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Antegrade interlocking nailing for distal femoral fractures

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ABSTRACT

Purpose. To assess outcomes of antegrade interlocking nailing for supracondylar or intercondylar fractures of the distal femur.

Methods. Records of 10 women and 20 men aged 20 to 70 (mean, 48.7) years who underwent antegrade interlocking nailing for distal femoral fractures were reviewed. 23 patients had closed fractures and 7 had open fractures; 6 had associated fractures of the forearm or tibia. According to the AO/ASIF system, fractures were classified as types A1 (n=13), A2 (n=6), A3 (n=3), and C1 (n=8). The affected leg was put in an extension shoe for traction, and reduction was achieved with the help of percutaneous lag screws. The nail was inserted from the tip of the greater trochanter and centred in both anteroposterior and lateral planes. The nail was modified to have 3 screw slots in the mediolateral plane and one screw slot in the anteroposterior plane distally for stability in multiple directions. Postoperatively early mobilisation and partial weight bearing were allowed. Patients were assessed using the modified knee-rating scale of the Hospital for Special Surgery.

Results. The mean time to bone union was 13.1 (range, 10–18) weeks. The mean follow-up period was 18.8 (range, 11–30) months. Three patients were lost to follow-up; outcomes in the remaining patients were excellent in 20 and good in 7. The mean range of knee flexion was 106° (range, 90°–120°). One patient developed a flexion deformity of 10°. All patients attained full quadriceps strength. No patient had ligamentous instability, nerve injuries, superficial or deep infections, or implant failure. Three patients had malunion, which was located in the meta-diaphyseal segment and not in the intra-articular segment. Hence, there was no functional problem or shortening. The mechanical axis was not deviated.

Conclusion. Antegrade interlocking nailing achieved good-to-excellent outcomes for distal femoral fractures

Key words: *femoral fractures; fracture fixation, intramedullary; treatment outcome*

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INTRODUCTION

Supracondylar femoral fractures occur in the distal 9 cm of the femur[1] between the diaphyseal-metaphyseal junction and the femoral condyles. Extension of the fracture into the diaphyseal region is not uncommon in the high-energy injuries. Closed intramedullary nailing is the treatment of choice for femoral shaft fractures.[2–4] For displaced supracondylar and intercondylar fractures of the distal femur, open reduction and internal fixation is advocated, as it can maintain alignment under the unbalanced pull of thigh and calf muscles.[5–8] Nonetheless, bony purchase of the distal fragment may not be adequate because of the lack of good cortical bone, and thus a non-surgical approach is recommended.[9] The treatment goals are correction of axial alignment, leg length, and rotation, restoration of range of motion, early bone union, and return to normal function.[10] Early use of a hinged brace may be appropriate for non-displaced supracondylar femoral fractures; range-of-motion exercises and ambulation can be initiated when pain and swelling subside. Early conversion to cast bracing after a period of traction achieves better outcomes than prolonged casting.[11,12]

Fixation with a lateral condylar blade plate, dynamic condylar screws, or locking compression plates for intra-articular fractures enables early mobilisation of the knee joint.[13–15] However, all these techniques involve opening the fracture site and draining of the haematoma. This results in excessive soft-tissue disruption, blood loss, and operating time, and may also require periosteal stripping. Delayed union/non-union, bone grafting, and infection may ensue.[13–18]

Closed intramedullary nailing minimises the extent of soft-tissue dissection and devitalisation, and the fracture haematoma is not disturbed. Early fracture healing is predictable because of abundant callus formation, and complications are few.

Retrograde nailing for distal femoral fractures is associated with stiffness and infection of the knee. Antegrade interlocking nailing avoids these complications. As the canal at the metaphyseal diaphyseal junction widens suddenly, the nail is modified in the form of multiple, multi-directional locking bolts at the distal end. This provides extra stability and enables early mobilisation. We assessed the outcomes of 30 patients who underwent antegrade interlocking nailing for supracondylar or intercondylar fractures of the distal femur.

MATERIALS AND METHODS

Records of 10 women and 20 men aged 20 to 70 (mean, 48.7) years who underwent antegrade interlocking nailing between 2008 and 2011 for distal femoral fractures within 9 cm from the joint line were reviewed. The causes of injury included motor vehicle accidents (n=27) and falls (n=3). 23 patients had closed fractures and 7 had open fractures (6 grade I and one grade II according to the Gustilo Anderson classification). Six patients had associated fractures of the forearm or tibia, which were fixed with intramedullary nails or plates as required. According to the AO/ASIF system,[19] fractures were classified as types A1 (n=13), A2 (n=6), A3 (n=3), and C1 (n=8) [Fig. 1].

Patients with open grade-I fractures underwent nailing with antibiotic impregnated cement beads as soon as their condition was stabilised. In one patient with a grade-II fracture, fixation was delayed for 7 days after thorough debridement. Prophylactic antibiotics were given half an hour prior to surgery. No tourniquet was used. Under general or spinal anaesthesia, patients were placed in a supine position on a fracture table; the unaffected leg was flexed 90° at the hip and placed abducted in a leg holder. The affected leg was put in an extension shoe for traction; a steinnman pin or femoral distracter was

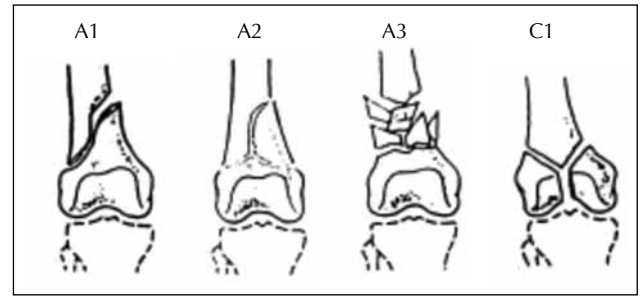

Figure 1 Fracture classification according to the AO system.

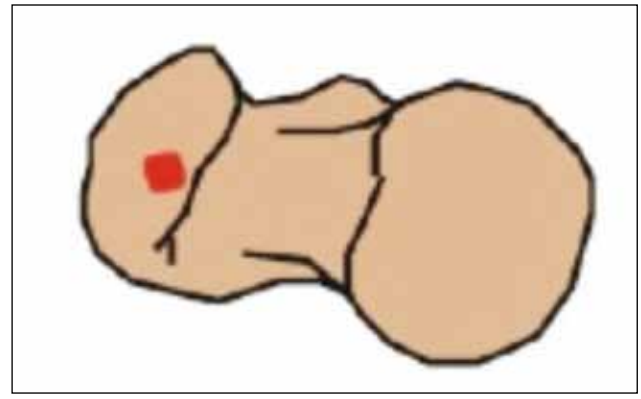

Figure 2 Entry point of the nail on the tip of the greater trochanter.

used if necessary. Reduction was confirmed using a C-arm. In patients with an intercondylar fracture, the intra-articular component was first reduced by traction and then the fracture fragments were held by percutaneous application of reduction forceps. Two 6.5 mm cancellous screws were then inserted percutaneously. The screws were positioned anteriorly or posteriorly away from the anticipated path of the interlocking nail.

The skin 70 mm proximal to the tip of the greater trochanter was incised. A guide pin was inserted and confirmed under a C-arm after palpating the tip of the greater trochanter (Fig. 2). The medullary canal was prepared, and the reamer guide and nail guide were passed across the fracture site and centred in both anteroposterior and lateral planes. The canal was over-reamed 0.5 to 1 mm more than the diameter of the selected nail.

The nail was mounted on a targeting device that had to be rotated approximately 90° during insertion, owing to the anatomic shape. This could avoid stress peaks in the bone. The nail and targeting device were

Figure 3 Closed antegrade interlocking nailing for **(a)** ipsilateral segmental and supracondylar femoral fractures in a 40-year-old woman, **(b)** a spiral oblique fracture extending into the supracondylar area in a 67-year-old man with osteoporosis, and **(c)** a supracondylar femoral fracture in a 30-year-old man. All patients achieve good bone union.

inserted over the guide wire into the medullary canal by hand using light pressure with the targeting device oriented anteriorly. As the patient was in a supine position, the targeting device was pointed upwards. After passage through the proximal metaphysis, the targeting device was rotated slowly by pushing the nail further down into the medullary canal. At the end of the insertion, the targeting device was rotated approximately 90º and to lie in a lateral direction. The guide wire was removed, and the nail position confirmed by fluoroscopy in anteroposterior and lateral planes (Fig. 3).

As the canal in the distal femur was widened, extra screws were inserted to attain stability in multiple directions. The nail was modified to have 3 screw slots in the mediolateral plane and one screw slot in the anteroposterior plane distally. Using a free-hand technique and under a C-arm, stab incisions were made on the lateral side, and 3 locking bolts were inserted after drilling. The knee was flexed to relax the quadriceps while locking the anteroposterior screw. Muscle entanglement between the screw head and the bone was avoided while the bolt was tightened to prevent possible flexion problems. Two proximal locking screws (either both static or one static and one dynamic) were then inserted.

Postoperatively, the leg was kept in 90º flexion. Suction drains were removed on day 2. Active and passive range-of-motion exercises were then started. Immediate weight bearing was allowed for fractures proximal to the joint. For fractures communicating with the joint or metaphysis, full weight bearing was allowed after bridging callus was seen on radiographs. The antibiotic beads were removed under local anaesthesia after 4 to 6 weeks. Patients were assessed using the modified knee-rating scale of the Hospital for Special Surgery (Table 1),[20] which places more emphasis on motor strength than ligamentous instability, because instability of the knee is not common after distal femoral fractures.

RESULTS

The mean operating time was 2.5 (range, 2–4) hours, which included the time for other procedures performed under anaesthesia. All fractures were reduced by the closed technique, and no bone grafting was required. The mean non–weight-bearing period was 7 (range, 4–10) weeks. The mean time to bone union (formation of circumferential bridging callus across the fracture) was 13.1 (range, 10–18) weeks. The mean follow-up period was 18.8 (range, 11-30) months.

Table 1
The modified knee-rating scale* of the Hospital for Special Surgery[20]

Item	Scores
Pain (30 points)	
During walking	
None	15
Mild	10
Moderate	5
Severe	0
At rest	
None	15
Mild	10
Moderate	5
Severe	0
Function (22 points)	
Walking and standing	
Unlimited	12
5–10 blocks, standing >30 mins	10
1–5 blocks, standing 15–30 mins	8
<1 block	4
Cannot walk	0
Stairs	
Normal	5
With support	2
Transfer	
Normal	5
With support	2
Range of motion (15 points)	
80º	10
90º	11
100º	12
110º	14
120º	15
Muscle strength (15 points)	
Grade 5	15
Grade 4	12
Grade 3	9
Grade 2	6
Grade 1	3
Grade 0	0
Flexion deformity (10 points)	
None	10
0º–10º	8
10º–20º	5
>20º	0
Instability (5 points)	
None	5
0º–5º	4
6º–15º	2
>15º	0
Total (97 points)	**-**
Subtractions	
Walking aid	
One cane	1
One crutch	2
Two crutches	3
Extension lag	
5º	2
10º	3
15º	5
Deformity (5º=1 point)	
Varus	-
Valgus	-

* Scores ≥85 are excellent, 70–84 good, 60–69 fair, and <60 poor

Three patients were lost to follow-up; outcomes for the remaining patients were excellent in 20 and good in 7 (Table 2). The mean range of knee flexion was 106º (range, 90º–120º); 5 patients had 90º, 10 had 100º, 5 had 110º, and 7 had ≥120º of knee flexion. One patient developed a flexion deformity of 10º; all others achieved full extension. All patients attained full quadriceps strength. No patient had ligamentous instability, nerve injuries, superficial or deep infections, or implant failure. Only one patient had the implant removed.

Three patients had malunion, which was located in the meta-diaphyseal segment and not in the intra-articular segment. Hence, there was no functional problem or shortening. The mechanical axis was not deviated. All fractures healed with minimum deformity and no patient had incongruity of the weight-bearing articular surface.

DISCUSSION

The standard treatment for distal femoral fractures with or without intra-articular involvement is open reduction and internal fixation with plates and screws.[21–26] This necessitates extensive exposure and may lead to non-union or infection.[21,24–27] Fixation using plates and screws has the inherent drawback of producing a load-shielding device. The resultant osteopenia creates a substantial risk of re-fracture proximal to the plate, particularly in elderly patients who have osteoporotic bones.

Closed intramedullary antegrade nailing with or without supplemental internal fixation is the treatment of choice for femoral shaft fractures, regardless of the extent of comminution.[23,27,28] Modification of the interlocking nails distally (3 locking slots for lateromedial locking and one for

Table 2
Fracture types and outcomes of the patients

Patient no.	Sex/age (years)	Fracture type	AO type	Other injury	Knee range of motion	Outcome*
1	F/40	Closed	A1	Ipsilateral segmental femoral fracture	120º	Excellent
2	F/50	Closed	C1	-	120º	Excellent
3	M/30	Closed	A1	-	120º	Excellent
4	F/50	Closed	A1	-	130º	Excellent
5	F/50	Closed	A1	-	110º	Excellent
6	M/63	Open grade I	A2	-	100º	Excellent
7	M/35	Open grade I	A3	Ipsilateral patellar & open grade I tibial fractures	90º	Good
8	M/70	Closed	A2	Osteoarthritis of knee	100º	Excellent
9	M/60	Closed	C1	-	90º	Good
10	M/63	Closed	C1	-	100º	Excellent
11	M/35	Closed	A2	Ipsilateral hip dislocation & compound tibial fracture	100º	Good
12	M/45	Closed	A1	-	110º	Excellent
13	M/40	Closed	C1	Open grade I proximal tibia fracture	90º	Good
14	M/30	Open grade I	A2	-	100º	Excellent
15	M/30	Closed	A3	Contralateral femoral shaft and ipsilateral tibial fractures	100º	Good
16	M/40	Open grade II	A1	-	110º	Excellent
17	M/20	Closed	A1	Ipsilateral both bone forearm fractures	100º	Excellent
18	M/45	Closed	A1	-	120º	Excellent
19	M/50	Closed	A1	-	110º	Excellent
20	M/49	Closed	A2	-	90º	Good
21	M/40	Open grade I	A1	-	100º	Excellent
22	F/55	Closed	A2	-	90º	Good
23	M/55	Closed	A1	-	100º	Excellent
24	F/60	Open grade I	C1	-	100º	Excellent
25	M/55	Closed	A1	-	120º	Excellent
26	M/67	Closed	A1	-	130º	Excellent
27	F/60	Open grade I	C1	-	100º	Excellent
28	F/70	Closed	A3	-	-	Lost to follow-up
29	F/60	Closed	C1	-	-	Lost to follow-up
30	F/45	Closed	C1	-	-	Lost to follow-up

* Based on knee rating scale of the Hospital for Special Surgery

anteroposterior locking) enables treatment for supracondylar and some intercondylar femoral fractures (types A and C1). The distance between 2 screws is 20 mm. The hole size is 5 mm to pass the 4.5 to 5 mm bolts, depending on the nail diameter. As the proximal part is lateralised, the entry point of the nail can be from the tip of the greater trochanter in a supine position, which requires less tissue dissection and fluoroscopic imaging. Entering from the piriform fossa in a supine position requires more exposure and fluoroscopic imaging. If the patient is placed in a lateral position, there is a chance of valgus angulation.[29] Distally the nail should be centred in both anteroposterior and lateral planes, with the help of blocking pins and fixation of the distal fragments with multiple, multilevel, multiplanar screws to provide extra stability.

Outcomes in our series were comparable to those of others using other modalities.[13,15,30] Closed reduction facilitated passage of the guide wire and resulted in no injury to other soft tissues, especially the periosteum and fracture haematoma persisted. The load-sharing mechanism of intramedullary nailing promoted secondary bone healing, and the morselised bone from reaming extravasated into the fracture site and served as bone grafts. Angular malunion in either the coronal or sagital plane may develop when displacement occurs during bone healing. Varus/valgus bending force is significantly reduced with intramedullary nailing than with lateral plating. Intramedullary positioning of the nail also provided 3-point fixation to prevent flexion/extension displacement of the distal fragment. Early bone union and stable fixation effectively reduced the risks of angular malunion.

Three patients developed malunion, but had no functional problems. The intra-articular segment was reduced anatomically by lag screws, whereas the multi-fragmented fractures were reduced non-anatomically by the closed method. The big butterfly fragment was fixed by a lag screw. All these fixations minimised soft-tissue interposition and the risk of malunion or even nonunion. Antegrade interlocking nailing minimises soft-tissue disruption and provides good purchase of the distal fragment through extra locking screws.

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