the location and size of the defect, the condition of the soft tissue and patient preference. Two of our patients who had interlocking nails had recurrence of their infection. In our series, the risk of recurrence was very high when interlocking nails were used after an infected open fracture. Emara and Allam reported that only one of their 17 cases of nailing after Ilizarov bone transport for infected non-union had recurrence of infection when the interlocking nail was placed one week after the removal of the Ilizarov frame.[14] The interval between interlocking nail placement and removal of the Ilizarov fixator or the absence of pin-tract infection does not always prevent infection. Yokoyama et al's study showed that the only significant factor in preventing infection in secondary nailing was early skin closure (i.e. within one week).[15]

We noted only one case of plating and bone graft for bone reconstruction. Plating for infected non-union has been used even before the Ilizarov method was introduced. Meyer et al have reported high success rates with stable plate osteosynthesis with or without bone graft in the treatment of infected non-union of the long bones when it was performed in stages. The first stage consists of debridement, open irrigation, antibiotics and drainage, followed by bone consolidation by rigid stabilisation in the second stage.[16] We had one case of tricortical bone graft for a 2-cm diaphyseal bone defect. The tibia was stabilised with a monolateral external fixator for three months followed by a cast. It took eight months for the graft to consolidate with the tibia.

In conclusion, we found that the use of an Ilizarov fixator with bone graft or bone transport has a lower infection recurrence than internal fixation. However, we reserve this surgery for patients with large defects or soft tissue in poor condition, which are the circumstances that make internal fixation dangerous. The Ilizarov fixator was not readily accepted by our patients due to its bulk, the tedious pin site care and difficult rehabilitation programme. Shiha et al likewise reported poor compliance among their patients.[17]

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