LOCKED INTRAMEDULLARY NAILING FOR DISPLACED TIBIAL SHAFT FRACTURES

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We analysed the results of 93 tibial shaft fractures treated with the Grosse–Kempf locked nail. Twenty-six fractures were comminuted, 19 were open grade I to II, and 54 were located outside the middle third of the tibia. The deep infection rate was 3.2%. There were only two poor results. The use of this method is recommended and discussed.

Most tibial shaft fractures are treated conservatively; this is safe and resource-sparing (Charnley 1961; Nicoll 1964; Sarmiento et al 1984), but is not suitable for all cases. A number of fractures will require an operative method (Charnley 1961; Böstman 1986; Ekeland et al 1988). We report our experience with locked intramedullary nailing for displaced tibial shaft fractures.

PATIENTS AND METHODS

From 1979 to 1986, we treated 98 displaced, recent, tibial shaft fractures in 94 patients with the Grosse–Kempf locked tibial nail (Grosse, Kempf and Lafforgue 1978). They represented 21% of all tibial fractures treated in our department, and another 2% were treated with an unlocked tibial nail. The only other operative method we used was external fixation for grade III open fractures. There were 64 men and 30 women, with a median age of 35 years (16 to 83). Five patients were excluded from review: one died of multiple injuries and four had incomplete follow-up.

Of the remaining 93 fractures, 47 resulted from high-energy trauma, mostly in traffic accidents (Fig. 1). Twenty-six patients had multiple injuries, including 14 patients with other lower limb fractures which were also treated with locked nails. Nineteen fractures were open grade I or II (Müller et al 1979). Thirty-four fractures were transverse or short oblique (line < 45° from the horizontal), 33 were long oblique or spiral, seven were segmental and 19 were otherwise comminuted, having at least one butterfly fragment larger than a third of the circumference of the bone.

Technique. We have described our technique elsewhere (Ekeland et al 1988), but some details deserve emphasis. The support under the knee should lie under the distal

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0301-620X/90/5166 $2.00
femur rather than in the popliteal fossa. The fracture site should remain closed, though for segmental fractures it is helpful to support the central fragment during reaming by two pointed clamps used percutaneously. In fractures with a long intact part of the shaft, the canal should be reamed to 1 mm more than the nail diameter. The fracture area should be freed from any transverse stress while the nail is inserted. If there is any doubt about the stability of the nailed fracture, static nailing is preferred. If there is a large fracture haematoma, a drain may be inserted percutaneously. The distal screws can be targeted manually within an acceptable range of irradiation (Skje!dal and Backe 1987).

We performed 47 of the operations within 24 hours, 19 within the first week and 27 later than two months after fracture. Fourteen of the 26 comminuted and 22 of the 67 non-comminuted fractures had static nails (difference p < 0.05). The median operation time was 65 minutes (30 to 200). Either reduction and plaster (36 cases) or calcaneal pin traction was used before the operative treatment. Two cases had failure of another type of osteosynthesis before they were nailed.

The median follow-up was 22 months (12 to 97); all 89 patients (93 fractures) were re-examined, and the results graded as excellent, good, fair or poor (Ekeland et al 1988). We defined malunion as shortening > 2 cm, angular deformity > 10°, or rotational deformity > 15°. The chi-squared test was used to assess statistical significance.

RESULTS

Of the 93 fractures, 51 were considered to be stable enough for early weight-bearing and 38 for unloaded exercises, while four with unstable dynamic fixation had plaster casts for four to eight weeks. However, during the first two weeks only 22 patients took any considerable amount of weight (Fig. 2). Time off work was not defined for 37 students, housewives or pensioners (Fig. 2). Five patients did not return to work for one to two years, partly because of other injuries.

Half of the fractures were radiographically united by 15 weeks (Fig. 2) with dense bridging callus. There were two cases of nonunion at one year. The 26 fractures which remained statically locked, and were not dynamised (Grosse et al 1978) healed in an average of 16 weeks (9 to 52), while those with dynamic locking healed in 14 weeks (9 to 40, p < 0.02).

Complications. The complications in the whole series are shown in Table I. Three patients had fasciotomies, and

Table I. Complications and their end results in 93 nailed tibial fractures

<table>
<thead>
<tr>
<th>Age and sex</th>
<th>Comminution</th>
<th>Type of nailing</th>
<th>Complication</th>
<th>Treatment</th>
<th>End result</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 M</td>
<td>Yes</td>
<td>Static</td>
<td>Vascular injury</td>
<td>Repair, fasciotomy</td>
<td>Good</td>
</tr>
<tr>
<td>31 M</td>
<td>Yes</td>
<td>Static</td>
<td>Compartment syndrome</td>
<td>Fasciotomy</td>
<td>Excellent</td>
</tr>
<tr>
<td>17 M</td>
<td>Yes</td>
<td>Dynamic</td>
<td>Compartment syndrome</td>
<td></td>
<td>Fair</td>
</tr>
<tr>
<td>56 M</td>
<td>Yes</td>
<td>Dynamic</td>
<td>Superficial injection</td>
<td>Antibiotics</td>
<td>Excellent</td>
</tr>
<tr>
<td>18 F</td>
<td>Yes*</td>
<td>Static</td>
<td>Superficial injection</td>
<td>Antibiotics</td>
<td>Excellent</td>
</tr>
<tr>
<td>23 M</td>
<td>No*</td>
<td>Static</td>
<td>Deep infection</td>
<td>Antibiotics, removal</td>
<td>Excellent</td>
</tr>
<tr>
<td>55 M</td>
<td>No†</td>
<td>Static</td>
<td>Deep infection</td>
<td>of nail after union</td>
<td></td>
</tr>
<tr>
<td>19 M</td>
<td>No</td>
<td>Static</td>
<td>Operative splintering</td>
<td></td>
<td>Excellent</td>
</tr>
<tr>
<td>61 M</td>
<td>No</td>
<td>Dynamic</td>
<td>Operative splintering</td>
<td></td>
<td>Fair</td>
</tr>
<tr>
<td>34 F</td>
<td>Yes</td>
<td>Dynamic</td>
<td>15° external rotation</td>
<td>Re-operation, static nailing</td>
<td>Excellent</td>
</tr>
<tr>
<td>18 F</td>
<td>Yes</td>
<td>Dynamic</td>
<td>Delayed union</td>
<td>Bone grafting</td>
<td>Excellent</td>
</tr>
<tr>
<td>20 M</td>
<td>Yes</td>
<td>Dynamic</td>
<td>Nonunion</td>
<td>Plate and bone graft</td>
<td>Poor</td>
</tr>
<tr>
<td>50 M</td>
<td>No</td>
<td>Static</td>
<td>Nonunion</td>
<td>Plate and bone graft</td>
<td>Poor</td>
</tr>
</tbody>
</table>

* grade I open fracture † grade II open fracture

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the result was only fair in one neglected case, with hammer toes and reduced dorsiflexion of the ankle. There were two superficial and three deep infections in three open and two closed fractures; the total infection rate was 5.3%.

Splintering of the fracture occurred during operation in two cases. One of them healed uneventfully after static nailing (Fig. 3), but the other, after dynamic nailing, had 2.5 cm shortening with only a fair result. One early re-operation was necessary for rotatory malalignment. In one case, distal fixation by only one screw resulted in nonunion (see Fig. 4).

There were three cases of delayed union or nonunion. Nonunion in two was successfully treated by plate osteosynthesis and cancellous bone grafting. The results were classified as poor due to the failure of the first method, though, after the second operation, they were good and fair respectively.

Five nails broke at the stress riser produced by the proximal end of the slot. One early breakage occurred as a result of significant re-injury and nonunion followed. The others were fatigue fractures after bone healing; their only effect was to make the removal of the nail more difficult.

**Outcome.** There was shortening of 1 cm in nine cases, 2 cm in two and 3 cm in two. Varus malalignment was 6° to 10° in four cases and valgus 6° to 10° in six cases. Anterior angulation of 6° to 10° occurred in three patients, and recurvatum deformity of 6° to 10° in three. One patient had an internal rotation deformity of 20° and one an external rotation of 15°.

Knee movement was full and free in all cases, but 14 patients complained of some anterior knee pain. Nine patients had a 10° to 30° loss of dorsiflexion of the ankle, four of them having a similar loss of plantar flexion, and six having a 50% reduction of subtalar movement. Two of the patients with reduced ankle and foot movement also had some pain including the short foot syndrome after undetected compartment syndrome. Nine patients had pain at the fracture site and 12 had some distal oedema. The working capacity of 12 patients was reduced. Nine other patients had reduced their sporting activities and five had not returned to sport.

In 44 patients the nail had been removed and 10
patients had had one or several screws removed after the dynamisation. Removal of the nail because of pain was planned for 14 other patients and because of their young age for another 11.

The result was excellent in 58 fractures, good in 22, fair in 11 and poor in two. The timing of operation did not affect the course or result and the results in the 19 open fractures did not differ from those for closed fractures. The median time for radiographic healing was 16 weeks (10 to 52) for comminuted and 14 weeks (9 to 40) for the others (difference not significant). The median time for full weight-bearing was 55 days for comminuted and 37 days for non-comminuted fractures (not significant), but the end results were no different.

DISCUSSION

During the study period, we treated most tibial shaft fractures conservatively; intramedullary nailing was the only primary operative method for closed fractures. Very few fractures were nailed without locking, and there was an increasing tendency for static locking during the period under review. This resulted from the shortening and occasional rotational instability seen after dynamic nailing. A fresh wound, less than eight hours old, was not considered to be a contra-indication for locked intramedullary nailing. There were more infections in the open than in the closed fractures, but they all resolved well and did not affect the end result.

There was a delay in the radiographic healing of statically nailed fractures, but this seemed to have no clinical consequences, since the patients could bear weight early even when callus formation was delayed. Dynamisation could possibly have accelerated the healing in some cases (Grosse et al 1978), but we have had some adverse experiences with early dynamisation resulting in malalignment and shortening (Thoresen et al 1985). We therefore recommend that dynamisation, when necessary, should be delayed until the fourth month.

Merianos, Cambouridis and Smyrnis (1985) reported favourable results in a series of 143 tibial shaft fractures treated with two Ender nails, but it seems that locked nailing may provide more rotational and longitudinal stability. Good results have also been achieved by plate fixation (Christensen, Greiff and Rosendahl 1982), but this carries a greater risk of wound infection and its consequences.

As in other reported series of intramedullary nailing (Puno et al 1986), we obtained satisfactory control of shortening and angular and rotatory deformities to give a 3% rate of malunion. This is significantly less than those reported for displaced, conservatively treated fractures, those treated by miniosteosynthesis with Rush

![Fig. 4](image-url)

An oblique tibial fracture in a 50-year-old man (a), nailed dynamically with distal locking (b). The lateral view shows that the most distal screw is not in the hole of the nail (c). The instability resulted in varus malalignment and loosening of the upper screw (d). Although able to work, he had a warm painful fracture site. The nonunion was treated by plate osteosynthesis with bone chips from the iliac crest (e).
pin, cerclage or screws, or by external fixation (Önnerfalt 1978; Puno et al 1986; Oni, Hui and Gregg 1988; Sarmiento et al 1989), where 6% to 12% malunion was reported. We found practically normal ankle movement in 84 cases (90%), as compared with the 75% reported by Sarmiento et al (1984) and 78% by Önnerfalt (1978).

A significant advantage of locked intramedullary nailing is, in addition to early joint motion, the possibility of early weight-bearing. This allows earlier return to work than after plaster fixation (Önnerfalt 1978) or intramedullary nailing without locking (Donald and Seligson 1983). It is important to the patient not only to have a satisfactory end result, but also to achieve it as soon as possible.

The operative treatment of tibial fractures is demanding, but, as in other fields of modern orthopaedics, technical difficulties should not deter the surgeon from using a method which gives superior results. The operative technique must be meticulously performed by adequately trained surgeons, and the cases must be carefully selected for each type of treatment.

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REFERENCES


