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Minimally invasive plate osteosynthesis of lower end of femur fractures using locking compression plating: a prospective study

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ABSTRACT

Background: The treatment of distal femur fractures has recently evolved towards indirect reduction and minimally invasive techniques. The goal is to strike a balance between the mechanical stability of the fragments and the biological viability. Pre-contoured Locking compression plates (LCPs) have shown to give best results in terms of recovery, fracture union, return to work and functional outcome. Advent of MIPO technique has reduced the amount of soft tissue injury, delayed healing, tissue necrosis and infections. The objective was to study the functional result of fracture distal femur treated by closed reduction with LCP by minimally invasive plate osteosynthesis (MIPO).
Methods: 20 cases of fracture distal end of femur were treated by closed reduction and internal fixation using LCP by MIPO between 1st October 2013 to 30th September 2015 at our centre. The patients were evaluated clinically and radiologically for functional outcomes. All patients were followed up for an average of 12 months. Outcome was assessed using NEER's score.
Results: 8 of my patients were male and 12 were female. All of them were closed injuries and fresh cases. The mean age was 51.8 years (21-68 yrs). 13 patients sustained RTA and 7 patients had accidental fall. 8 patients had right sided distal femur fracture and 12 had left sided injury. According to NEER's score 50% had excellent results, 35% had good results and 15% had fair results. Gait and weight bearing after union was satisfactory. Range of motion of knee joint in majority of patients was within acceptable limits.
Conclusions: Closed reduction and internal fixation of fracture lower end of femur by MIPO using LCP is one of the best modalities of treatment for good results.

Keywords: Supracondylar femur fracture, LCP, MIPO, Open reduction internal fixation, Intraarticular fractures, Neer's scoring system

INTRODUCTION

Distal femur fractures are rare and serious, with high mortality and morbidity.[1,2] Treatment of these fractures have evolved from non operative to operative treatment over the years.[2-7] Distal femur fractures are associated with high energy trauma such as road traffic accident and fall from height in young and osteoporosis in elderly.[8,9] Mechanically unstable fractures of distal femur have been difficult to treat. Problems such as varus collapse, malunion, non union, infection, frequently resulted before the introduction of Less Invasive Stabilization System (LISS) and Indirect mode of Reduction which used the concept of Minimal Invasive Plate Osteosynthesis (MIPO) were popularized.[10-12] Management of distal femur fractures is a challenge to orthopaedic surgeon in general and more so in elderly patients with osteoporosis.[13] Use of distal femur Locking Compression Plate (LCP) overcomes many pitfalls over the earlier implants. The LCP forms a fixed angle construct and allows placement of plate without any contact to bone, thus maintaining vascularity of the bone underneath and

functions as an internal fixator.[5,7,13] indirect reduction relies on traction across the soft tissue to achieve reduction and use of MIPO allows for biological plating where by restoration of articular congruity, maintenance of soft tissue attachment and vascularity to the cortical bone fragment is achieved.[15] For past several years, the use of MIPO technique has been accepted and increasingly used, where the plate is extraperiostealy inserted beneath the muscle, crossing over the fracture site distally onto the bone cortex and fixed by proximal and distal locking.[14,16] Several methods of internal fixation are available for distal femur fracture like, Angle Blade Plate, Condylar Buttress Plate, Condylar Blade Plate, Retrograde/ Antegrade Nailing, LCP, Fixed Angle Precontured Plate etc. The advantage of MIPO and use of LCP includes limited soft tissue dissection, preservation of fracture hematoma, thereby reduce the incidence of malunion and non-union, Early mobilization, there by reducing stiffness, leading to an improvement in the union rates, even in the elderly with osteoporosis and decreased need for bone grafting. The purpose of this study is to evaluate the results of fracture lower end of femur treated by closed reduction and internal fixation using LCP by MIPO technique.

METHODS

In our study, 20 patients with closed distal femur fractures were evaluated. All cases were treated at Bapuji and Chigateri Hospital attached to JJM Medical College, Davangere, Karnataka, between from October 2013 to September 2015. *Inclusion criteria:* Patients with lower third femoral fracture aged 18 years and above. *Exclusion criteria:* Patients with pathological fractures of lower third of femur other than osteoporosis, Patients below 18 years of age, Patients managed conservatively for other medical reasons, lower third femoral fractures with neurovascular deficit, Compound fractures associated with vascular injuries.

General, systemic and local examinations of patients were done. Head, Chest, Abdominal, Spinal, and Pelvic injuries were ruled out. Resuscitation of patients with fluids, oxygen and blood transfusion was done as and when required. Primary immobilization in Thomas splint with adequate padding and radiological assessment of the patients; Anteroposterior and true lateral views of injured limb including complete knee joint and distal femur was done.

Routine pre-operative investigations were done and other specific investigations were done in patients as per Anaesthetic requirement. Fractures were classified according to the AO-ASIF classification.[5] Preoperative evaluation was done to determine the size of the plate.

The limb to be operated was prepared before scheduled surgery. One gram of intravenous cephalosporin was injected few hours before surgery. The patients demographic data, fracture type, mechanism of injury, duration of surgery, length of hospital stay, time to partial weight bearing, time to full weight bearing, time to union, knee range of motion at final follow-up, other clinical and radiological findings, and complications were recorded.

Surgical technique

All patients were operated under spinal anaesthesia. Patients were positioned supine on a radiolucent operating table. Injured limb was kept in minimal flexion at knee and normal limb was flexed at knee and abducted for creating adequate space for image intensifier. Surgical approach was decided based on, whether the fracture is extraarticular or intraarticular. For extraarticular fractures, a modified standard lateral approach was used. For intraarticular fractures, a lateral parapatellar approach was used. All reduction were achieved by indirect methods. This involved using small bolsters/bumps placed underneath the distal thigh to correct saggital plane deformities. Reduction clamps and traction were used to correct alignment in the coronal plane. Under image intensifier guidance, alignment and rotation were restored by judging the hip rotation on the uninjured side using the lesser trochanter as a guide. Leg length was maintained by traction. Following reduction, appropriate-sized plates (anatomically pre-contoured LCP for distal femur made of 316L stainless steel alloy was used in our study. LCP are available from 6-13 hole with plate thickness of 4.5 mm) were slid in the submuscular plane holding one end of the plate with a sleeve. The plate was then aligned to the contour of the bone. After confirming the alignment of the plate with distal segment was fixed provisionally with the help of K-wire. The length of the plate was determined intraoperatively after reduction. For distal fixation, at least 3 metaphyseal locking screws were used, their sizes did not violate the intercondylar notch space. Under fluoroscopic guidance, the incision was made over the lateral aspect of the thigh at the level of the proximal screw holes. The tensor fascia lata and vastus lateralis were split in the direction of their fibres. This proximal incision was used to check the approximation of plate to bone. Reduction was sometimes maintained by Kirschner wires placed through holes in the LCP. A bridging technique was used for comminuted fractures, whereas a compression technique was used for simple fractures. Bone grafting was not performed. All proximal screws were bicortical. At least 3 screw holes were beyond the proximal extent of the fracture, and distally the plate did not extend beyond the joint line. Type of proximal fixation used was based on the fracture pattern and the bone quality. Regular screws in neutral or compression mode, locking screws or a combination of these was used. In cases of simple transverse metaphyseal fracture in good quality bone, a screw in compression mode was followed by three or four screws placed in neutral position. These screws were placed in the appropriate dynamic compression holes in the plate, using appropriate drill guides to ensure accurate drill hole positioning. In case of poor bone quality, use of locking screws in the proximal segment was preferred.

Once the plate was provisionally applied to the proximal segment, it was checked under fluoroscopy if the plate was properly centred on the shaft for secure locking screw insertion. In some cases combination of conventional and locking screws were used, in those cases conventional screws were inserted before locking screws to bring the plate and fragment nearer.

Postoperatively, the operated limb was kept in elevation on a splint with the knee in 10º to 15º of flexion. Active hip and knee mobilisation and static quadriceps exercises were allowed at postoperative day 1.Patients were mobilized on crutches/walker, and toe touch weight bearing was allowed. Weight bearing was initiated depending on the radiological evidence of bone union. Full weight bearing was not permitted until consolidation of the fracture site. The progress of healing was assessed with routine anteroposterior and lateral radiographs at 4 weekly intervals up to 24 weeks, then every 3 months up to one year, and 6 monthly thereafter. Bone union was defined as bridging callus across the fracture site in three of the four cortices on both anteroposterior and lateral radiographs in the absence of migration, loosening or breakage of hardware, and a painless fracture site during weight bearing. Clinical and functional outcomes were assessed using the NEER's score.

RESULTS

It was a prospective study. The study population comprised of 20 patients with mean age of 51.8 years ranging from 21 yrs to 68 yrs (Table 2), 8 of our patients were male and 12 were female (Table 1). 13 patients sustained RTA (Road Traffic accident) and 7 patients had accidental fall (Table 3, Figure 2 and 3). 8 patients had right sided distal femur fracture and 12 had left sided injury (Figure 1). Among our 20 patients, 6 were Muller's type A1; 1 was Muller's type A2; 4 were Muller's type A3; 3 were Muller's type C1; rest 6 were Muller's type C2 (Table 4). 1 patient had associated contra lateral shaft of femur fracture treated with retrograde nailing. 2 patients had sustained injury to their poliotic limb (Table 5). All the patients in our study were treated by closed reduction and internal fixation by MIPO. Patients were treated within 6 days of injury (Table 6). Average surgical time was 96 minutes, shortest being 70 minutes and longest being 135 minutes (Figure 4). Plate size was decided upon fracture requirement with 7 to 9 holed being commonly used. 16 patients (80%) showed radiological union within 18 weeks (Table 7 and 8). Average knee flexion gained in our study was 108º (85-120) (Figure 5). Among 20 patients one had superficial infection which subsided on parenteral antibiotics (Table 9). 2 patients had limb length discrepancy of less than 1 cm (Figure 6). 4 patients had varus/valgus malalignment (of less than 5º deviation compared to anatomical axis in both planes) which was clinically not significant (Figure 7). Final results were assessed based on the NEER's scoring system according to which out of 20 cases we had 10 (50%) cases with excellent outcome, 7(35%) cases with good and 3 (15%) with fair outcome (Figure 8).

Patient demographics and outcomes are shown below. And clinical pictures on follow up are in Figure 9-12.

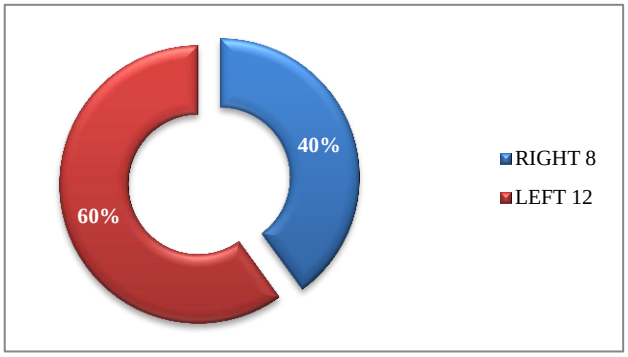

Figure 1: Side involvement.

Table 1: Sex distribution.

Sex	Cases	Percentage (%)
Male	8	40.00
Female	12	60.00
Total	20	100.00

Table 2: Age distribution.

Age group (years)	Cases	Percentage (%)
18-30	3	15.00
31-40	2	10.00
41-50	2	10.00
51-60	8	40.00
>60	5	25.00
Total	20	100.00

Table 3: Mechanism of injury.

Mechanism	Cases	Percentage (%)
RTA	13	65.00
Fall	7	35.00
Total	20	100.00

Table 4: Fracture type distribution.

AO – muller type	Cases	Percentage (%)
A1	6	30.00
A2	1	5.00
A3	4	20.00
B1	-	-
B2	-	-
B3	-	-
C1	3	15.00
C2	6	30.00
C3	-	-
Total	20	100.00

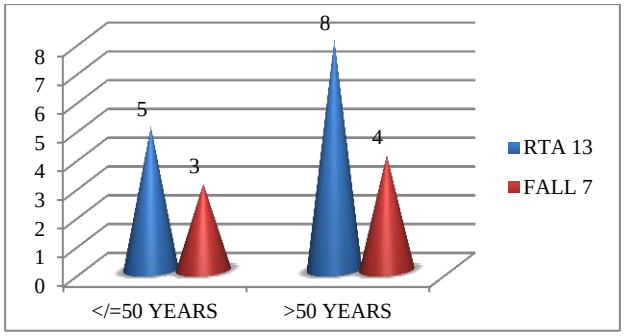

Figure 2: Age and mechanism of injury relationship.

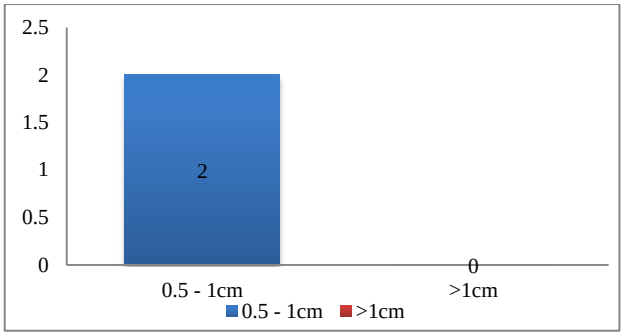

Figure 6: Limb length discrepancy.

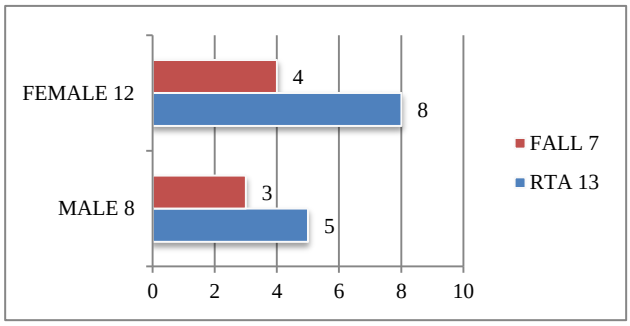

Figure 3: Sex and mechanism of injury relationship.

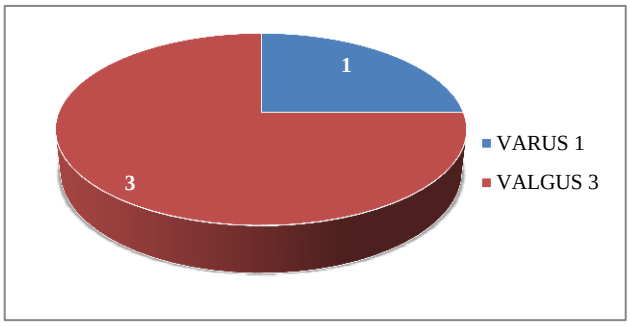

Figure 7: Varus / valgus mal-alignment.

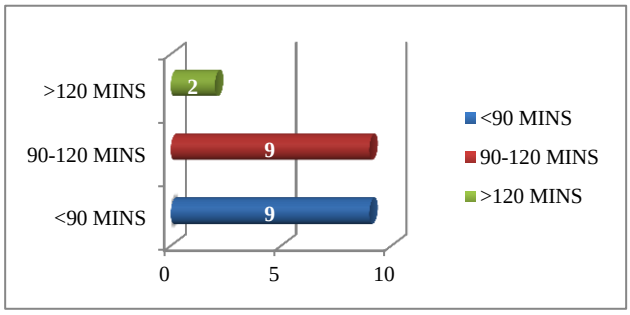

Figure 4: Duration of surgery.

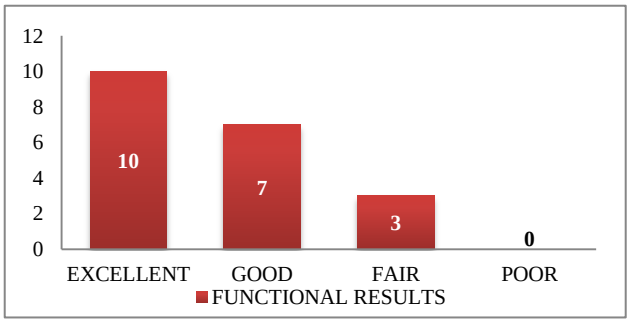

Figure 8: Functional results.

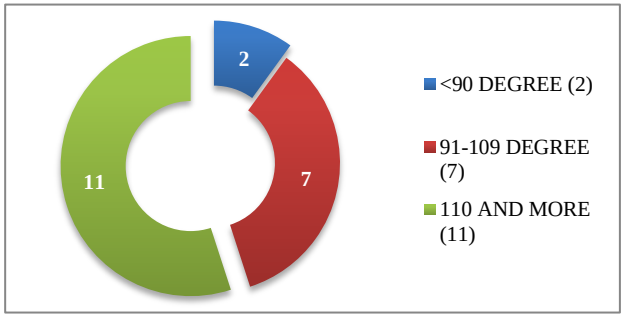

Figure 5: Knee flexion.

Table 5: Associated injuries / complications.

Associated injuries	Cases	Percentage
Present	3	15.00
Absent	17	85.00
Total	20	100.00

Table 6: Injury to surgery interval.

Injury – surgery interval (days)	Cases	Percentage (%)
1-3	11	55.00
4-7	9	45.00
>7	-	-
Total	20	100.00

Table 7: Time taken for full weight bearing.

Full weight bearing time (weeks)	Cases	Percentage (%)
12-14	4	20.00
15-16	8	40.00
17-18	7	35.00
>18	1	5.00
Total	20	100.00

Figure 9: Case 1 (A) pre-operative, (B) post-operative, (C) 3 month follow up, (D) 6 month follow up, (E) flexion, (F) extension.

Figure 10: Case 2 (A) pre-operative, (B) post-operative, (C) 3 month follow up, (D) 6 month follow up, (E) flexion, (F) extension.

Table 8: Time taken for radiological union.

Radiological union (weeks)	Cases	Percentage (%)
<16	3	15.00
16-18	13	65.00
19-20	4	20.00
21-22	-	-
Delayed union	-	-
Non-union	-	-
Total	20	100.00

Figure 11: Case 3 (A) pre-operative, (B) post-operative, (C) 3 month follow up, (D) 6 month follow up, (E) flexion, (F) extension.

Figure 12: Case 2 (A) pre-operative, (B) post-operative, (C) 3 month follow up, (D) 6 month follow up, (E) flexion, (F) extension.

Table 9: Complications.

Complications	Cases	Percentage (%)
Superficial infection	1	5.00
Deep infection	-	-
Delayed union	-	-
Non union	-	-
Plate backout	-	-
Implant failure	-	-
Stress fracture	-	-

DISCUSSION

This study was conducted to assess the results of MIPO of lower end of femur fracture using pre contoured LCP. Various treatment modalities have been used from conventional plates, dynamic condylar screw even to intramedullary nailing. These treatment modalities have problems of loss of reduction, excessive soft tissue stripping and violation of joint with complications such as non-union, malunion, implant failure and infection.

MIPO can be used in the treatment of supracondylar and intracondylar fracture of distal femur with few complications and good outcome.

Kregor et al reported a series with equal distribution of Types A and C distal femoral fractures and obtained a 100% union rate. Only 5% of the cases required bone grafting but it is unclear from the description what was the time to union and the indications for bone grafting.[3]

In our study of 20 distal femur fractures, 10 (50%) had excellent results, 7 (35%) had good results and 3 (15%) patients had fair results. These results were comparable to a study conducted by Kolb et al.[12]

Jain et al concluded that provided it is applied with proper understanding of biomechanics, LCP is one of the best available options for management of challenging peri- and intra-articular fractures of distal femur.[17]

EL-Ganainy et al concluded that minimally invasive percutaneous locked plating provided favourable results in the treatment of distal femoral fractures in geriatric population with diabetes.[18]

Subasi et al stated that minimally invasive percutaneous plate fixation can be considered an alternative technique in type IIIA and type IIIB open fractures resulting from high-velocity gunshot injuries.[19]

Farouk et al concluded percutaneous minimally invasive plating technique disrupts the femoral blood supply less than the traditional open method. Such minimally invasive methods may be more advantageous biologically than the traditional method.

Laubethal has demonstrated that average motion required for: Normal sitting – 93*, Stair climbing – 100*, Squatting – 117*, Average knee flexion gained in our study was 108*.[20]

Yeap, Deepak conducted a retrospective review on eleven patients who were treated for type A and C distal femoral fractures between January 2004 and December 2004. All fractures were fixed with titanium locking compression plating. The patient's age ranged from 15 to 85 with a mean of 44. Clinical assessment was conducted at least 6 months post-operatively using Schatzker score system. Results showed that four patients had excellent, four good, two fair and one failed.[21]

Zhongguogushang et al concluded that this method for treatment of supracondylar femur fracture can get satisfactory function, high rate of bone union and less complications. Familiarity with the close reduction technique and the geometry shape of anatomic plate as well as femoral supracondylar area are important to treat the supracondylar femur fractures. In his study of 39 supracondylar fractures treated by MIPPO 28 got excellent, 10 got good and remaining got fair results.[22]

In a study by Doshi et al and a similar study conduted by Khursheed et al on clinical outcomes of distal femoral fractures in geriatric population using locking plates with a minimally invasive approach they concluded that it resulted in a favourable outcome and the method appears to be useful and safe. All patients in their study had satisfactory functional outcomes with no mortalities and few postoperative complications.[23,13]

Mast et al in 1989 first reported the importance of reduced surgical dissection of the fracture site and utilised the surrounding soft tissues for fracture reduction. He termed this 'indirect reduction' of the fracture. This was aimed at maintaining blood supply to the fracture ends and to reduce the rate of non-union in operative cases. Subsequently, Krettek and co-workers took this concept further by emphasising the need to obtain relative rather than absolute stability of the fracture by internal fixation. This concept was already familiar to most in relation to intramedullary nails. They also suggested minimal interference with the zone of injury, which was achieved by sliding plates in the submuscular plane on the lateral side of the femur (minimally invasive percutaneous plate osteosynthesis (MIPPO).[24,15]

Our results are comparable with the previous literature by Nayak et al. They evaluated treatment outcomes of minimally invasive plate osteosynthesis for distal femoral fractures in 31 patients, found 93.54% patients had good or excellent outcomes with radiological union grade-I & II and the mean time to union was achieved in 3.7 (range, 2.8–4.6) months. None of the patients had patient had angular or rotational deformity of >10.[25]

CONCLUSION

Closed reduction and pre-contoured LCP plating for Distal Femur by MIPO is soft tissue friendly approach preserving blood supply and can get satisfactory function, high rate of bone union and less complications. And less complications, also minimizing the use of bone grafting and donor site complications. It provides rigid fixation in the region of femur, where widened canal, thin cortices and frequently poor bone stock makes fixation difficult. To conclude, locking compression plating by MIPO technique is an important procedure in treatment of distal femur fractures especially when fracture is severely

comminuted and in situations of osteoporosis. Further study in large number is required to comment regarding disadvantages and complications.

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Ethical approval: The study was approved by the institutional ethics committee

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