



## Medical audit

# Audit of open tibial diaphyseal fracture management at a district accident centre

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Preston Acute Hospital is a designated district accident centre with a 24 h flying squad and on-site plastic and orthopaedic units. We performed a retrospective 5-year survey of open tibial shaft fracture management at our unit and compared our treatment to the guidelines of the British Orthopaedic Association (BOA) and British Association of Plastic Surgeons (BAPS). Deficiencies were highlighted and changes in practice made. We then re-audited our figures over an 18-month period to see if clinical improvements had been made.

The audit demonstrated an incidence of open tibial shaft fractures of 15 per 50,000 new patients per year in accident and emergency. Gustilo grading, and thus full appreciation of soft tissues injury, was being underestimated, with 8% of the injuries undergraded at the time of surgery: 17% of Gustilo IIIA and 85% Gustilo IIIB required flap cover. Seventy-four percent of patients received their first orthopaedic procedure within the recommended 6 h of admission, but despite the on-site plastics unit, only 50% of cases in the initial survey had their soft tissue defect covered by the recommended 5 days. After changes to practice, 80% patients received their first orthopaedic procedure within the recommended 6 h of admission, and all had their soft tissue defect covered within 5 days; 5% of cases required fasciotomy to relieve compartment syndrome.

We highlight features to alert the high energy (Gustilo III) status and recommend immediate involvement of plastic surgical colleagues with these injuries. We also highlight a high incidence of compartment syndrome in the young male patient with the lower energy Gustilo I injury.

*Key words:* Audit – Open tibial fractures – Compartment syndrome

Open fractures have been estimated to occur with a frequency of around 23 per 100,000 patients per year.<sup>1</sup> Open tibial diaphyseal fractures account for

around 25% of all open fractures, and approximately 55% of all open tibial diaphyseal fractures require some form of plastic surgery and, therefore a combined

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approach with plastic surgical colleagues.<sup>2,3</sup> Given the combined British Orthopaedic Association (BOA) and British Association of Plastic Surgeons (BAPS) guidelines for the management of open tibial fractures,<sup>2</sup> we decided to audit our figures as a designated district accident centre with a combined on-site orthopaedic and plastic surgical unit, to see if any deficiencies could be highlighted and changes in practice made.

## Patients and Methods

Preston Acute Hospital is a designated district accident centre.<sup>4</sup> It has a 24 h flying squad service, and the hospital also receives admissions from ambulance and police helicopters (which cover a large geographical area of the North West – from Manchester to the south and east, the Lake District to the north and the Irish Sea coastline to the west). Due to both its geographical location and the on-site provision of the subregional specialities of plastic surgery, maxillofacial surgery and neurosurgery, it has been felt that the unit could in time be upgraded to a regional trauma centre.<sup>4,5</sup> The accident and emergency (A&E) department sees about 55,000 new patients per year.

We initially performed a retrospective 5-year survey (April 1991 to March 1996) of the treatment of all patients who were admitted through the A&E department with open tibial diaphyseal fractures. The patients were identified via a computer search using the International Classification of Diseases, Version 10 (ICD10) diagnosis code for open tibial diaphyseal fractures. Of those patients identified from the hospital information system (ICD10), all case notes and radiographs were retrieved. The following data were recorded: the Gustilo grading of the fracture,<sup>6,7</sup> the polytrauma rate, time taken from arrival in the A&E department to the first orthopaedic procedure, initial treatment undertaken, definitive orthopaedic management, requirement for plastic surgery, time taken to get definitive soft tissue cover, requirement for fasciotomy and amputation rate.

Polytrauma was defined as the patient having either one other long bone fracture, an associated head injury or significant associated chest or abdominal trauma.<sup>4</sup> The time taken from arrival in the A&E department to the first orthopaedic procedure was obtained from the A&E record card and the time on the anaesthetic record sheet for the commencement of surgery.

Data from the initial survey were critically analysed against the published BOA/BAPS guidelines for the management of these injuries.<sup>2</sup> Deficiencies were highlighted and several changes in practice made, such that any high-energy tibial injury subsequently received a

*Table 1 Open tibial shaft fractures (April 1991 to March 1996); distribution of Gustilo grades, requirement for plastic surgery, time taken to definitive soft tissue cover, treatment regime and incidence of compartment syndrome*

	Gustilo grade				
	I	II	IIIA	IIIB	IIIC
Incidence	25	22	30	10	–
Polytrauma	–	2	12	9	–
Death	–	–	4	1	–
<i>Requirement for plastic surgery</i>					
SSG	1	3	8	2	–
Local flap	–	1	5	7	–
Free flap	–	–	–	1	–
Amputation	–	–	–	–	–
<i>Time to definitive soft tissue cover</i>					
< 5 days	1	1	7	5	–
6–10 days	–	2	3	2	–
11–20 days	–	–	2	1	–
> 20 days	–	1	1	2	–
<i>Treatment regimen</i>					
MUA cast	22	14	4	–	–
Plate	1	–	–	–	–
Unreamed nail	–	2	7	3	–
Reamed nail	2	1	1	1	–
External fixator	2	5	18	6	–
Compartment syndrome	4	1	–	–	–

plastic surgical opinion at the first look procedure. To complete the audit loop, we then prospectively analysed management of all patients with open tibial diaphyseal fractures admitted through the A&E department during the 18 month period from December 1997 to May 1999. The same data were recorded and analysed as stated above for our initial 5 year retrospective period.

## Results

There were 87 open tibial diaphyseal fractures (in 86 patients) during the retrospective 5 year study period (April 1991 to March 1996) and 20 fractures in the prospective 18-month period (December 1997 to May 1999). Tables 1 and 2 summarise the results. Overall, the incidence of associated polytrauma was 27%. There were 5 deaths in the series, all occurring in the polytrauma patients.

There were 7 patients from the initial 87 (8%) who after review of the case notes, reading of the mechanism of injury, description of the soft tissue wound at the time of surgery and review of the fracture pattern on the radiographs, had their Gustilo grading subsequently upgraded (from the original grade in the case notes) for the purposes of this audit to IIIA (high-energy injury). All

Table 2 Open tibial shaft fractures (December 1997 to May 1999); distribution of Gustilo grades, requirement for plastic surgery, time taken to definitive soft tissue cover, treatment regime and incidence of compartment syndrome

	Gustilo grade				
	I	II	IIIA	IIIB	IIIC
Incidence	5	6	5	3	1
Polytrauma	-	-	3	2	1
Death	-	-	-	-	-
<i>Requirement for plastic surgery</i>					
SSG	-	1	2	-	-
Local flap	-	-	1	3	-
Free flap	-	-	-	-	-
Amputation	-	-	-	-	1
<i>Time to definitive soft tissue cover</i>					
< 5 days	-	1	3	3	-
<i>Treatment regimen</i>					
MUA cast	5	2	-	-	-
Plate	-	-	-	-	-
Unreamed nail	-	-	1	-	-
Reamed nail	-	3	-	-	-
External fixator	-	1	4	3	-
Compartment syndrome	-	-	-	-	-

20 patients in the prospective series had their associated soft tissue component to the fracture correctly graded at the time of initial inspection and debridement.

Overall, 33% of patients (35 cases) required plastic surgery. There was both an increasing requirement for plastic surgery and a greater requirement for flap cover in the more severe open tibial shaft fracture. There was one amputation in a patient with a Gustilo IIIC fracture. During the retrospective 5-year period, only 50% of patients obtained definitive soft tissue cover within the first 5 days (as recommended by BOA/BAPS). For 14% of patients, the time period for definitive soft tissue cover was more than 20 days. The numbers were too small to analyse whether the delayed period to definitive soft tissue cover or Gustilo grading of the fracture had any statistical bearing on the superficial or deep infection rates. In the prospective 18-month period, all patients had definitive soft tissue cover within the recommended 5 days.

During the retrospective 5 year period, 74% of patients received surgery within the recommended first 6 h, 26% received surgery within 7–12 h of arrival and no patient took longer than 12 h to receive primary surgery (wound extension, wound debridement, copious lavage

with at least 6 l of N saline or Hartmann's solution and fracture stabilisation). By comparison, 80% of patients in the prospective 18-month period had surgery within the first 6 h, with the remaining 20% having surgery within 7–12 h.

Manipulation under anaesthesia and application of an above-knee cast (MUA and cast) was the most popular treatment adopted for the less severe Gustilo grades of fracture, with external fixation being more commonly adopted to manage those fractures associated with greater soft tissue injury.

Overall there was a 4.6% incidence (5 patients) of compartment syndrome requiring fasciotomy, with the highest proportion associated with the lower energy Gustilo I injury (13.3%). All cases of compartment syndrome occurred in the young male patient (average age 24 years; range, 20–30 years). Three of these patients had been treated with a reamed intramedullary nail, one patient had been treated with an external fixator and one patient had been treated with MUA and cast. There were no cases of missed compartment syndrome during the study period.

## Discussion

From our audit, open tibial diaphyseal fractures occur with a frequency of 30 per 100,000 new patients seen in the A&E department. This contrasts with the figure from the Edinburgh trauma unit of 44 per 100,000 new A&E patients.<sup>2</sup> Thus, for an average district general hospital (DGH) serving a population of 250,000 (and seeing around 50,000 new patients in A&E per year),<sup>7</sup> there would be 15–18 open tibial shaft fractures per year. Given that about 70% of these would be Gustilo grade II or above (and thus with an increased probability of shared involvement between orthopaedic and plastic surgical disciplines), this equates to 12 patients per year at an average DGH who would possibly require joint management. The 27% associated polytrauma rate was slightly higher than the 19% found by Court-Brown *et al.*<sup>3</sup>

Early inter-speciality co-operation is essential in the management of these fractures. This begins with the recognition of the high energy injury, as these are immediately graded Gustilo III regardless of the size of the soft tissue wound,<sup>7</sup> and, as such, have a poorer prognosis. Our retrospective 5-year series showed that for 8% of cases, the high energy imparted to the soft tissues (and thus requirement for a plastic surgical opinion) was not fully appreciated, as after subsequent analysis from the case notes of the mechanism of injury, the description of the soft tissue wound at the time of initial surgery and the radiographic appearance of the

fracture pattern, it was clear that, in these cases, the injuries were under-graded at the time of treatment. In order to grade these fractures correctly, knowledge of the mechanism of injury is essential, as this will often give the only indication of the level of energy transfer to the soft tissues. Indicators of high energy from the history include any road traffic accident (drivers, passengers or pedestrians), falls from height or any crush injury. From the examination, indicators include imprints or tattooing from tyres or dirt, crush or burst wounds, de-gloving injuries or signs of compartment syndrome. Radiographic features include multiple bone fragments, wide separation of the fracture fragments, segmental fractures, air in the tissues or more than one fracture in the same limb. Because of the poor outcome often associated with high-energy injuries, it is essential that both the orthopaedic consultant and (if possible) the plastic surgical consultant be informed on the night of admission in these cases, so that a joint treatment plan can be initiated.<sup>2</sup> The minimal response from the plastic surgeon is advice, although ideally the plastic surgeon should review the wound on admission or at the initial surgical procedure,<sup>2</sup> as we found that 17% of Gustilo IIIA and 85% Gustilo IIIB injuries required flap cover.

It is recommended that all open tibial fractures be treated as an orthopaedic emergency, with the first orthopaedic procedure undertaken within 6 h of admission.<sup>2</sup> In the retrospective 5-year series, 74% of cases had surgery within 6 h, but all within 12 hours of admission. All wounds should be covered within 5 days.<sup>2</sup> Whilst analysis of our retrospective series revealed good figures for time to first surgical procedure, the time to definitive cover of the soft tissue wound was poor. In only 50% of cases was the wound covered within the recommended 5 days, despite plastic surgical colleagues being on site. In 14% of cases, definitive surgical cover was not obtained until more than 20 days from admission (maximum 28 days). We felt that the main reason for this was due to an underestimation of the full extent of the soft tissue injury associated with these fractures, both at the time of the initial examination in A&E and at the time of the primary surgical procedure, thus leading to poor co-ordination with the plastic surgical team. To re-address this problem, we instituted a change in policy such that any high energy tibial injury subsequently received a plastic surgical opinion at the first re-look procedure.

In the 18-month series, all the injuries were correctly graded according to the Gustilo classification:<sup>7</sup> 80% of patients had their initial orthopaedic procedure within 6 h of arrival to A&E, but all within 12 h of admission. In contrast to the earlier 5 year series, all high-energy

injuries received an early opinion from the plastic surgical team and all wounds had definitive soft tissue cover by the recommended 5 days (Table 2).

Overall, 33% of the open tibial fractures required plastic surgery. This is much less than the 55% reported by the Edinburgh unit.<sup>2</sup> Comparing the figures, it appears that a much more conservative approach to the soft tissue management of the Gustilo II injuries was taken by the Preston unit, with only 18% of this subgroup undergoing plastic surgery.

There was, as expected, a trend towards external fixation for those fractures associated with the greatest soft tissue trauma (Tables 1 & 2). Compartment syndrome requiring fasciotomy does occur in open fractures. Our audit revealed an overall rate of 4.7%, which is comparable with 6% as reported by Keating *et al.*,<sup>9</sup> but we noticed a much higher incidence (13.3%) in the lower energy Gustilo I injuries. All cases of compartment syndrome occurred in the young male patient, with the average patient's age being 24 years. Whilst there was a higher incidence in those patients treated with reamed intramedullary nailing (Tables 1 & 2), the numbers are too small to draw any conclusions. There were no cases of missed compartment syndrome in this study (the endpoint taken as reported cases of ischaemic muscle contracture). There are two reasons why compartment syndrome may occur in open fractures.<sup>2</sup> First, some of the compartments in the limb remain closed, despite the severity of the soft tissue defect. Second, compartment syndrome can remain localised (part of the muscle in which adjacent parts have been decompressed, due to overlying fascial damage, is enclosed in intact fascia and consequently develops a high compartment pressure). The pressure threshold for fasciotomy has now been established<sup>10</sup> and depends on both the diastolic blood pressure and the actual compartment pressure. If the differential pressure is less than 30 mmHg, then fasciotomy is recommended.

## Conclusions

The findings from this audit highlight several points.

1. An average DGH seeing around 50,000 new patients per year in A&E will expect to see around 15–18 open tibial shaft fractures per year. Of these, 12 will be Gustilo grade II or above and, as such, have a high probability of requiring joint care with the plastic surgical colleagues. Their involvement should start as early as possible, preferably on the night of admission.

2. Gustilo grading, and thus full appreciation of the energy imparted to the soft tissues, is still underestimated. Specific points in the history, examination and radiographic features highlighted above should alert one to the high energy (Gustilo III) status. We found that 17% of Gustilo IIIA and 85% of Gustilo IIIB injuries required flap cover.
3. An open tibial shaft fracture should be treated as an orthopaedic emergency with the first orthopaedic procedure being undertaken within 6 h of admission.
4. Soft tissue defects should be preferentially covered within 5 days. Our initial survey, even with plastic surgery on site, indicated that this was not happening in 50% of cases. Greater appreciation of the soft tissues and greater immediate involvement of the plastic surgery team must occur.
5. Compartment syndrome in open tibial fractures requiring fasciotomy occurs with an overall frequency of around 5%. There is, however, a much higher incidence (13%) in lower energy Gustilo I injuries. The incidence is also much higher in the young male patient.

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