Immediate interlocking nailing versus external fixation followed by delayed interlocking nailing for Gustilo type IIIB open tibial fractures

HJ Park, M Uchino, K Nakamura, M Ueno, Y Kojima, M Itoman
Department of Orthopaedic Surgery, School of Medicine, Kitasato University, Sagamihara, Kanagawa, Japan

K Yokoyama
Department of Orthopaedic Surgery, Machida Municipal Hospital, Machida, Tokyo, Japan

T Suzuki
Department of Emergency and Critical Care Medicine, School of Medicine, Kitasato University, Sagamihara, Kanagawa, Japan

M Nemoto
Department of Plastic and Reconstructive Surgery, School of Medicine, Kitasato University, Sagamihara, Kanagawa, Japan

ABSTRACT

Purpose. To compare immediate interlocking nailing with external fixation followed by delayed interlocking nailing, for Gustilo type IIIB open tibial fractures.

Methods. 23 patients with Gustilo IIIB open tibial fractures were treated with either immediate unreamed interlocking nailing (n=9) or external fixation followed by delayed unreamed interlocking nailing (n=14). Patient age, sex ratio, fracture site, fracture type, and severity were similar in both groups. The time to union, deep infection rate, and nonunion rate in the 2 groups were compared.

Results. In the immediate and delayed nailing groups, respective mean times to union were 21 (standard deviation [SD], 14) months and 14 (SD, 8) months; nonunion rates were 44% (4/9) and 36% (5/14), and deep infection rates were 22% (2/9) and 7% (1/14). All corresponding differences were not statistically significant.

Conclusion. Prospective, randomised, multicentre studies are needed to assess whether there are significant differences between the 2 treatment methods.

Key words: fracture fixation, intramedullary; fractures, open; infection; tibial fractures

INTRODUCTION

The management of open tibial fractures remains controversial. The rates of infection and nonunion...
are higher in Gustilo type IIIB than in types I, II, and IIIA open fractures. To prevent complications, various treatment regimens have been developed, including acute delivery of intravenous antibiotics, repeated radical debridement followed by early local or free flap closure, rigid stabilisation with external fixation or interlocking unreamed nailing, and prophylactic bone grafting.

Immediate unreamed interlocking nailing (immediate nailing) for Gustilo type IIIB open tibial fractures has the risk of deep infection. External fixation alone is associated with delayed union, nonunion, malunion, and ankle joint stiffness. External fixation followed by delayed interlocking nailing (delayed nailing) is associated with intramedullary and pin-site infection.

We therefore aimed to compare the outcome of immediate nailing with delayed nailing for Gustilo type IIIB open tibial fractures.

### MATERIALS AND METHODS

Between January 1986 and March 2002 inclusive, 52 of 58 Gustilo type IIIB open tibial fractures with Hannover Fracture Scale (HFS) score of ≤10 (good viability) were salvaged. 29 of them were stabilised by either immediate nailing or delayed nailing after external fixation. Among the delayed nailing group, 4 patients requiring massive bone grafting and 2 patients with nonunion after external fixation were excluded.

The mean age of the remaining 19 men and 4 women was 40 (range, 17–64) years. The causes of injury were motorcycle accident (n=10, 44%), motor vehicle accident (n=10, 44%), machinery injury (n=2, 9%), and pedestrian/motor vehicle accident (n=1, 4%). The mean Injury Severity Score (ISS) was 12.4 (range, 9–29). Three (13%) of the fractures affected the proximal third, 14 (61%) the middle third, 3 (13%) the distal third, and 3 (13%) were segmental fractures. Fracture severity was classified according to the AO/ASIF classification:

- A1
- A2
- B1
- B2
- C3

We therefore aimed to compare the outcome of immediate nailing with delayed nailing for Gustilo type IIIB open tibial fractures.

### Table 1

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Immediate nailing group (n=9)</th>
<th>Delayed nailing group (n=14)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (SD, range) [years]</td>
<td>38 (17, 17–67)</td>
<td>30 (16, 19–64)</td>
<td>0.29*</td>
</tr>
<tr>
<td>Sex (male:female)</td>
<td>8:1</td>
<td>11:3</td>
<td>0.52†</td>
</tr>
<tr>
<td>Fracture site</td>
<td></td>
<td></td>
<td>0.24†</td>
</tr>
<tr>
<td>Proximal third</td>
<td>2</td>
<td>1</td>
<td>0.24†</td>
</tr>
<tr>
<td>Middle third</td>
<td>5</td>
<td>9</td>
<td>0.24†</td>
</tr>
<tr>
<td>Distal third</td>
<td>0</td>
<td>3</td>
<td>0.24†</td>
</tr>
<tr>
<td>Segmental</td>
<td>2</td>
<td>1</td>
<td>0.24†</td>
</tr>
<tr>
<td>AO/ASIF type</td>
<td></td>
<td></td>
<td>0.75†</td>
</tr>
<tr>
<td>A1</td>
<td>0</td>
<td>1</td>
<td>0.75†</td>
</tr>
<tr>
<td>A2</td>
<td>2</td>
<td>2</td>
<td>0.75†</td>
</tr>
<tr>
<td>B1</td>
<td>3</td>
<td>4</td>
<td>0.75†</td>
</tr>
<tr>
<td>B2</td>
<td>1</td>
<td>4</td>
<td>0.75†</td>
</tr>
<tr>
<td>C3</td>
<td>3</td>
<td>3</td>
<td>0.75†</td>
</tr>
<tr>
<td>Mean Hannover Fracture Scale (SD, range)</td>
<td>6 (2, 4–10)</td>
<td>7 (2, 4–10)</td>
<td>0.17*</td>
</tr>
<tr>
<td>Mean Injury Severity Score (SD, range)</td>
<td>15 (8, 9–29)</td>
<td>11 (3, 9–18)</td>
<td>0.27*</td>
</tr>
<tr>
<td>Polytrauma rate</td>
<td>33% (3/9)</td>
<td>14% (2/14)</td>
<td>0.34†</td>
</tr>
<tr>
<td>Mean skin closure time (SD, range) [days]</td>
<td>9 (12, 0–36)</td>
<td>8 (12, 0–33)</td>
<td>0.93*</td>
</tr>
<tr>
<td>Bone shortening (No. of patients)</td>
<td>2</td>
<td>5</td>
<td>0.66†</td>
</tr>
</tbody>
</table>

* Unpaired t-test or Mann-Whitney U test
† Chi squared test or Fisher’s exact test
All interlocking nails were unreamed in a static fashion. External fixators used were Hoffmann type (n=12) and AO/ASIF pinless-type (n=2). The mean external fixation period was 24 (standard deviation [SD], 25; range, 2–71) days. After removal of the external fixator, either a long-leg plaster cast or skeletal traction was applied for a mean period of 4 (SD, 5; range, 0–14) days prior to interlocking nailing, depending on the level of bacteria in smears of the wound and pin sites.

In the immediate nailing group, a delayed local flap (fasciocutaneous or muscle) [n=8] and a free flap (n=1) were used for soft tissue coverage, whereas in the delayed nailing group, a delayed local flap (n=8), a free flap (n=4), a secondary skin graft (n=1), and a delayed primary suture (n=1) were used. Soft tissue was reconstructed either in a single stage (n=5), within 72 hours (n=12), or later (n=6). The mean skin closure times in the immediate and delayed nailing groups were 9 (SD, 10–48) days and 8 (SD, 7–48) days, respectively; the difference was not statistically significant. The bony shortening rate for both groups was also similar (Table 1).

All patients had similar postoperative protocols. Physiotherapy of the knee and ankle joints began on the day after the surgical intervention and early weight bearing was encouraged. No cast or brace was applied. The mean follow-up period was 54 (range, 13–156) months. Medical records and radiographs were reviewed; the time to union, deep infection rates, and nonunion rates were assessed. Bony union was determined clinically (no pain or tenderness, ability to walk without aids) and radiologically (solid, bridging callus connected the fracture fragment on both anteroposterior and lateral radiographs). Nonunion was defined as having neither clinical nor radiographic evidence of union 12 months after injury and requiring a secondary procedure. Deep infection was defined as infection involving tissue below the muscular fascia.

The differences in the nonunion and deep infection rates between the 2 groups were analysed using either the Chi squared or Fisher’s exact tests. The mean times to union were compared using an unpaired t-test. All statistical analyses were performed using Stat-View 5.0 for Macintosh (Abacus Concepts, Berkeley [CA], USA) at a 0.05 level of significance.

### RESULTS

Patient age, sex ratio, fracture site, fracture type, and severity of injury (including ISS and HFS) were similar in both groups (Table 1). In the immediate and delayed nailing groups, respective mean times to union were 21 (SD, 14) months and 14 (SD, 8) months; nonunion rates were 44% (4/9) and 36% (5/14); no malunion occurred in either group. All corresponding differences were not statistically significant (Table 2).

<table>
<thead>
<tr>
<th></th>
<th>Immediate nailing group (n=9)</th>
<th>Delayed nailing group (n=14)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonunion rate</td>
<td>44% (4/9)</td>
<td>36% (5/14)</td>
<td>0.42†</td>
</tr>
<tr>
<td>Deep infection rate</td>
<td>22% (2/9)</td>
<td>7% (1/14)</td>
<td>0.54†</td>
</tr>
<tr>
<td>Mean time to union (SD, range) [months]</td>
<td>21 (14, 10–48)</td>
<td>14 (8, 7–48)</td>
<td>0.23*</td>
</tr>
</tbody>
</table>

* Unpaired t-test or Mann-Whitney U test  
† Chi squared test or Fisher’s exact test
nailing group. Infections were caused by: methicillin-resistant Staphylococcus aureus (MRSA) [n=1], both MRSA and Pseudomonas aeruginosa (n=1), and both MRSA and methicillin-sensitive S. aureus (n=1). The deep infection rate in patients with skin closure times of <72 hours was 12% (2/17), whereas in whom the times exceeded 72 hours the rate was 17% (1/6). This difference was not statistically significant.

DISCUSSION

Severe open tibial fracture is associated with a high complication rate.\(^1,20\) Repeated radical debridement of soft tissues and devitalised bony structures becomes necessary to prevent such complications but results in large skin and bone defects. These defects and associated injuries of other organs complicate treatment regimens, requiring bony stabilisation and reconstruction of soft tissues and bony structures. Six treatment options based on early skin closure\(^2-4\) (preferably within one week) were available in our hospital. They were: (1) secondary unreamed interlocking nailing after temporary external fixation with early flap coverage,\(^2,22\) (2) secondary definitive external fixation (Ilizarov external fixation or hybrid external fixation) after temporary external fixation (bridging fixation across the knee or ankle joint) with early flap coverage, (3) immediate unreamed interlocking nailing with early flap coverage,\(^23\) (4) immediate external fixation with staged reconstruction by free vascularised tissue transfer,\(^24,25\) (5) segmental bone transport combined with early flap coverage,\(^25,26\) and (6) primary shortening and secondary limb lengthening.\(^17,27\)

External fixation followed by delayed unreamed interlocking nailing minimises the disadvantages of external fixation alone (bad cosmesis, frequent pin trouble, risk of fracture through the pin tract, risks of malunion, delayed union, and nonunion, and non-compliance of patients in pin tract care affecting fixator durability).\(^11\) This type of fixation is often used for severe open tibial fractures, especially for patients with polytrauma, as a ‘damage control’ method. It is a useful and safe solution for open or closed femoral fractures in severely damaged multi-trauma patients.\(^26,29\) However, it risks having intramedullary infection as a result of: pin-site infection, prolonged external fixation, the short safety interval between removal of the external fixator and intramedullary nailing, reamed procedure in secondary nailing, non-curettage of pin sites at the removal of the external fixator, and poorly vascularised soft tissue coverage or delayed skin coverage.\(^11,12,30-36\)

In our previous study on risk factors for deep infection in 42 open tibial fractures (type II=11, type IIIB=22, type IIIC=1) treated with external fixation followed by delayed interlocking nailing, early skin closure within one week was found to be the single most important factor preventing deep infection.\(^37\) A meta-analysis\(^38\) on infection risk reported that avoidance of pin tract infection was very important, and that a shorter period of external fixation (<28 days) resulted in an 83% reduction in infection risk. A shorter interval between external fixator removal and interlocking nailing (<14 days) significantly reduced the infection rate.

Despite the risk of deep infection, immediate interlocking nailing has the merits of high patient acceptance, good cosmesis, access to soft tissue care, secure control of alignment and rotation, early mobilisation, biomechanical safety, and early weight bearing.\(^11\) Some have concluded that immediate unreamed interlocking nailing was the treatment of choice for Gustilo type IIIB open tibial fractures,\(^9\) but others did not recommend it for such fractures because of the high infection rate, despite it being a good treatment choice for type IIIA fractures.\(^8\) Comparison of unreamed interlocking nailing (n=104) to half-pin external fixation (n=70) for open tibial fractures (type II=73, IIIA=75, IIIB=26) showed that the severe infection rate was 2% (2/104) in the former group, but the rate for patients with type IIIB fractures alone was not described.\(^11\) Interlocking nailing was suggested as the treatment of choice for open tibial fractures, in particular, for complex fractures in which alignment was difficult to maintain and adjunctive soft tissue transfer was necessary.\(^11\) A meta-analysis\(^10\) on the appropriate method for type IIIB tibial fractures concluded that intramedullary nailing significantly shortened union time, whereas external fixation showed a trend towards a higher incidence of malunion and superficial sepsis.

In the present study, patient characteristics in the 2 groups were similar, but allocation to surgery was not randomised. The mean HFS score was higher (but not significantly) in the delayed nailing group. It is therefore possible that some sub-grading effect among the same Gustilo type IIIB fractures was responsible for the results, as selection of delayed nailing for the more severe Gustilo type IIIB cases may have occurred. There were no comparisons of functional outcomes and quality-of-life scores between the 2 groups.

In recent years, a ‘fix and flap’ protocol has been recommended for severe open tibial fractures and entails cooperation between orthopaedic and plastic surgeons.\(^39,40\) The protocol consists of radical
debridement, immediate skeletal stabilisation (preferably internal fixation) with an implant appropriate for the bony anatomy, and immediate or very early (within 72 hours) soft tissue reconstruction/skin closure. It was reported to result in faster union time, lower infection rate, and better functional outcome. The infection rate in the unreamed nailing group was only 3%, and the cause of infection was related to delay of flap surgeries. In particular, the low infection rate was attributed to the adequacy of the debridement, skeletal stabilisation, and the subsequent obliteration of dead space by a healthy, well-vascularised muscle flap. Both of our treatment groups belonged to the ‘fix and flap’ protocol. Thus, their outcomes were expected to be favourable, provided the protocol was strictly followed.

CONCLUSION

There was no significant difference in deep infection and nonunion rates between the immediate unreamed interlocking nailing group and the external fixation followed by delayed unreamed interlocking nailing group. Nonetheless, prospective randomised, multicentre studies are needed to compare functional outcomes and determine whether there are significant differences between the 2 methods.

REFERENCES