

Original Research Article

Functional outcome of distal femoral fractures treated with distal femoral locking compression plate: a cross-sectional study

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ABSTRACT

Background: Despite advances in fixation techniques, distal femoral fractures still pose significant challenges for orthopedic surgeons. Effective treatment hinges on a detailed understanding of local anatomy, accurate clinical and imaging assessments, recognition of the fracture morphology, and the judicious choice of a fixation device suited to the particular case. Locking compression plates (LCPs), with their numerous advantages such as enhanced stability, fixed-angle screw locking, and minimal disruption to periosteal blood supply have proven to be highly effective in addressing these challenges and are especially valuable in osteoporotic bone.

Methods: This cross-sectional study was conducted at a tertiary care institution in Tripura between October 2016 and September 2019, comprising 60 patients with distal femoral fractures who underwent open reduction and internal fixation utilizing a distal femoral locking compression plate (DF-LCP). The functional outcome was assessed using Neer's criteria.

Results: The study included 60 patients, of whom 42 were male and 18 were female. The majority of fractures (70%) were attributed to road traffic accidents. The mean duration for radiological evidence of fracture union was 17.2 weeks. According to Neer's criteria, the final functional outcome of the knee was rated as excellent in 34 patients (56.7%), good in 20 patients (33.3%), fair in 5 patients (8.33%), and poor in 1 patient (1.67%).

Conclusions: Surgical fixation of distal femoral fractures with distal femoral LCP provides good functional outcome and is one of the best modalities of treatment available for these kinds of fractures especially in severely comminuted and in osteoporotic cases.

Keywords: Distal femur fractures, Functional outcome, Plate osteosynthesis

INTRODUCTION

Distal femoral fractures represent a challenging subset of lower limb injuries, accounting for approximately 6% of all femoral fractures.¹ "The advent of mechanization and the widespread use of high-speed transportation have contributed to a noticeable increase in both the frequency and severity of distal femoral fractures."² This upward trend continues, reflecting the growing impact of modern trauma mechanisms on musculoskeletal injuries." A bimodal pattern is observed in distal femoral fractures, with high-

energy trauma affecting younger males and low-energy mechanisms, such as falls, leading to injury in older females.³

Surgical stabilization is now widely recognized as the standard of care for most distal femoral fractures, as non-operative management is associated with poor outcomes. Key surgical goals in managing distal femoral fractures include anatomic joint surface reduction, restoration of mechanical axis, limb length and rotation, stabilization of the metaphyseal region, and preservation of knee

function.⁴ Significant bone defects may necessitate the use of autograft or allograft to achieve adequate structural support. Additionally, stable fixation is crucial to permit early mobilization and optimize recovery.⁴

However, internal fixation of distal femoral fractures remains technically challenging due to a combination of anatomical and pathological factors, including thin cortical bone, relative osteopenia, and the frequent occurrence of comminution. These characteristics often complicate the achievement of stable and reliable fixation.

Distal femoral fractures remain a significant challenge for orthopedic surgeons. Effective treatment hinges on a detailed understanding of local anatomy, accurate clinical and imaging assessments, recognition of the fracture pattern, and the judicious choice of a fixation device suited to the particular case. The locking compression plate (LCP) combines the principles of traditional compression plating with those of locked plating, enhancing stability and promoting more effective plate osteosynthesis.⁷ This hybrid approach allows for better fixation, particularly in osteoporotic or comminuted bone, and supports early mobilization.⁷

A key advantage of the LCP system lies in its ability to ensure rigid fixation with limited interference to the periosteal and soft tissue environment which is crucial for promoting biological fracture healing. Additionally, locking plates are designed to accommodate multiple screws in the diaphyseal region, allowing for enhanced stability and maximal fixation, especially in complex or osteoporotic fractures.⁸

The locking compression plate (LCP), with its anatomically contoured design, helps limit soft tissue irritation while providing biomechanical stability akin to an internal-external fixator.⁹ Moreover, the LCP offers distinct advantages such as the ability to achieve secure unicortical fixation and a significantly reduced risk of plate back-out, as the locking mechanism ensures that the screw threads firmly engage with the plate itself, providing a stable construct.⁹

The present study aims to assess the technical considerations, clinical and radiological outcomes, as well as to identify potential pitfalls, complications, and overall effectiveness of this fixation method in varied fracture patterns.

METHODS

A cross-sectional study was carried out over a three-year period (October 2016 to September 2019) in the Department of Orthopaedics at Agartala Government Medical College and Gobind Ballabh Pant Hospital, Agartala. The study enrolled 60 patients presenting with either intra-articular or extra-articular distal femoral fractures. All patients were managed surgically using

distal femoral locking compression plates. Prior to initiation, Institutional Ethics Committee approval for the study was taken. Written informed consent was taken from all patients. The study protocol adhered to the principles outlined in international ethical guidelines, ensuring the protection of patient rights and data confidentiality throughout.

Inclusion criteria

Adults (≥ 18 years) with confirmed distal femoral fractures. Open distal femoral fractures up to Gustilo-Anderson type I, II, and IIIA.

Exclusion criteria

Pathological fractures, open distal femoral fractures classified as Gustilo-Anderson type IIIB and IIIC. Non-union or delayed union of fractures. Peri-prosthetic fractures.

Preoperative anteroposterior and lateral radiograph of whole femur including knee and hip were obtained from all patients. An X-ray of the pelvis with both hips anteroposterior view was done to rule out associated fractures of the hip region and pelvis. Other x rays of extremities, spine and chest were done in accordance with sustained trauma. CT scan was done in selected patients.

Operative procedure

The operation was performed under regional anesthesia (spinal lumbar block) in all cases. All patients were operated in supine position with a bump placed beneath the knee to maintain slight flexion and facilitate fracture reduction. After proper positioning, a pneumatic tourniquet was applied.

Skin preparation was performed using povidone-iodine and spirit, covering the entire involved extremity up to the ipsilateral iliac crest, followed by draping with sterile sheets. The pneumatic tourniquet was then inflated, and the C-arm was draped separately in a sterile fashion.

A standard lateral approach or lateral parapatellar approach was taken depending upon the fracture configuration. Minimal soft tissue stripping was performed, limited to what was essential for proper plate application and articular surface reduction. Exposure and anatomical reduction of comminuted anterior and metaphyseal fragments were avoided to maintain vascularity, as per biological fixation principles.

Provisional fixation was achieved using K-wires to hold the fracture fragments in place. Once satisfactory reduction and alignment were confirmed under fluoroscopy, interfragmentary screws were inserted where appropriate to improve stability prior to definitive plate fixation.

After selecting the appropriate plate length intraoperatively based on the fracture pattern with a minimum plate length three times the length of the fracture comminution segments a distal femoral locking compression plate (DF-LCP) was slid submuscularly along the lateral surface of the femur, advancing from distal to proximal. For proximal fixation, three to four bicortical screws were placed percutaneously under fluoroscopic control to optimize construct stability while minimizing soft tissue disruption. Distal fixation was accomplished with a minimum of five locking screws, ensuring robust fixation across the distal femoral segment and providing stable support for fracture healing.

In cases with severe comminution, primary bone grafting was performed to enhance fracture stability and promote healing. This was done intraoperatively when significant bone loss or fragmentation was encountered, aiding in structural support and union.

Post-operative care and rehabilitation

Postoperatively, anteroposterior (AP) and lateral radiographs of the whole femur with knee joint were obtained to evaluate fracture alignment and assess the adequacy of fixation. The surgical wound was assessed on the second postoperative day to monitor for signs of infection or complications. Suture removal was performed on the fourteenth postoperative day. Patients commenced non-weight-bearing mobilization within the first postoperative week, in accordance with standard rehabilitation protocols to facilitate healing while preventing mechanical stress on the operative limb. This was maintained for 6 to 8 weeks, tailored to the individual's pain threshold, stability of fixation, and fracture morphology. Partial weight bearing was then allowed following radiological confirmation of early fracture healing and continued until complete fracture union.

Follow up and evaluation of outcome

Postoperative follow-up was conducted at regular intervals, beginning at 4, 8, and 12 weeks after surgery, and continuing monthly thereafter until fracture union was confirmed both clinically and radiographically. Subsequent follow-ups were conducted at the 6th month, 9th month, and at 1 year. At each follow-up visit, patients underwent clinical, radiological, and functional assessment, with outcomes evaluated according to Neer's criteria.¹⁰ Each patient was followed for at least 24 weeks to monitor the progress of fracture healing and assess functional outcomes during recovery.

Statistical analysis

The data were entered into a master chart and analyzed using appropriate statistical methods, including proportions, means, standard deviations, and other tests as required. Analysis was conducted using statistical

software, such as SPSS version 16. The results were interpreted, discussed, and compared with existing literature, with conclusions drawn in consideration of the study's limitations. Findings were presented in the form of tables, charts, graphs, figures, and photographs.

RESULTS

The present study was conducted among 60 patients admitted under orthopedics department of AGMC & GB Pant Hospital in between October 2016 to September 2019 of West Tripura.

Table 1: Demographic characteristics of the study population.

Characteristics	No. of patients (%)
Age group (in years)	18-30 14 (23.3)
	31-45 20 (33.3)
	46-60 16 (26.7)
	>60 10 (16.7)
Sex	Male 42 (70)
	Female 18 (30)
Laterality	Right 38 (63.3)
	Left 22 (36.7)
Mode of injury	Rta 42 (70)
	Fall 18 (30)
Closed or open injury	Closed 8 (13.3)
	Open 52 (86.7)
Muller classification	A1 12 (20)
	A2 10 (16.7)
	A3 16 (26.7)
	C1 6 (10)
	C2 12 (20)
	C3 4 (6.7)

The mean age of the patients was 45.7 years (± 18.2), with ages ranging from 18 to 80 years. A higher incidence of fractures was noted among individuals aged 18 to 45 years, reflecting a greater vulnerability in this younger demographic. Males comprised 70% of the study population, while females accounted for 30%. The majority of injuries (63.3%) occurred on the right side, whereas 36.7% were on the left side. The study found that Type A fractures were the most prevalent, comprising 63.4% of all cases. Among the AO classification subtypes, the most common was type A3, which constituted 26.7% of the total cases. Extra-articular fractures were more prevalent, observed in 38 patients (63.4%), compared to intra-articular fractures, which were noted in 22 patients (36.6%) (Table 1).

Majority (86.7%) of the patients had closed type of fracture followed by open type in 13% of the patients. Out of 60 cases, 14 cases presented with associated injuries like head injury, fracture ulna, fracture both bone forearm etc. 28.6% cases presented with fracture patella as associated injuries with the distal femur fracture.

The average interval between injury and surgery was 13.5 days, with a standard deviation of 5.3 days. Majority (83%) of the patients stayed in the hospital for 3-5 weeks

followed by more than 5 weeks (10%). The average hospital stay was 3.8 ± 1.06 weeks.

Table 2: Outcome characteristics of the study population.

Parameters		Frequency (n=60)	Percentage (%)
Radiological union	<16 weeks	14	23.3
	16-18 weeks	36	60
	>18 weeks	9	15
	Non-union	1	1.67
Functional outcome (Neer's Grading)	Excellent (>85)	34	56.7
	Good (70-85)	20	33.3
	Fair (55-69)	5	8.33
	Poor (<55)	1	1.67
Knee flexion (in degrees)	<90 degrees	6	10
	90-109 degrees	18	30
	≥ 110 degrees	36	60

Table 3: Association of patho-anatomic factors with functional outcome of the patient.

Characteristics		Excellent	Good	Fair	Poor	P value
Affected side	Right	14	18	5	1	0.0023*
	Left	20	2	0	0	
Mode of injury	RTA	24	16	3	0	0.359*
	Fall	10	4	2	1	
Gustilo Anderson classification	Open	0	4	3	1	0.006*
	Closed	34	16	2	0	
Muller classification	A1	10	2	0	0	0.002*
	A2	6	2	2	0	
	A3	14	0	1	1	
	C1	4	2	0	0	
	C2	0	10	2	0	
	C3	0	4	0	0	

*P value using Fishers exact test.

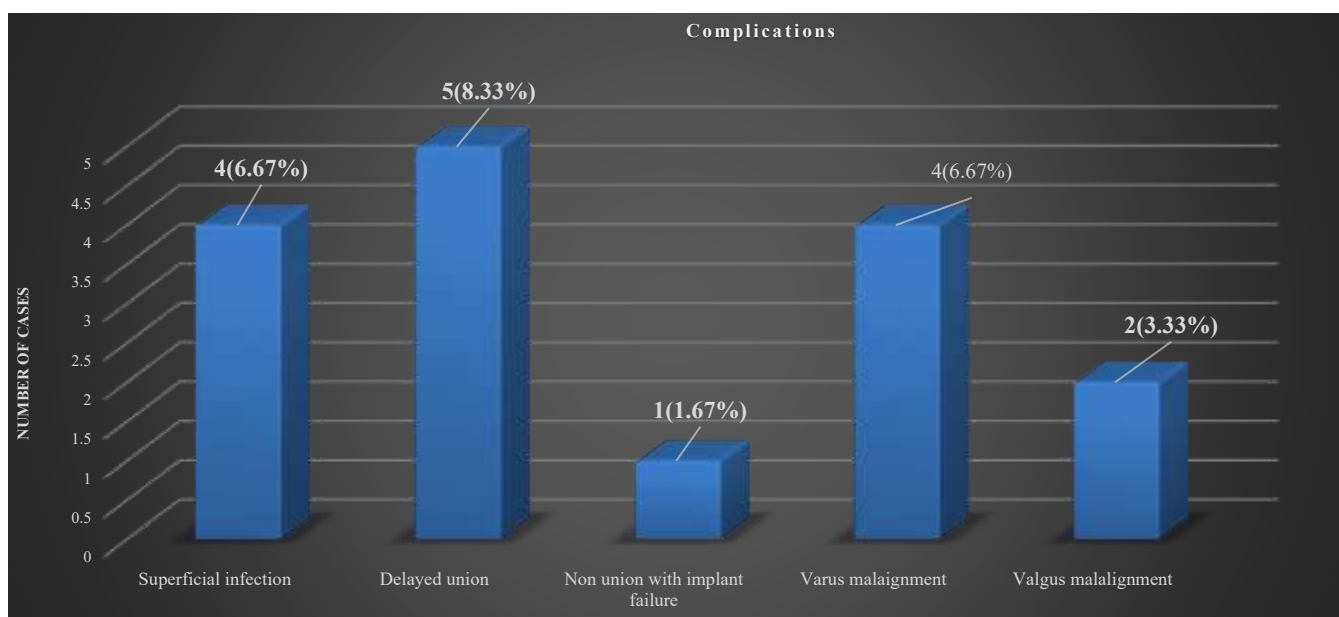


Figure 1: Complications in our study.



Figure 2: (A) Pre-Operative X-ray showing fracture of distal femur, (B) post-Op X-ray showing fixation by DF-LCP, (C) X-ray of post-operative follow-up after 6 months, (D) clinical pictures of post-operative follow-up after 6 months.



Figure 4: (A) X-ray of implant failure after 5 months with non union, (B) X-ray of revised operation at 5 months with DF-LCP with bone grafting, (C) X-ray of post-operative follow-up after 4 months of revised operation showing union.

The mean duration for radiological evidence of fracture union was 17.2 weeks. However, one patient developed non-union accompanied by implant failure. The Neer's score among the patients ranged from 50 to 94, with a mean score of 82.7 ± 9.69 . Final analysis revealed excellent outcomes in 56.7% of patients, good outcomes in 33.3%, and fair outcomes in 8.33%. One patient experienced a poor outcome due to implant failure. The average knee flexion achieved in this study was 115° , with 60% of patients demonstrating a range of motion equal to or greater than 110° (Table 2).

In our study, four patients developed superficial infections, five experienced delayed union, and four presented with varus malalignment. One patient progressed to non-union accompanied by implant failure (Figure 1).

Association of distal femoral fracture patients functional outcome with patho-anatomic factors of fracture were found to be significantly associated with affected side of fracture, Gustilo Anderson classification and Muller classification (Table 3).

DISCUSSION

Distal femoral fractures are often regarded with significant concern due to their complexity and the challenges they pose in treatment. The successful management of distal femoral fractures, particularly intra-articular fractures, requires surgical intervention to precisely restore and maintain the congruence of the articular surfaces.¹¹

The success of implant selection heavily depends on a meticulous evaluation of the patient's fracture pattern and bone quality. Each case presents unique challenges, and no single surgical implant guarantees optimal outcomes in all situations.¹² Careful planning and individualized decision-making are crucial to achieving the best possible surgical results

The mean age of patients in this study was 45.7±18.2 years, with ages ranging from 18 to 80 years. The mean age of patients in other similar studies were 44 years in Rajaiah et al, 36.64 years in Virk et al and 44.69 years in Shriharsha et al.¹³⁻¹⁵ Fracture incidence was higher in the 18–45 years age group, primarily due to an increase in vehicular accidents in recent times.

In our study, 70% (n=42) of the patients were male and 30% (n=18) were female. In most of the literature males are affected more than female patients indicating increase involvement of young males in high energy trauma. Shriharsha et al found 64% were male and 36% were female patients.¹⁵ Erhardt et al reported 56% male and 44% female patients.¹⁶

Road traffic accidents (RTAs) represented the predominant mechanism of injury in our study, comprising 70% of cases, while falls accounted for the remaining 30%. In most of the literature RTA was found to be the commonest mode of injury. Shriharsha et al reported mode of injury as RTA in 81% patients and fall in 19% patients.¹⁵ Yeap and Deepak reported 70% fractures being caused by RTA with fall accounting for 30% of the patients.¹⁷ The primary cause of distal femoral fractures in this study was road traffic accidents (RTA), predominantly involving two-wheelers. This is largely attributed to the increased vulnerability of the knee joint in such high-impact injuries, making it a common site of trauma in these scenarios.

In our study we classified fractures according to AO Muller's classification. A3 was the most common type of fracture constituting 26.7% (16) of cases with A1 and C2 next most common fracture comprising 20% (12) cases. Overall type A fractures (63.4%) were more common than type C fractures (36.6%). No cases of type B fractures were found in our study. Rohra et al found there were 20% type A1, 27.5% type A2, 17.5% A3, 5% C1, 25% type C2, 5% type C3 fracture in their study. Hesham M et al found type A in 80% patients, type B in 3.33% patient, and type C in 16.67% patients according to the AO classification.¹⁸ Shriharsha et al found 16/26 (61.54%) type C fractures as compared to 10/26 (38.46%) type A fractures.¹⁵ There is variation in literature about the most common type of fracture with an increasing trend towards intra-articular fractures. In our study however, extra-articular fractures were common with comminuted extra-articular fracture (A3) the commonest.

Table 4: Comparison of common implants and techniques to treat distal femoral fractures based on time to radiological union.

At present commonly used techniques	Published articles	Radiological union (in weeks)
ORIF with DCS	Patil et al ²³	15
	Mulay et al ²⁴	24
	Dar et al ²⁵	18.7
Retrograde interlocking nail	Giddie et al ²⁶	17.5
	Elmowafy et al ²⁷	13
	Dar et al ²⁵	18.5
MIPO with DF-LCP or LISS	Nayak et al ²⁸	14.8
	Padha et al ²⁹	14.2
	Gupta et al ³⁰	18
ORIF with DF-LCP	Our study	17.2

Mean injury-surgery interval in our study 13.5 days± 5.3 days. Delay in surgery in our study was mainly caused by anaesthetic fitness problems, medical comorbidities and increased patient load in our hospital. The study by Seinshiemer demonstrated that longer delays before surgery were linked to worse outcomes, suggesting that surgical intervention should ideally occur within one week.¹⁹ We found that there was an increase in operative time and blood loss associated with delay in surgery injury

interval but final functional outcome was not affected if surgery was done within 2 weeks.

Bone grafting was required in nine patients in our study. Of these, eight patients underwent primary bone grafting due to severe comminution or bone loss, whereas one patient required secondary grafting later during the course of treatment to address nonunion associated with implant failure. Our findings suggest that achieving satisfactory

fracture reduction, along with timely bone grafting, plays a critical role in ensuring positive outcomes for patients with extensive comminution. These steps are essential for ensuring optimal stability, promoting fracture healing, and ultimately leading to better functional outcomes. Mize et al emphasized the critical role of bone grafting in the management of severely comminuted femoral fractures.²⁰ In their study, bone grafting was performed in 87% of the patients, highlighting its crucial role in promoting healing and ensuring stable fixation in complex fractures. Pritchett et al further emphasized the critical need for bone grafting in managing delayed or nonunion fractures of the distal femur.²¹

The average duration of hospitalization in this study was 3.8 weeks, which was extended due to several factors, including associated injuries, increased patient load, anaesthetic fitness issues, and the requirement for strict postoperative physiotherapy. These factors significantly impacted the treatment and rehabilitation process.

The mean duration for radiological evidence of fracture union was 17.2 weeks, with 60% of patients achieving union within 16 to 18 weeks. However, one patient experienced nonunion with implant failure, and five patients developed delayed union. Sriharsha et al in their study observed mean time for union 19.36 weeks while Sah S et al found it to be 20 weeks.^{15,22} Time to radiological union in our study is in concordance with other similar studies (Table 4).

In our study, one patient experienced non-union with implant failure, and five patients developed delayed union. The underlying causes of implant failure and non-union were multifactorial, including severe comminution, significant osteoporosis, inadequate fixation, and early full weight-bearing. These factors compromised the stability of the fracture site and hindered the healing process, ultimately leading to implant failure and non-union. Upon diagnosing implant failure, we promptly removed the failed implant and re-stabilized the fracture using a DF-LCP along with secondary bone grafting. Following this intervention, the fracture successfully united after 4 months. Sharma et al reported three cases of delayed or non-union in distal femoral fractures, which required additional procedures for successful healing. Similarly, Kolb et al in their study, reported three cases of delayed union and one case of non-union, emphasizing the challenges in managing complex femoral fractures and the need for further interventions in certain cases.^{31,32}

In our cohort, there were four cases of 5 degrees of varus malalignment, yielding a malalignment rate of 6.6%, as well as two cases of valgus malalignment (3.3%). Mize et al reported a malunion rate of 7.3% in his series.²⁰ Similarly, Kolb et al observed malalignment in 12.1% of cases following fixation of distal femoral fractures.³² This highlights the importance of achieving accurate alignment during surgical treatment to minimize the risk of complications and ensure optimal functional outcomes.

In our study superficial infection occurred in 4 patients, yielding an infection rate of 6.7%. Our infection rate was similar to other studies, including Kim et al who reported two postoperative infections, Kolb et al with a 4.8% rate in 41 patients and Sanders et al who reported a 5.3% infection rate.³²⁻³⁴

The average knee flexion in our study was 115°, with 60% of patients achieving a knee range of motion greater than or equal to 110°. The average knee flexion for type C fractures was 100°, whereas for type A fractures, it was 112°. This disparity indicates that intra-articular fractures lead to increased stiffness and a reduced range of motion. Rademaker et al reported a mean range of motion of 118 degrees, while Erhardt et al in their study reported range of motion at the knee joint of 117° on average (range 70-140).^{12,35}

In our final analysis, the Neer's score ranged from 50 to 94, with a mean score of 82.7±9.69. The final analysis using Neer's score revealed an excellent outcome in 56.7% of patients, followed by good outcomes in 33.3%, and fair outcomes in 8.3% of patients.¹ patient had poor outcome because of implant failure. In our study, extra-articular and closed fractures demonstrated better outcomes compared to intra-articular and open fractures, respectively. Final Neer's score in our study were comparable to other studies like Rao et al, Girisha et al and Sahu et al using DF-LCP in distal femoral fractures.³⁶⁻³⁸

CONCLUSION

The outcome of treatment with DF-LCP in distal femoral fractures depend upon many factors- age of patient, type of fracture, stable fixation, post-operative care and rehabilitation. Meticulous preoperative planning, careful patient selection, and precise surgical technique are crucial to minimize complications and achieve optimal outcomes. Adhering to the fundamental principles of fracture fixation ensures optimal fracture healing and minimizes the risk of adverse effects. The DF-LCP is the implant of choice for distal femoral fractures due to its numerous advantages, including superior angular stability, rigid fixation, and minimal periosteal stripping. It is especially effective in cases involving metaphyseal comminution, complex intra-articular fracture geometries (such as AO Müller's C3 type fractures), and osteoporosis.

However, a more comprehensive study with longer follow up periods is essential to throw more light into the advantages, complications and possible disadvantages of the use of DF-LCP with special attention to the long-term outcomes.

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