Supracondylar nailing for difficult distal femur fractures

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INTRODUCTION

In treating distal femur fractures, it can be difficult to maintain bony alignment, due to the unbalanced pull of thigh and calf muscles. For cases treated with internal fixation, bony purchase of the distal fragment may not be adequate due to the paucity of good cortical bone. In 1967, Neer et al. recommended a non-surgical approach to supracondylar fractures after reviewing 110 unselected cases, noting a high rate of local complications and a low rate for patient satisfaction. Early conversion to cast bracing after a period of traction was later introduced, claiming to offer better functional outcomes compared with prolonged casting across the knee. Later, fixation with a lateral condylar blade plate or its modifications became popular, because it allowed fixation of intra-articular fractures and early mobilisation of the knee joint. Soft tissue disruption with open reduction and periosteal stripping for placement of the implant may interfere with the healing process, resulting in a delay in union or non-union. Bone grafting was frequently indicated and wound infection was not uncommon with this approach. Flexible intramedullary nailing, modified antegrade

ABSTRACT

Purpose. To evaluate outcome following supracondylar nailing for distal femur fractures.

Methods. The clinical and radiological outcome for 13 patients treated between January 1995 and December 1998 at the University Malaya Medical Center was assessed. Patients were seen for follow-up for a mean duration of 20.2 months.

Results. There were no cases of non-union or infection. Overall assessment of clinical outcome based on the criteria of Schatzker and Lambert was graded excellent in 6 patients, good in 3 patients, fair in 3 patients, and one graded as a failure.

Conclusion. Supracondylar nailing for fixation of supracondylar (Arbeitsgemeinschaft für Osteosynthesefragen [AO] type A) and less comminuted intercondylar (AO type C1 and C2) fractures is recommended by the authors.

Key words: femoral fracture; internal fixators; treatment outcome
nailing,\textsuperscript{12,13} and external fixation\textsuperscript{14} allowed fracture fixation with minimal exposure of the fracture site. However, axial and rotational stability of these implants were inferior, and early mobilisation of the limb could result in loss of reduction. Retrograde insertion of a standard femur nail did not allow fixation of very low fractures in addition, and free hand interlocking of the proximal end could be difficult.

Supracondylar nailing was initially introduced for the treatment of low femur shaft fractures. Due to the distal position of the interlocking screws, they were later used for distal femur fractures. Fixation of intercondylar fractures was also possible with additional compression screws to stabilise the intra-articular fragments.\textsuperscript{15,16} In cases with severe metaphyseal comminution, supracondylar nailing offers a more biological method of fixation with less devitalisation of soft tissue. However, outcome evaluation of this treatment has been limited.\textsuperscript{15,16} We reviewed the medical records of 14 patients treated with supracondylar nailing for distal femur fractures at our institution over a 3-year period, to determine overall outcome in this patient group.

### METHODS

From January 1995 to December 1998, approximately 400 intramedullary nailing procedures were performed for femur fractures in our institution, with 14 patients undergoing supracondylar nail fixation. During the period of study, lateral condylar blade plate or dynamic condylar screws were the implants of choice for intercondylar fractures, and for supracondylar fractures too low for standard antegrade femur nailing. Indications for supracondylar nail fixation included distal femur fractures with severe comminution or segmental fractures, the presence of pre-existing deformity that rendered lateral plate fixation difficult, and selected intra-articular fractures. Unicondylar fractures (Arbeitsgemeinschaft für Osteosynthesefragen [AO] type B) were better treated with either compression screws or buttress plates. Fractures with intra-articular comminution (AO type 3C) were usually treated with circular frame external fixation.

Surgery was performed with the patient in supine position on a standard operating table that allowed imaging of the knee with image intensifier. Knee flexion

### Table

<table>
<thead>
<tr>
<th>Case No.</th>
<th>AO type</th>
<th>Sex/Age (years)</th>
<th>Fracture type</th>
<th>Side</th>
<th>Other injuries/pathology</th>
<th>Knee ROM\textsuperscript{1} (°)</th>
<th>Outcome\textsuperscript{1}</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A1</td>
<td>M/14</td>
<td>Closed</td>
<td>left</td>
<td>Pre-existing malunion in varus and shortening</td>
<td>90</td>
<td>Fair</td>
</tr>
<tr>
<td>2</td>
<td>A1</td>
<td>M/20</td>
<td>Closed</td>
<td>left</td>
<td>Right dento-maxillary fracture</td>
<td>130</td>
<td>Excellent</td>
</tr>
<tr>
<td>3</td>
<td>A1</td>
<td>M/26</td>
<td>Closed</td>
<td>right</td>
<td>Segmental fracture same femur treated by a longer supracondylar nail\textsuperscript{b}</td>
<td>150</td>
<td>Excellent</td>
</tr>
<tr>
<td>4</td>
<td>A1</td>
<td>M/30</td>
<td>Closed</td>
<td>left</td>
<td>Unicondylar fracture same femur (AO type B1) treated with screw fixation\textsuperscript{b}</td>
<td>130</td>
<td>Excellent</td>
</tr>
<tr>
<td>5</td>
<td>A1</td>
<td>M/30</td>
<td>Closed</td>
<td>left</td>
<td>Nil</td>
<td>150</td>
<td>Excellent</td>
</tr>
<tr>
<td>6</td>
<td>A3</td>
<td>F/65</td>
<td>Closed</td>
<td>right</td>
<td>Squamous cell carcinoma of the scalp; osteoporosis; osteoarthritis both knees</td>
<td>90</td>
<td>Fair</td>
</tr>
<tr>
<td>7</td>
<td>A3</td>
<td>F/69</td>
<td>Closed</td>
<td>left</td>
<td>Osteoarthritis both knees</td>
<td>100</td>
<td>Good</td>
</tr>
<tr>
<td>8</td>
<td>C1</td>
<td>M/36</td>
<td>Closed</td>
<td>right</td>
<td>Nil</td>
<td>130</td>
<td>Excellent</td>
</tr>
<tr>
<td>9</td>
<td>C2</td>
<td>M/17</td>
<td>Open</td>
<td>right</td>
<td>Open fracture right patella treated by circlage wiring,\textsuperscript{8} closed segmental fracture left femur; closed fracture left tibia/fibula</td>
<td>45</td>
<td>Failure</td>
</tr>
<tr>
<td>10</td>
<td>C2</td>
<td>M/20</td>
<td>Open</td>
<td>left</td>
<td>Extrudal haematoma; open fracture right femur shaft and femur neck treated by reconstruction nail;\textsuperscript{b} open fracture left patellar treated by patellectomy;\textsuperscript{b} frontal bone fracture</td>
<td>130</td>
<td>Fair</td>
</tr>
<tr>
<td>11</td>
<td>C2</td>
<td>M/29</td>
<td>Open</td>
<td>left</td>
<td>Open undisplaced fracture left patellar\textsuperscript{b}</td>
<td>140</td>
<td>Excellent</td>
</tr>
<tr>
<td>12</td>
<td>C2</td>
<td>M/34</td>
<td>Closed</td>
<td>right</td>
<td>Cerebral concussion</td>
<td>110</td>
<td>Good</td>
</tr>
<tr>
<td>13</td>
<td>C2</td>
<td>M/34</td>
<td>Closed</td>
<td>right</td>
<td>Closed fracture right patellar treated with screw fixation\textsuperscript{b}</td>
<td>130</td>
<td>Good</td>
</tr>
</tbody>
</table>

* AO Association for the Study of Internal Fixation
† ROM range of motion
‡ Evaluation based on Schatzker's\textsuperscript{5} criteria
§ Fracture fixation performed during the same anaesthesia with index procedure
\textsuperscript{b}
was achieved by placing sterile linen under the knee. No tourniquet was used. For extra-articular fractures, a midline infra-patellar incision extending through the patellar tendon was used, to assess the entry point on the intercondylar notch. For displaced intercondylar fractures, an anterior midline skin incision with para-patellar arthrotomy was performed for open reduction. The 2 condylar fragments were initially fixed with AO cancellous screws. If the fracture extended close to or through the intercondylar notch, the entry hole of the nail had to be created by connecting multiple drill holes, in order to avoid splitting of the 2 condyles. The distal interlocking screws of the nail provided additional fixation to the condylar fragments. In open fractures, location of the open wound governed the skin incision and approach to the fracture. Knee joint mobilisation without weightbearing was allowed after the second postoperative day.

One foreign worker returned to his country shortly after surgery. We retrospectively reviewed the medical notes, including X-rays, of the 13 remaining patients.

Fracture union and alignment were judged on clinical and X-ray findings. The criteria recommended by Schatzker and Lambert was used for overall outcome evaluation. Three patients with inadequate information on file were called back to the clinic for further assessment.

RESULTS

The mean age of the patients was 32.6 years (range, 14–69 years). There were 11 men and 2 women. There were 7 supracondylar (AO type A) fractures and 6 intercondylar (AO type C) fractures (Table). Three fractures were open, with the remaining closed. All except one patient (case 6) were involved in high velocity road traffic accidents. The mean operation time was 1.4 hours (range, 1–4 hours), inclusive of time for other procedures performed under anaesthesia. Suction drains were used in 8 cases and they were removed between one to 2 days after surgery. In most

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Figure 1  A 69-year-old woman with osteoarthritis of both knees (case 7): (a) comminuted supracondylar fracture with a degenerative knee, (b) supracondylar nail fixation after closed reduction, (c) loosening of distal interlocking screw, with outward migration, and (d) fracture united well with no loss of reduction.
patients, knee movement commenced 2 days after surgery. The duration before partial weightbearing varied, because about half of the patients had additional injuries affecting their lower limb.

The mean duration of follow-up was 20.2 months (range, 12.4–45.8 months). A bone graft was applied during the primary operation in one of the early cases where comminution of the medial cortex was thought to pose a risk of delay in union. In subsequent cases, there was no primary or secondary bone grafting. Full weightbearing was allowed only when the fracture was assessed as clinically and radiologically united. The mean time required to achieve union was 4.4 months (range, 2.0–9.6 months). Fracture alignment, limb length measurement, and range of knee movements were based on the last recorded clinical evaluation. One patient developed a knee flexion contracture of 10°, while the remainder were able to fully extend their knee. The mean range of knee movement on last review was 123.8° (range, 150°–90°). For younger patients, we advised removal of hardware about 2 years after surgery. Routine removal of implants was not necessary in older patients. By the time of last clinical review, 6 patients had had their implants removed.

One patient developed foot drop, presumably due to peroneal nerve injury, after insertion of a tibial pin for traction. The pin was removed and the neurological deficit completely resolved. Another patient developed pain on knee movement 3 months after surgery. One of the distal interlocking screws had backed out and migrated into subcutaneous tissue (Figs. 1a–c). The screw was removed under local anaesthesia and reduction was maintained until the time of union (Fig. 1d). There were no cases of superficial or deep infection. There were no instances of implant breakage.

**Figure 2** A 14-year-old male with history of distal femur fracture treated with plaster cast (case 1): (a) pre-existing valgus malunion of femur with shortening, (b) second fracture just proximal to the previous fracture site, and (c) supracondylar nail fixation of the femur after closed reduction.
or loss of fracture alignment during the healing process either.

Based on the criteria recommended by Schatzker and Lambert,\textsuperscript{5} the outcome was assessed as excellent in 6 cases, good in 3 cases, and fair in 3 cases. The outcome in one further case (case 9) was graded as a failure due to loss of knee movement postsurgery. This patient sustained open fracture of the ipsilateral patella, and closed fractures of the contralateral femur and tibia. The patellar fracture was fixed with circlage wires and the knee was immobilised for 8 weeks after surgery. At 12-month follow-up, the patient could only achieve 45° of passive knee movement despite intensive physiotherapy. Arthrotomy and release of adhesions were performed and eventually the patient was able to achieve 130° knee flexion.

Two of the 3 patients (cases 1 and 6) whose outcome was graded as fair had pre-existing knee abnormalities. One patient had sustained a closed supracondylar fracture of the same femur 11 months before the index injury (case 1). He was treated with a plaster cast and the fracture united in varus, with shortening and a stiff knee (Fig. 2a). This patient subsequently sustained a second fracture of the same femur just proximal to the previous fracture site (Fig. 2b). Supracondylar nailing was performed and alignment of the distal fragment was corrected. On final evaluation 13 months after nailing, the patient had recovered 90° of knee movement, with good bony alignment (Fig. 2c). The patient felt that the limb length discrepancy was less after treatment of the second fracture, although the affected femur was 2.0 cm shorter compared with the opposite side. The second patient was a 65-year-old woman, who suffered from squamous cell carcinoma of the scalp (case 6). She had systemic chemotherapy plus local irradiation after which she developed complete blindness of one eye with poor vision in the other. She had been walking with a frame for the previous few years due to pain and stiffness of both knees. She sustained a closed fracture of the right distal femur after a trivial fall at home. This was a comminuted supracondylar fracture in osteoporotic bone (Figs. 3a and b). Closed reduction followed by supracondylar nailing was performed and a plaster cast was applied for additional support until fracture callus was noted radiologically. The plaster cast was

Figure 3 A 65-year-old woman with squamous cell carcinoma of the scalp, osteoporosis and osteoarthritis of both knees (case 6): (a) anteroposterior view of a closed comminuted supracondylar fracture in an osteoporotic bone, (b) lateral view showing tricompartmental osteoarthritis of the knee, (c) fracture united in good alignment, with no loosening of the implant, and (d) lateral view showing good callus formation.
converted to cast bracing for another 4 months before full weightbearing was allowed. On review 20 months after surgery, the patient was able to walk with the help of a walking frame, and could actively flex the knee up to 90°. The fracture united with good alignment (Figs. 3c and d). The third patient (case 10) sustained multiple trauma, and the distal femur fracture united with 20° varus due to inadequate reduction of the fracture initially.

**DISCUSSION**

The time to union of 4.4 months with no case of non-union seen in this study compares favourably to other treatment methods reported in the literature. Many trauma surgeons recommend primary bone grafting for comminuted fractures or those with significant cortical defects, but this was performed in only one of our early patients. All fractures united without secondary procedures to enhance union. Closed reduction or minimal fracture exposure to facilitate the passage of the guidewire resulted in little additional injury to the adjacent soft tissue, especially the periosteum, and fracture haematoma was preserved in most cases. The load sharing mechanism of intramedullary nailing promotes secondary bone healing, and morselized bone from medullary reaming extravasated into the fracture site serves as a bone graft. All these factors likely contributed to the good union rate seen and the low incidence of soft tissue complications, especially infection.

There have been very few outcome studies on distal femur fractures treated with retrograde intramedullary nailing. Retrograde nailing for femur shaft fractures has been shown to produce comparable rates of union to antegrade nailing. Janzing et al. recently studied outcomes for 24 elderly patients with distal femur fractures treated with retrograde intramedullary nailing. Using the Neer scoring system criteria, they reported excellent or good results in 16 (89%) patients. Only 4 of the 24 patients had intra-articular fractures. Nine of our 13 (71%) patients had excellent or good results based on Schatzker’s scoring system. However, nearly half of them (6 out of 13) had intra-articular fractures.

Angular malunion, in either the coronal or sagittal plane, may develop due to inadequate reduction or subsequent displacement during bone healing. Schatzker and Lambert classified fracture alignment of less than 10° varus or valgus as good in their outcome evaluation. In our series, good alignment was achieved in all but one patient (case 10), and this was due to inadequate reduction of the fracture. We did not observe any breakage of implants, and loosening of a distal screw was noted in only one case. Moment arm of varus/valgus bending force is significantly reduced with intramedullary nailing compared with use of the lateral blade plate system. Four cortical fixations are also possible, with 2 well-placed distal interlocking screws. Moreover, intramedullary positioning of the nail also provides 3-point fixation of the fracture to prevent flexion/extension displacement of the distal fragment. The combination of early union and stability of fixation seen with this approach effectively reduces the risks of angular malunion.

Siliski et al. reported that 15 of 52 patients in their series of distal femur fractures treated with plate fixation had limb shortening of 1 to 3 cm. Shortening was intentional in 11 patients to allow impaction for better bone healing. In our series, we aimed to restore original bone length. One patient (case 1) had 2 cm femur shortening which was most likely due to malunion of a previous fracture. Three other patients had 1 cm shortening that did not interfere with their gait. Intentional fracture impaction was not necessary in any case.

Of the 7 patients with extra-articular fractures, 3 (cases 1, 6, and 7) experienced a mild degree of pain after walking for a short distance. Two of these patients had pre-existing osteoarthritis of the knee, while the other patient had a previous fracture of the same femur that was malunited. The remaining 4 patients, including one with a concurrent fracture of the lateral femoral condyle, did not experience any pain over the knee joint. In our experience, splitting the patellar tendon for insertion of the nail did not appear to cause any symptomatic or functional problems with the knee.

In patients with multiple fractures, simultaneous fracture fixation in more than one limb may be desirable. Supracondylar nailing is performed supine on a normal operating table, allowing simultaneous procedures for upper limbs and the opposite lower limb. When there is an indication for life-saving procedures, such as craniotomy or laparotomy, repositioning of the patient is not necessary for subsequent fracture fixation.

Long-term effects on the knee joint following nail entry through the intercondylar notch are not clear. Although we did not observe any significant deterioration of joint congruency or reduction in the thickness of the articular space based on X-ray evaluation, no conclusion can be reached since the number of cases was small and the duration of follow-up relatively short. Moreover, it would be difficult to separate the effect of trauma from that of intercondylar nail entry. The benefits of maintaining good fracture alignment and early joint mobilisation with the use of
Supracondylar nailing may prove to be more important overall for the long-term integrity of the knee joint.

CONCLUSION

Supracondylar nailing is useful for fixation of supracondylar and less comminuted intercondylar fractures. With minimal disruption to soft tissue, and good purchase of the distal bone fragment, this approach provides stable fracture fixation, allowing early joint mobilisation. The rate of union is high, with a low incidence of complications. The simplicity of the procedure also facilitates fracture fixation in patients with multiple trauma, including those with multiple fractures.

REFERENCES