Open tibial fractures in children are reported to be associated with a high incidence of early and late complications, which are more frequent in those with Gustilo III injuries. Buckley et al. reviewed 41 children and found that the frequencies of compartment syndrome, vascular injury, infection and delayed union over the long term were similar to those reported for open fractures in adults. There is also still considerable controversy about the use of external fixation to manage children's fractures. The indications for external fixation are examined in the light of our results and the evidence available in the literature. We have reviewed our cases and compared them with similar reported series.

**Methods**

The notes and X-rays of 27 children (15 boys and 11 girls) aged 3-15 (mean 9.5) years who sustained an...
open tibial fracture between 1992 and 1998 were reviewed. In the same period 360 children under the age of 16 sustained closed fractures of the tibia, therefore open injuries accounted for 6.3% of tibial fractures. They were all treated in Bradford Royal Infirmary.

The injury followed car accidents in 25, in one it was caused by a kick by a horse and in another following a fall. The right side was involved in 12 and the left in 15. Two patients had an associated head injury and one had an ipsilateral femoral fracture. Gustilo classification was used for wound grading. Thirteen patients had grade I, 6 patients had grade II, 3 patients had grade IIIa and 5 patients had grade IIIb.

The fracture patterns were assessed. The commonest injury seen was a transverse or oblique fracture at the junction between the middle and lower thirds of the tibia, the fracture was situated in the distal third of tibia in 4 patients, and between the upper and the middle third of tibia in 2 patients. The fracture affected the mid-shaft in one patient. The fibula was intact in 3 cases and the fracture was segmental in one patient.

All patients were managed by primary aggressive debridement and wound toilet with lavage. Two patients had immediate primary wound closure. Debridement primary (1-2 days after initial debridement) wound closure was carried out in 8 and the wound was closed secondarily (1-2 days after initial debridement) in 3. Partial split skin graft was required in 5 patients and fasciocutaneous flap in 4, in the remainder the wound healed by secondary intention over a mean period of 2 weeks (Table 1).

The decision for type of stabilization of the fracture was made according to surgeon’s preference. Primary external fixation was used in 3 patients, in three because of unstable fracture configuration (segmental or comminuted), and in a further two to aid with soft tissue management. The remainder (Twenty-two cases) was treated with above-knee plaster of Paris splintage with a window in the wound. Once stable (5-8 weeks after injury), the above knee cast was replaced by a tibial cast brace until radiological fracture union. In the group treated by external fixation, the fixator was removed in all apart from one 6-7 weeks after the operation. A below knee walking cast was then applied until radiological fracture union.

### Table 1. Showing the methods of wound closure in this series

<table>
<thead>
<tr>
<th>Grade</th>
<th>I</th>
<th>II</th>
<th>IIIA</th>
<th>IIIB</th>
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<tbody>
<tr>
<td>Primary closure</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delayed primary closure</td>
<td>2</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary closure</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skin graft</td>
<td>1</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Granulation tissue</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Fasciocutaneous flap</td>
<td>4</td>
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</table>

**Results**

Mean length of in-patient hospital admission was 9.4 days (1-25 days), the duration of hospital stay was longer in patients with open Gustilo IIIb fracture. One patient in our series was treated by skeletal traction of ipsilateral femoral fracture and slab immobilization for tibial fracture. Following primary debridement and skeletal stabilization, the mean number of visits after this was 2 visits (1-5 visits). Repeat visits to the orthopaedic clinic was 5 (1-11). Visits change of above knee plaster to a below knee Miami cast was carried out when the senior surgeon felt that there is callus. This period ranged from a mean 5 weeks duration for grade II to a mean period of 8 weeks for grade IIIb cases. The fracture was considered united when radiological signs of healing were noticed. Mean duration for healing was 9 weeks for grade II, 11 weeks for grade IIIA and 12 weeks for grade III open tibial fracture. The mean period of follow up was 6 months (1.5-48 months). The final outcome of our patients was good, there was no limb length inequality or joint stiffness. The fractures healed in all of our cases.

**Complications**

1. One case of compartment syndrome was encountered and was released/decompressed in the standard manner. This patient’s fracture was grade IIIb open treated by external fixator.
2. In five cases the tibial fracture displaced in plaster, external fixator was applied to maintain the position in 2 and in internal fixator using Kirshner...
wire and screw fixation in one. Re-manipulation with further POP application was required in the remaining two.

3. In a case, 15 degrees varus malunion required corrective osteotomy at 15 months after injury occurred in a case. This patient, 12 years old boy sustained a grade IIIB open tibial fracture, the tibia was fixed initially using an Orthofix unilateral frame and the skin defect was closed using partial split skin graft. Malunion resulted from problems encountered with the fixator and delayed healing of this short oblique comminuted fracture. Within two weeks of injury, the patient developed severe pin track infection requiring re-sitting of one set of pins, the fixator was dynamised 5 weeks following injury. Because of delayed healing, the fixator was kept for three months.

4. Two cases of delayed union (took 6 months to heal) were encountered, both were comminuted grade IIIB fractures, both treated in external fixator frames. Neither required further intervention.

Problems of surgical treatment

1. Painful keloid scar for ma tion of split skin graft, which settled spontaneously.¹
2. Four cases of pin track infection. These were treated with antibiotics and pin toilet. In one case re-sitting of one set of pins was required and position of the fracture was lost.

Discussion

Several issues surrounding the management of open tibial fractures in children remain unresolved and controversial. The issues of main concern revolve around the management of the bony injury, whether to definitively fix, either intramedially or extramedially, or whether to treat conservatively in a cast. Other is sues of per haps less concern, but which add con fusion to the sub ject, in clude the ques tion of the imperfection of Gustilo grading of fractures with inter and intra observer er rors, and the ques tion of how much re- modelling we might ex pect in a child (and con se quently how much de for mity we can con sider acceptable).³

The man age ment of the ske tal injury re mains controversial. In adults skeletal fixa tion is used rou tinely for open frac tures whereas in chil dren it has been dem on strated that aggres sive man age ment of the soft tis sues with con servative frac ture man age ment leads to a sat is fac tory out come in a ma jor ity of cases. The frac tor of age has well been stu died in re la tion to open tibial frac ture in chil dren.⁴ Children younger than eleven has lower in ci dence of in fe c tion and better heal ing po ten tial of the frac ture com pared to adults.⁴-⁸

In the ma jor ity of our pa tients, we were able to man age the soft tis sue in jury in col lab o ra tion with the plas tic team in through a win dow in the plas ter cast. Plas ter of Paris did not sig nif i cantly im pede the man age ment of the soft tis sue in ju ries.

Although most au thor s would agree on the ab solute in di ca tions for de fin i tive sta bili sa tion. (1. The pa tient with mul ti ple in ju ries. 2. The leg with a com bi na tion of se vere ske tal and soft tis sue in ju ries re quir ing in ten sive plas tic or vas cu lar sur gi cal man age ment), the rel a tive in di ca tions are not so well-established, with au thors vari ously re port ing ex ter nal fixator us age as high as 80% in Buck ley se ries and as low as 10.3% in Irwin se ries.¹⁷ (Ta ble 2). Fac tors such as frac ture con fig u ra tion and sta bil ity are men tioned, with no clear guide lines. In prac tice, we be lieve that these in ju ries are of such di verse pat terns that they have to be treated in di vid u ally; those frac tures which ex hibit gross in sta bil ity, as a re sult of the frac ture pat-

<table>
<thead>
<tr>
<th>Table 2. Method of treatment compared with Hope and Cole and Irwin</th>
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<tr>
<td>Treatment</td>
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<tr>
<td>---------------------</td>
</tr>
<tr>
<td>This study</td>
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<tr>
<td>Irwin et al.</td>
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<td>Hope and Cole</td>
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tern (displaced segmental fracture or with bone loss or extensive comminution) with associated soft tissue stripping, should be treated with an external fixator; the remaining fractures, which in children represent the majority of cases, are manageable by standard conservative casting techniques. Using these principles, only 6 of our 16 Type III B fractures (37.5%) required external fixator. The main indication for external fixation in our experience is the failure of retaining the position of the fracture in plaster after reduction. Severe soft tissue requiring repeated intervention was another indication for external fixation. The complication most encountered in our series when an external fixator was used, is pin track infection. The incidence of pin track infection in our series was comparable to that reported in other series.

Delayed union and re-fracture are also well documented in relation to the use external fixation. One of our patients developed a significant malunion requiring corrective osteotomy. This patient was initially treated by external fixation of the fracture and lost position due to pin loosening with infection. An early dynamization of the external fixation (five weeks following surgery) may have contributed to the pin track infection.

Malunion is reported in 12% in Irwin series, the rate of malunion was 12% compared to ours (3.4%). Delayed union following open fracture of tibia is reported to be as high as 14%. In Irwin series this is as low as 5%. Two of our cases (7.3%) had delayed union, none required surgical intervention. We believe that delayed union is related to the severity of initial skeletal and soft tissue injury.

Our results and others support the statement that external fixation is not necessary in the treatment of open tibial fractures in children. Open tibial fracture in children should be treated differently from adult open fractures of the tibia. A randomized study comparing the use of external fixator and cast in maintaining the position of the fracture in plaster after reduction is needed to answer the question definitively, but because of the nature of these injuries with a high degree of iatrogenic variaton, we believe that such a trial would be difficult to arrange.

References