Outcome of retrograde intramedullary nailing and locking compression plating of distal femoral fractures in adults

SKV Gupta*, CVS Govindappa, RK Yalamanchili

Abstract
Introduction
In recent years, the treatment of distal femoral fractures has evolved although these fractures remain complex to treat and carry an inconsistent prognosis. Debate continues around choice of implant for fixation of metaphyseal–diaphyseal fractures. In this retrospective study, we evaluated and compared clinical and radiological outcomes of distal femur fracture stabilisation using retrograde nailing and locking compression plate constructs.

Materials and Methods
Between 2008 and 2013, 103 patients with distal femoral fracture who had been treated by retrograde intramedullary interlocking (IMIL) nailing (n = 57) and locking compression plating (LCP) (n = 46) were evaluated in this study at our centre.

Results
Clinical and radiographic evaluation demonstrated osseous healing within 6 months following retrograde nail and LCP plating in over 75% of patients. Average time of union in LCP group was 6.8 months and in retrograde nailing group was about 7.4 months. In the retrograde nail group, 5 out of 57 patients (9%) developed nonunion as no bony consolidation of the femoral fracture was observed 9 months after fixation. In the LCP group, nonunion was observed in 2 out of 46 patients (4%).

Conclusion
Persisted knee pain and inability to use in type C fractures are the main limiting factors of retrograde nail. In type A fractures, LCP plating was associated with less morbidity in terms of persistent knee pain and better range of movements at 2 years of follow-up than retrograde nailing. Locked plating may be utilised for all distal femur fractures including complex type C fractures and osteoporotic fractures.

Introduction
In recent years, the treatment of distal femoral fractures has evolved although these fractures remain complex to treat and carry an inconsistent prognosis. An estimated 6% of all fractures of the femur account for the distal part of the bone. The fractures occur in a bimodal distribution. One group including patients below 40 years of age, predominantly males, sustained high-energy trauma such as traffic accidents or a fall from heights. The other group consists of patients >50 years, predominantly females, with osteoporosis, who sustained relatively low energy trauma.

Fractures of the distal third of the femur are a treatment challenge despite new fixation options. Locking plates have been developed in conjunction with a minimally invasive biologically friendly insertion technique which allows the plate to be placed without excessive soft tissue stripping and with minimal disruption of the bone blood supply. Similar to intramedullary nails these plates are used to span zones of comminution which then must heal with an external callus. They have been designed to limit fracture gap strain with physiologic loads and have improved fixation in osteoporotic, cancellous or comminuted bone.

In 1988, Green introduced to orthopaedic surgery the use of a new intramedullary nail placed in a retrograde fashion. Intramedullary nails have many of the same advantages as locking plates such as percutaneous placement without disruption of blood supply, indirect fracture reduction, success in osteoporotic bone and have been reported to lead to high healing rates in fractures of the distal femur.

Debate continues around choice of implant for fixation of metaphyseal–diaphyseal fractures. In this retrospective study, we evaluated and compared clinical and radiological outcomes of distal femur fracture stabilisation using retrograde nailing and locking compression plate constructs.

Materials and Methods
This work conforms to the values laid down in the Declaration of Helsinki (1964). The protocol of this study has been approved by the relevant ethical committee related to our institution in which it was performed. All subjects gave full informed consent to participate in this study.

Between 2008 and 2013, 103 patients with distal femoral fracture who had been treated by retrograde intramedullary IMIL nailing (n = 57) and LCP plating (n = 46) were evaluated in this study at our centre. Here 74 patients were men and 29 were women with a mean age of 54 years (range 17–89 years). AO type B distal femoral fractures, compound Grade III-B and -C (Gustilo –

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Anderson’s) fractures and pathological fractures were excluded from the study. The exclusion criterion to use a retrograde IM nail was a type C2 or C3 fracture. In these cases, a distal femur locking compression plate osteosynthesis was performed. The anteroposterior and lateral X-rays of the knee with distal femur were performed. CT scan was performed in all type C3 fracture pattern to assess displacement of fragments, intra-articular involvement, degree of comminution, as well as detection of coronal plane fractures that are difficult to identify on plane films. Compound injuries were thoroughly debrided at admission and treated with third-generation cephalosporins and after ensuring that the wound is healthy, they were proceeded with definitive fixation with an appropriate implant. The choice of implant for definitive osteosynthesis was dependent on the fracture type, quality of bone and local skin conditions.

Operative procedure

Locking compression plate osteosynthesis

The patient was positioned supine on the radiolucent table with the knee flexed over a folded drape, which helps to improve the sagittal plane reduction of the fracture by relaxing the primary deforming force of the gastrocnemius.

In extra-articular fractures, a closed reduction was performed to avoid breaching of the periosteum. In extra-articular fractures, open reduction or mini-open reduction was performed to ensure anatomic reduction of the joint surface. In complex extra-articular fractures, a lateral parapatellar arthroscopy was performed to expose the articular surface as necessary after incision of the joint capsule. In these cases, the articular fracture was initially reduced and the condyle block was reconstructed and stabilised using temporary K-wire fixation.

According to preoperative planning, a distal femoral condylar LCP plate was inserted under the vastus lateralis muscle, and was slid proximally. Key success factor of the operation was the anatomic reduction of the articular fragments of the fracture and axis of the femoral shaft as well as correct implant position along the lateral femoral cortex. Plate position was considered correct if the distal monaxially locking screws were parallel to the horizontal plane of the joint line on AP view. The plate position was secured by K-wires. Fracture reduction and implant positioning were verified by biplanar intraoperative fluoroscopic imaging. In extra-articular fractures four, and in intra-articular fractures five, self-cutting, self-tapping and fixed-angle screws were inserted into the metaphyseal, distal fragment using the trocar system. In the femoral diaphysis, bicortical screws were preferentially inserted. The knee was moved through its range of motion, and ligamentous stability was tested under anaesthesia.

Retrograde IM nailing

The fractured leg was positioned with a knee flexion of 60 degrees to facilitate nail insertion. Following infra-patellar skin incision, direct transpatellar access to the knee joint was performed. In extra-articular fractures, percutaneous insertion of the retrograde nail was possible, whereas in comminuted intra-articular fractures additional lateral arthroscopy was required. With the bone awl, PCL was identified and 1 cm anterior to it, entry was taken that is confirmed under C-arm guidance. Under C-arm guidance, the guide wire was inserted into the medullary canal through the entry point taken, respecting a 7-degree valgus angle to the horizontal plane of the joint. After ensuing fracture reduction, reaming was done and a retrograde nail was inserted. Final position of the distal end of the nail was below the chondral surface in the subchondral bone of the distal femur. The distal interlocking screws were inserted using the aiming device and trocar.

Careful postoperative treatment, with active and active-assisted physiotherapy where range of motion was limited by pain and discomfort, was initiated within the next day following surgery. Mobilisation was initiated with toe touch-down weight bearing appropriate to stability of fixation or fracture healing.

Osseous healing was defined radiographically as the presence of at least three of four healed cortices, with bridging callus formation and crossing trabeculae on AP and lateral radiographs. Clinical healing was defined as the absence of functional pain and local tenderness at the previous fracture site.

Patients were followed up every 1st, 2nd, 3rd, 6th, 12th, 18th, 24th months and at 3 years. Functional outcome was assessed by the hospital for special surgery knee scoring criteria (HSS score). Patients were followed up every 1st, 2nd, 3rd, 6th, 12th, 18th, 24th months and at 3 years. Functional outcome was assessed by the hospital for special surgery knee scoring criteria (HSS score)

Results

Among the two groups, mean age was 52 years (range 18–79 years). Mean follow-up was 16.2 months (range of 7–36 months) for the entire study group, with a mean follow-up of 17 months for the LCP group and 15 months for the retrograde nailing group. Mechanism of injury was high-energy impact in 61 patients (59%) [retrogradenailing 42% (n = 26); LCP 58% (n = 35)] and low-energy injury in 42 patients (41%) [retrograde nailing 64% (n = 21); LCP 36% (n = 15)]. Fractures were classified according to AO classification: there were 65 type A fractures (retrograde nailing 41, LCP 24) and 38 type C fractures (retrograde nailing 16, LCP 22). A total of 21% (n = 12) and 16% (n = 7) were open fractures in the retrograde nailing and LCP group, respectively (Figure 1).

Clinical and radiographic evaluation demonstrated osseous healing.
within 6 months following retrograde intramedullary nailing and LCP plating in over 75% of patients (Figures 2–4). Average time of union in the LCP group was 6.8 months and in the retrograde nailing group was about 7.4 months. In the retrograde nail group, 5 out of 57 patients (9%) developed nonunion as no bony consolidation of the femoral fracture was observed 9 months after fixation. In the LCP group, nonunion was observed in 2 out of 46 patients (4%). There was no significant statistical difference with respect to time of bone healing among both the groups ($P < 0.05$). Radiographic signs of healing correlated with clinical signs of healing, including the absence of pain or tenderness over the fracture site and the absence of pain with motion. The additional secondary bone grafting was required 3 months after the primary operation in 4 patients (7%) in the retrograde nailing group and 2 (4%) in the LCP group.

In patients who postoperatively complained about persisting joint pain with motion or weight bearing had close proximity of the hardware to the knee joint as seen on X-rays. In the LCP group, we found intra-articular penetration of distal screws in one patient, necessitating exchange of screws. In the retrograde nailing group, three cases had the tip of the nail within the joint and it was re-driven within the subchondral bone. Knee pain was more common after nailing and it affected the knee flexion postoperatively and thereby functional outcome significantly ($P = 0.032$).

All the four patients (2 in LCP group; 2 in retrograde nailing) with superficial infection and one patient with deep infection had suffered open fractures of the distal femur. One (5.3%) patient in the LCP group developed a late-onset deep infection 5 months after surgery. The patient underwent implant removal, debridement and received antibiotics. The infection resolved completely 6 weeks later. No deep infection was documented in the retrograde nailing group. The difference in deep infection rate was not significant ($P = 1.000$).

The mean range of movement was $96.83 \pm 38.93^\circ$ in the LCP group and $94.2 \pm 10.25^\circ$ in the retrograde nailing group at the end of 8 weeks. The range of movement improved to $124.4 \pm 21.5^\circ$ in the LCP group and $117.2 \pm 15.5^\circ$ in the retrograde nailing group by 6 months follow-up after vigorous physiotherapy (Table 1). Anterior knee pain in the retrograde group ($n = 14$) was the main limiting factor in achieving better knee flexion even after 2 years. The mean HSS score was $89.0 \pm 11.3$ points in the LCP group and $868.2 \pm 6.8$ points in the retrograde nailing group (Figure 5).

**Discussion**

Distal femur fractures occur with a bimodal pattern of mechanism of injury: (1) high-energy impact in young patients often resulting in

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nailing and locking compression plate osteosynthesis follow the principle of biological osteosynthesis. Protection of soft-tissue envelope due to the minimally invasive approach and closed reduction techniques is better realised using retrograde intramedullary nailing.

In our study of 103 patients with distal femoral fracture, 57 patients were treated with retrograde nail and 46 patients with LCP plate osteosynthesis. No statistically significant differences between the nailing and the LCP group were found so far for the parameters time to osseous healing, rate of nonunion and postoperative complications. In the present study, we have noticed no complications in the patients with type A fractures treated with LCP plating. The limitation of the study is that the patients were not randomised to each group. Comprehension of fracture anatomy is essential for successful operative treatment of distal femoral fractures. In addition, advantages and limitations of each implant must be known and considered.

Both surgical strategies employ indirect reduction techniques for the metaphyseal region, ensure anatomic reconstruction of the articular surface and aim at restoration of axial alignment, rotation and length of the femur.

Locking compression plates

The LCP system is an extramedullary, anatomically contoured internal fixator. Locking plate provides good fixation in osteoporotic bones in elderly patients. Previously, implants were selected depending on fracture type, whereas the LCP system can be universally applied for the treatment of all distal femoral fractures, AO type A to C with the exception of AO type B Hoffa fractures, which are preferentially stabilised using lag screw osteosynthesis. The LCP plate provides enhanced distal screw fixation, even in osteoporotic bone, at the expense of more displacement.

Table 1 Evaluation of post-operative flexion at knee joint

<table>
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<tr>
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<th>Retrograde IMIL nail</th>
<th>LCP</th>
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<tr>
<td>Flexion at knee after 4 weeks</td>
<td>41.20 ± 5.40°</td>
<td>38.66 ± 12.83°</td>
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<tr>
<td>Flexion at knee after 8 weeks</td>
<td>94.2 ± 10.25°</td>
<td>96.83 ± 38.93°</td>
</tr>
<tr>
<td>Flexion at knee after 12 weeks</td>
<td>102.5 ± 5.62°</td>
<td>112.8 ± 23°</td>
</tr>
<tr>
<td>Flexion at knee at 6th month</td>
<td>117.2 ± 15.5°</td>
<td>124.4 ± 21.5°</td>
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Comminuted and open fractures and (2) low-energy impact in elderly patients with osteopenic or osteoporotic bone. Both retrograde IM

Research Study

Figure 3: (a) Preoperative radiograph of a 54-years-old male with type A1 supracondylar fracture. (b) Immediate post-operative X-rays with LCP plate fixation. (c) X-ray after removal at 28th month.

Figure 4: Preoperative and post-operative X-rays of a type A3 fracture treated with retrograde nail.
Retrograde nailing

Nailing provides favourable IM stability and can be successfully implanted in bilateral or multisegmental fractures of the lower extremity. In addition, a variety of distal femur fractures ranging from AO type A extra-articular metaphyseal, supracondylar, as well as intra-articular type C1 fractures can be stabilised. In these fractures, retrograde IM nailing may be used and closed indirect fracture reduction is achieved by inserting the nail at a correct insertion point leaving the soft-tissue envelope intact.

Intra-articular C1 fractures may also be treated with the retrograde nail but only if direct visualisation and perfect reduction of the articular surface is possible. In contrast to the position of the distal screws in LCP plating which have to be positioned perfectly parallel to the joint line, distal interlocking screws of the retrograde nail have to be inserted at a valgus angle of approximately 7° to the joint line. Only then the physiological valgus angle of the femoral condyle and the femoral shaft is respected and can be reconstructed.

Compared to plate fixation techniques, advantages of retrograde femoral nail include soft-tissue protection due to small incision, decreased blood loss following limited exposure, “percutaneous” joint fixation, the increased stability by IM fixation and load-sharing.

Indications for retrograde IM nailing for the treatment of distal femur fractures include:

1. Bilateral or multisegmental fractures of the lower extremity.
2. Intra-articular C1 fractures may also be treated with the retrograde nail but only if direct visualisation and perfect reduction of the articular surface is possible. In contrast to the position of the distal screws in LCP plating which have to be positioned perfectly parallel to the joint line, distal interlocking screws of the retrograde nail have to be inserted at a valgus angle of approximately 7° to the joint line. Only then the physiological valgus angle of the femoral condyle and the femoral shaft is respected and can be reconstructed.

Disadvantages of the nailing technique may be a lack of alignment control, posterior angulation, perforation of joint cartilage and intra-articular distribution of reaming debris. Stability is limited if small diameter and short nails are inserted.

Figure 5: Graphical outcome analysis of LCP plating and retrograde IML nailing in distal femur fractures.

at the fracture site. The rate of implant failure ranges between 5% and 10%. Compared with the results published in the literature with nonunion rates following LCP plate osteosynthesis ranging from 1.6% to 6.1%, the high rate of nonunion in the LCP group found in our study may be attributed to the high incidence of open and comminuted C-type fractures in the cohort.

The main advantage of the anatomically precontoured LCP plate is soft-tissue protection using a limited approach and submuscular plate insertion, as well as percutaneous screw insertion. Fracture stabilisation with the LCP system may render adequate reduction more difficult since the plate and the locking screws are not designed to approximate the fracture toward the plate. In fact, prior to plate fixation, fracture reduction has to be performed and completed. Once a locking screw has been placed through the plate into bone, this particular bone segment can no longer be manipulated by insertion of additional screws or by using compression devices. The sequence of screw placement has to be well planned to avoid fracture malreduction. Distal screws are inserted perfectly parallel to the distal femoral joint line. Any angulation of screws in projection to the joint line may result in increased valgus or, more detrimentally, in varus deviation.

The concept of bridging osteosynthesis implicates that the final fracture construct should be elastic and not too stiff to prevent nonunion. Therefore, the screws should not be positioned too close to the fracture line in order to allow for elastic deformation of the plate-screw construct, thereby preventing the screws adjacent to the fracture from failing and being pulled out. The combination of a stiff plate, stiff screws and fracture distraction leads to a result of nonunion. The size and contour of the plate may result in irritation of the iliotibial tract and may cause persistent pain. Symptomatic hardware has to be removed.

Indication for LCP plate osteosynthesis are as follows:

- Short distal fragment, C2 and C3 fracture patterns, failed closed reduction with retrograde IM nailing, salvage implant for revision surgery and complicated situations.
- In our series, predominant indications for LCP plate osteosynthesis included short distal fragment and C2 and C3 fracture configuration, severe osteoporosis and severe degenerative changes of the knee joint.

Conclusion
Both retrograde IM nailing and LCP plating may be adequate treatment options for distal femur fractures. No differences between implants regarding fracture healing, nonunion and infection were found but the LCP group had better outcome at 2 years follow-up. IM nailing may provide favourable intramedullary stability and stable callus, and may be successfully implanted in bilateral or segmental fractures of the lower extremity. Persistent knee pain and inability to use in type C fractures are the main limiting factors of retrograde nail. In type A fractures, LCP plating was associated with less morbidity in terms of persistent knee pain and better range of movements at 2 years of follow-up than retrograde nailing. Locked plating may be utilised for all distal femur fractures including complex type C fractures and osteoporotic fractures.

References

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