ABSTRACT

Purpose. To review the outcome of retrograde locked nailing for aseptic supracondylar femoral nonunions following failed locked plating.

Methods. Records of 20 men and 4 women aged 20 to 57 (mean, 39) years who underwent retrograde locked intramedullary nailing for aseptic supracondylar femoral nonunion following failed locked plating were reviewed. There were 20 closed and 4 open Gustilo type II or IIIA fractures secondary to motor vehicle accidents (n=21) or falls (n=3). Patients had undergone one to 3 operations. The mean time from injury to the present revision surgery was 1.3 years. No patient had a flexion contracture. The locked plate was removed and replaced with a retrograde dynamic locked nail (with or without buttress plate augmentation) followed by bone grafting.

Results. 17 men and 4 women were followed up for a mean of 3.4 years. The rest were lost to follow-up. The 21 patients achieved bone union after a mean of 4.3 months. The mean maximal knee flexion improved from 97.1° to 107.6° (p=0.03). Knee function was excellent in one, good in 15, and fair in 5 knees. The fair outcome was due to extension contracture, varus knee deformity, or knee pain. There were 3 malunions with varus deformity of 7°, 8°, and 9° each. No patient had deep infection causing a nonunion. All 21 patients could walk without aids.

Conclusion. Retrograde locked intramedullary nailing for aseptic supracondylar femoral nonunions following failed locked plating achieved a high union rate.

Key words: bone nails; bone plates; femur

INTRODUCTION

Buttress condylar plate, angled blade plate, locked plate, dynamic condylar screw, and retrograde locked intramedullary nail are commonly used for treatment of supracondylar femoral fractures and nonunions. Locked plate is less invasive and more rigid, but it has a high nonunion rate of 17% to 20%. The high rigidity of the locked plate suppresses...
callus formation in simple fractures. When comminuted fractures are treated with less invasive techniques, the local area is bridged by locked plates and the remaining fracture gaps can interfere with bone healing. If stability is sufficient, non-surgical techniques (such as ultrasound, electrical stimulation or shock waves) should be effective. However, non-surgical techniques cannot concomitantly correct local problems and knee stiffness. If surgical treatment is chosen, recanalisation of the marrow canal should be performed. Recanalisation can penetrate through the sclerotic blockage and reconstruct intramedullary vascular webs, but it is challenging because of blockage of the canal by multiple locked plate screws. Recanalisation is easier for intramedullary nailing. Retrograde locked nailing is a successful treatment for aseptic supracondylar femoral nonunions. This study reviewed the outcome of retrograde locked nailing for aseptic supracondylar femoral nonunions following failed locked plating.

**MATERIALS AND METHODS**

Records of 20 men and 4 women aged 20 to 57 (mean, 39) years who underwent retrograde locked intramedullary nailing between March 2003 and December 2009 for aseptic supracondylar femoral nonunions following failed locked plating were reviewed. There were 20 closed and 4 open Gustilo type II or IIIA fractures secondary to motor vehicle accidents (n=21) or falls (n=3). Patients had undergone one to 3 operations. The mean time from injury to the present revision surgery was 1.3 (range, 0.7–2.4) years. No patient had a flexion contracture.

Under general or spinal anaesthesia, the patient was placed in a supine position. A pneumatic tourniquet was used; an image intensifier was not used. A skin incision was made along the prior surgical wound, and screws and locked plates were removed. A 3-cm curved incision was made along the medial or lateral aspect of the patella and patellar tendon. The trochlear groove of the femur was identified and the knee was bent to 45º. A hole was made in the trochlear groove with a power drill, 5 to 10 mm anterior to the insertion of the posterior cruciate ligament. The nonunion site was exposed and fibrous tissues were removed. The alignment of the lower extremity was adjusted. A rigid guide wire was inserted from the hole in the trochlear groove into the femoral canal under direct vision. Subsequently, the rigid guide wire was replaced by a flexible guide wire and the marrow canal was reamed in a retrograde fashion. Then, a 1-mm smaller-sized femoral locked nail (Russell-Taylor locked nail; Smith & Nephew, Memphis [TN, USA]) was inserted in a retrograde fashion. To maintain a dynamic mode, only the distal oblique locked screw was inserted, and the 2 upper nail holes were left vacant. The rotational stability at the nonunion site was checked. In 8 patients, a humeral buttress plate (Synthes, Bettlach, Switzerland) was used. Cancellous bone grafts or bone graft substitutes were packed into the gaps of the nonunion site. In 4 patients with knee extension contracture (inability to bend the knee >45º), V-Y lengthening of the quadriceps was performed prior to revision surgery. At postoperative day 1, passive knee range of motion (ROM) exercises were encouraged. Protected weightbearing was allowed.

A fracture union was defined as no pain when walking without aids and a solid callus bridging the fracture gap in 3 or 4 cortices on radiographs. A nonunion was defined as a fracture that had not healed after one year. Knee function was evaluated using a modified Mize scoring system with 4 grades. Outcome was defined as excellent when there was <10º of flexion loss, full extension, a lack of varus, valgus, or rotational deformity, and absence of pain. Outcome was defined as good when there was no more than one of the following: >20º of flexion loss, >10º of extension loss, >5º of varus or valgus deformity, and minimal pain. Leg length was determined by measuring the spinomalleolar distance with the patient in the supine position. Patients with leg length inequality of >2 cm were advised to undergo lengthening with external fixation.

Continuous variables were compared using the paired Student’s t-test, and discrete variables were compared using the Fisher’s exact test. A p value of <0.05 was considered statistically significant.

**RESULTS**

17 men and 4 women were followed up for a mean of 3.4 (standard deviation [SD], 1.3; range, 1.1–5.8) years. The rest were lost to follow-up. The 21 patients achieved bone union after a mean of 4.3 (SD, 0.5; range, 3.5–5.5) months (Table). The mean maximal knee flexion improved from 97.1º (SD, 38.2º; range, 0º–140º) to 107.6º (SD, 21.7º; range, 50º–140º) [p=0.03]. Knee function was excellent in one, good in 15, and fair in 5 knees. The fair outcome was due to extension contracture, varus knee deformity, or knee pain; the patients declined quadricepsplasty to improve knee flexion. There were 3 malunions with varus deformity of 7º, 8º, and 9º each (Fig.). No patient had...
Table
Patient characteristics and outcome

<table>
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<tr>
<th>Sex/age</th>
<th>Period since injury (years)</th>
<th>No. of previous surgeries</th>
<th>Plate augmentation</th>
<th>Time to bone union (months)</th>
<th>Complication</th>
<th>Knee function</th>
<th>Maximal knee flexion</th>
<th>Follow-up (years)</th>
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Figure  (a) A supracondylar femoral fracture fails to unite 1.1 years after locked plate fixation. (b) The nonunion is fixed with retrograde locked nailing with buttress plate augmentation after removal of the old implant. (c) Bone union is achieved at 4.5 months despite a varus deformity of 9°.
deep infection causing a nonunion. All 21 patients could walk without aids.

**DISCUSSION**

Fractures with a minimal gap, adequate stability, and sufficient blood supply heal more easily. Both mechanical and biological effects are involved during fracture healing through primary or secondary processes. The primary process requires high rigidity without local fracture gaps. A locked plate enables high rigidity, but callus is sparse in the fracture site. Delayed union or nonunion after locked plate fixation has been reported.

To treat an atrophic or hypertrophic nonunion, the fracture gap should be minimised, stability should be reinforced, and osteogenic potential should be initiated. For aseptic nonunions following locked plate fixation, non-surgical methods can be used. The locked plate can be preserved and supplemented with cancellous bone grafts, but the marrow cavity cannot be recanalised and intramedullary bone growth interrupted lowering the likelihood of union. The locked plate can also be removed and replaced with a new locked or unlocked plate following recanalisation of the bone marrow.

Replacement with a retrograde locked nail supplemented with cancellous bone grafts, with or without plate augmentation to prevent rotational instability or shortening, has achieved a high success rate. The tip of the retrograde locked nail should reach the level of the lesser trochanter. As the curvatures of the femur and the locked nail are normally mismatched, the tip of a short nail will introduce a stress riser in the anterior femoral cortex, and a secondary fracture may occur before the initial fracture has healed. Inserting two upper transverse locked screws into the subtrochanteric region to achieve a static mode is technically demanding, and neurovascular injury may occur. Therefore, a dynamic locked nail was used in our patients. The knee must be flexed 45° during insertion of a retrograde locked nail. For knees with extension contracture, quadricepsplasty must be performed first. The optimal technique is V-Y quadriceps lengthening. As the quadriceps tendon is approached through the midline, the prior locked plate can be removed using the same incision. After the bony procedure is finished, the quadriceps tendon is sutured with the knee bent 45°.

In comminuted fractures, the locked plate is too rigid to enable callus formation and increases the risk of a nonunion. Whether increasing the screw distance, use of a shorter locked plate, or far cortical locking decreases rigidity remains controversial. Flexible fixation may be an appropriate treatment for comminuted fractures.

The mechanism of intramedullary nailing is by way of splinting. Partial loads are transferred through the nail and cortex to enable the secondary fracture healing process. Callus formation is copious. In our patients, no callus was noted in the nonunion site, as the locked plate suppresses the secondary fracture healing process, although a large fracture gap and severe local injury can also inhibit callus formation. To stimulate osteogenic potential, cancellous bone grafts should be used. In our patients, wide dissection was avoided to prevent compromising local vascular supply. Thus, the extension contracture was not completely corrected and may have resulted in unsatisfactory knee function. Quadricepsplasty was suggested to improve knee flexion after bony union, but all patients declined.

One of the limitations of this study was the small, heterogeneous sample; as locked plates are expensive, most patients with supracondylar femoral fractures are usually treated with traditional or a retrograde locked nail. Flexible fixation may be an appropriate treatment for comminuted fractures. In addition, comparisons with simple bone grafting or non-surgical methods were not made, owing to the small sample size. Further studies to compare various methods of treatment are needed.

**DISCLOSURE**

No conflicts of interest were declared by the authors.

**REFERENCES**