



## Audit

# The effect of time delay on infection in open long-bone fractures: a 5-year prospective audit from a district general hospital

Jonathan Spencer, Andrew Smith, David Woods

*The Princess Margaret Hospital, Swindon, UK*

**Objectives:** To determine whether a time delay of greater than 6 h from injury to surgical debridement affected the infection rate in open long-bone fractures in a typical district general hospital in the UK.

**Design:** Prospective audit over 5 years.

**Methods:** 142 open long-bone fractures in 130 patients were seen over a 5-year period between 1996 and 2001 in our hospital. 115 fractures in 103 patients were available for study. The data were collected prospectively in weekly audit meetings. Patients were followed until clinical or radiological union occurred or until a secondary procedure for non-union or infection was carried out.

**Results:** Surgical debridement was carried out in less than 6 h from injury in 60% of cases and in greater than 6 h from injury in 40% of cases. Infection rates were 10.1% and 10.8%, respectively.

**Conclusions:** We could not demonstrate a significantly increased infection rate in patients in whom surgical debridement occurred greater than 6 h after injury.

**Key words:** Open – Fracture – Infection – National CEPOD

The management of open long-bone fractures involves resuscitation of the patient, assessment of the wound and limb, classification of the fracture, intravenous antibiotics and tetanus toxoid. Best practice would suggest urgent debridement of the wound and stabilisation of the fracture using a range of techniques.<sup>1–4</sup> Infection, mal and non-union are the main complications following open fractures. The severity of the injury, the bone affected and time delays to each of the management steps may affect the outcome.<sup>2,3</sup> The urgency with which debridement should be performed has not been clearly

defined. However, a rule has been established that this should be within 6 h of injury and this is endorsed by the British Orthopaedic Association.<sup>5</sup> This may result in complex operations being performed late at night with the associated risks as outlined by sequential National CEPOD reports.<sup>6</sup> These disadvantages may outweigh the perceived advantages of an emergency operation.

In Swindon, we have prospectively audited the outcome of 142 open long-bone fractures presenting to our hospital over a 5-year period between January 1996 and January 2001. Standards of care of these patients were

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**Correspondence to:** Mr Jonathan Spencer, Specialist Registrar Trauma and Orthopaedics, Nuffield Department of Orthopaedic Surgery, Nuffield Orthopaedic Centre, Windmill Road, Oxford OX3 7LD, UK. E-mail: jonmfspencer@aol.com

**Present addresses:** Mr Andrew Smith, Specialist Registrar Trauma and Orthopaedics, Royal Sussex County Hospital, Brighton, UK  
Mr David Woods, Consultant Orthopaedic Surgeon, Great Western Hospital, Swindon, UK

Table 1 Site of open fracture

Site	Number	United without infection	Infected
Femur	11	11	0
Tibia	41	35	6
Ankle	7	6	1
Humerus	12	12	0
Forearm	22	19	3
Wrist	22	20	2
Total	115	103	12

set in our protocol and we record our ability to comply with them. We have analysed our deep infection rate and discuss factors involved in this. We challenge the view that debridement and fixation needs to be achieved within 6 h and discuss reasons why this may not be advantageous.

### Patients and Methods

The management of all open long-bone fractures presenting to our hospital between January 1996 and January 2001 was based on a simple protocol. This stated that during the initial management of these injuries:

1. Senior orthopaedic surgeons (registrar and above) are involved from the outset.
2. All wounds are superficially cleaned, photographed and then covered.
3. Fractures are splinted.
4. 1 g of i.v. cephadrine ( $\pm$  metronidazole) is given.
5. Antitetanus prophylaxis is given (0.5 ml) if the patient has not been immunised within 10 years.
6. Wound debridement, lavage (with at least 6 l of saline) and fracture stabilisation occurs within 6 h of injury.

Fractures were stabilised using a variety of techniques, depending on individual characteristics. Wounds were left open and brought back to theatre at 48 h for secondary debridement or closure. Patients requiring plastic surgery for wound closure were referred to the regional centre as soon as possible.

Patients with multiple injuries or severe head injuries were transferred either immediately or after initial stabilisation, depending on the circumstances. These patients have been excluded from the study as the treatment of the long-bone fracture occurred outside our hospital.

### Data collection

The data on all open fractures were recorded in a regular weekly audit meeting at the end of each consultant's 'trauma week'. The duty trauma consultant and all the junior staff attended this meeting.

Table 2 Gustilo and Anderson grade

Grade	Number	United without infection	Infected
I	39	37	2
II	19	14	5
IIIa	36	34	2
IIIb	21	18	3
IIIc	0	0	0
Total	115	103	12

In each case, in addition to the demographic data, we recorded: (i) the site of the fracture and grade using the Gustilo and Anderson classification;<sup>3</sup> (ii) the time of the injury; (iii) administration of intravenous antibiotics; and (iv) the time the patient went to theatre.

The patients were followed up until radiological union had occurred or infection (or non-union) was confirmed. The diagnosis of deep infection was made clinically (swelling, erythema and pain) and confirmed with deep cultures.<sup>1,4,7</sup> Cultures were obtained either at secondary procedure to treat infection or non-union, or from discharging wounds.

### Results

During this time period, 130 patients presented to our hospital with 142 open fractures. Seventeen were transferred to other units prior to definitive treatment and 10 patients died of their injuries or related problems within 4 months of their initial fracture (with no evidence of infection). These patients were excluded from the study.

This left 103 patients with 115 open fractures in the study group. The mean age was 45 years (range, 4–98 years). The mechanism of injury was a fall (51%), road traffic accident (40%) and other causes (9%). Table 1 shows the distribution of the fractures. The tibia accounted for 35% of fractures studied; of these, 14.6% became infected.

Table 2 shows the distribution of fracture grades (using the Gustilo and Anderson grading system<sup>3</sup>) throughout the study group. No grade IIIc fractures were included as these were associated with other severe injuries requiring transfer to regional centres.

Intramedullary nails were used in 35 cases for the lower limb, open reduction and internal fixation in 43 cases and external fixators in 15 cases. The remaining 25 cases were treated by other methods, including plaster of Paris and K-wires for distal radial fractures.

Of the open fractures, 69 (60%) were surgically debrided within 6 h of injury, 95 (82%) within 8 h, 107 (93%) within 12 h and 8 (7%) were not debrided for over 12 h, usually due to late presentation. This is represented graphically in Figure 1.

The overall infection rate was 10.4%. Of the 60% of fractures that were surgically debrided within 6 h of

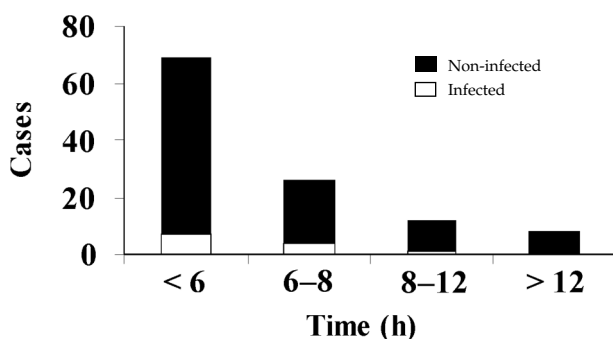


Figure 1 Time to surgical debridement.

injury, the infection rate was 10.1%. Of the 40% of fractures debrided after 6 h from injury, the infection rate was 10.8% (Table 3). Analysis using the Chi-squared test shows no significant difference in the results ( $P > 0.05$ ). However, the small numbers of cases may produce misleading results (type II error).

#### Infected cases debrided after the 6-h threshold

Table 4 shows the individual infected cases and their outcome. Of note, four of the five grade III fractures were in the group debrided within 6 h. We recognise that this may bias the results. All patients received intravenous antibiotics within 4 h of injury and the longest time delay to debridement was 9.5 h. In two patients, both of whom developed discharging sinus, the infective organism was not isolated despite repeated attempts at culture. Both were treated with broad-spectrum antibiotics (cephradine and metronidazole), which may have interfered with the culture result. The fracture in case 8 eventually united. Case 9 was an elderly diabetic lady who refused further treatment after 6 months follow-up.

#### Discussion

The management of open long-bone fractures has created much controversy and many of the protocols perceived as best practice are based on historical precedent rather than scientific evidence.<sup>3,4,8</sup> Although much has been written on the management of open fractures, there is little

Table 3 Time delay to surgical debridement

Time delay to debridement	No.	United without infection	Infected
Less than 6 h	69 (60%)	62 (89.9%)	7 (10.1%)
Over 6 h	46 (40%)	41 (89.1%)	5 (10.8%)
Total	115	103	12

evidence to support the need for emergency surgical treatment.

The policy of treating these injuries within 6 h may not be in the patient's best interest in all cases. It can result in complex cases being performed out-of-hours by relatively inexperienced surgeons, anaesthetists and theatre staff, with a potentially less favourable outcome.

From observational studies, it would appear that there is an association between deep infection a high Gustilo and Anderson fracture grade<sup>3,9</sup> and the lower limb.<sup>10</sup> Our study concurs with this, finding a high rate of infection in Gustilo and Anderson grade II and III fractures involving the lower limb (seven of our twelve infected cases). Only one recent paper has described an association between delay to treatment and an adverse outcome. However, 77% of their grade III fractures were in the delayed group.<sup>11</sup> Other papers have shown no clear link with time to antibiotics or theatre.<sup>9,10</sup>

Our audit revealed that 60% of open fractures were operated on within 6 h and 40% were delayed. In our study, many of the delays were due to late presentation, lack of hospital beds and lack of availability of operating time, which is a common problem in many district general hospitals in the UK. Our overall infection rate was 10.4%, which is similar to levels reported in other studies.<sup>3,10</sup> We did not feel that the infection rates in those patients treated within 6 h differed significantly from those treated after 6 h. In order to acquire a definitive answer, a randomised controlled trial would be required. This is difficult to perform because large numbers of patients are required in order to overcome confounding factors created by patients (*e.g.* smoking and diabetes), fractures (*e.g.* site and grade) and surgeons (*e.g.* experience, aggressiveness of debridement and choice of stabilisation device). In addition, it would be unethical to delay a patient's treatment solely for the purposes of a trial.

If emergency treatment can be demonstrated to give clear advantage to the patient, then it can be justified. However, a delay may be appropriate under certain circumstances in order to provide the best overall treatment of the fracture.

#### Conclusions

Current best practice suggests open long-bone fractures should be treated with debridement and fixation within 6 h of injury. We have prospectively audited our compliance with these clinical standards, and have found that, in a typical district general hospital setting in the UK, only 60% of patients were actually in theatre within 6 h. We have not been able to demonstrate a significantly increased infection rate in those patients who were delayed. Given the disadvantages of treating such injuries

Table 4 Infected cases debrided before and after the 6-h threshold

Case	Age	Mechanism of injury	Site of injury	Gustilo and Anderson grade	Time delay to i.v. antibiotics (h)	Time delay to surgical debridement (h)	Method of skeletal stabilisation	Infecting organism	Presentation	Outcome
<b>Before the 6-h threshold</b>										
1	41	RTA	Distal third tibia	IIIa	1.5	3.5	External fixation	Diphtheroids	Non-union requiring bone grafting	United at 1 year
2	36	Fall	Distal radius	II	4	4	ORIF	<i>Staphylococcus aureus</i>	Wound breakdown	Settled and united after plate removal
3	26	RTA	Midshaft tibia	II	1	5	i.m. nail	<i>Staphylococcus aureus</i>	Non-union	Referred for specialist treatment
4	86	Fall	Distal third tibia	II	2	4	External fixation	<i>Staphylococcus aureus</i>	Wound breakdown	Below knee amputation
5	38	RTA	Midshaft tibia	IIIb	1	5	i.m. nail	MRSA	Non-union	Referred for specialist treatment
6	28	RTA	Distal radius and ulna	IIIb	2	4	External fixation	<i>Staphylococcus aureus</i>	Non-union	Referred for specialist treatment
7	17	RTA	Distal third tibia	IIIb	3	6	External fixation	<i>Staphylococcus aureus</i>	Non-union	Referred for specialist treatment
<b>After the 6-h threshold</b>										
8	66	Fall	Distal radius	I	1	7	ORIF	Not isolated	Developed discharging sinus	Settled and united with i.v. antibiotics
9	80	Fall	Ankle	II	0.5	7	ORIF	Not isolated	Diabetic developed discharging sinus	Lost to follow-up after 6 months
10	38	RTA	Midshaft ulna	I	3	7	External fixation	Coagulase negative <i>Staphylococcus</i>	Non-union	Referred for specialist treatment
11	36	Assault	Midshaft radius and ulna	IIIa	3	7	ORIF	<i>Staphylococcus aureus</i>	Wound breakdown	Settled and united with i.v. antibiotics
12	26	RTA	Midshaft tibia	II	2.5	9.5	i.m. nail	<i>Staphylococcus aureus</i>	Wound breakdown	Settled and united after locking screw removal

out-of-hours and the lack of evidence from recent literature that it is indeed best practice, we propose that these injuries may be better treated during normal theatre hours by experienced teams, provided the early administration of intravenous antibiotics, basic wound care and splintage occurs.

We plan to continue to audit these cases and would strongly urge all similar units to do the same using our protocol as described above. It may then, using meta-analysis, be possible to decide whether emergency care of the patients is justified in all circumstances, or a change to the protocol is in the patient's best interest.

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