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Stability, Biology, and Function: Outcomes of Lateral Locking Plate Fixation in Distal Femur Fractures

Dr Babaji Sitaram Thorat [1], Dr Ravi Mavani [2], Dr Avtar Singh Kamboj [3], Dr Abhijit Das [4], Dr Arcot Reddy Vamsi Krishna [4], Dr Prabhat Mittal *[4]

[1]Senior Consultant, Department of Orthopaedics, Amandeep Hospital, Amritsar, Punjab, India.
[2]Senior Resident, Department of Orthopaedics, Amandeep Hospital, Amritsar, Punjab, India.
[3]Head of Department, Department of Orthopaedics, Amandeep Hospital, Amritsar, Punjab, India.
[4]Fellow Resident, Department of Orthopaedics, Amandeep Hospital, Amritsar, Punjab, India.

*Corresponding Author: Dr Prabhat Mittal; *prabhatmittal28@gmail.com*

Abstract

Objective: To evaluate radiological union, functional outcomes, and complications following lateral distal femoral locking compression plate (DF-LCP) fixation in distal femur fractures. ***Design:*** Prospective observational study. ***Subjects/Patients:*** Sixty skeletally mature patients (≥18 years) with AO/OTA type A, B, or C distal femur fractures treated at a tertiary care centre between 2023–2024. ***Methods:*** Patients underwent lateral DF-LCP fixation via standard lateral or minimally invasive percutaneous approaches. Radiological union was assessed using serial anteroposterior and lateral radiographs. Functional outcomes were evaluated with the Knee Society Score (KSS) at 1, 3, 6, and 12 months. Knee range of motion (ROM) and postoperative complications were recorded. All assessments were performed by a single senior orthopaedic surgeon to reduce inter-observer variability. ***Results:*** The mean age was 42.9 ± 16.5 years; 73.3% were male. Road traffic accidents caused 95% of fractures; AO type C fractures comprised 55%. Radiological union was achieved in 96.6% of patients, with a mean union time of 15.3 weeks. Complications occurred in 10% of cases. Mean knee flexion improved from 83.3° at 1 month to 103.3° at 12 months ($p < 0.001$). At 12 months, 81.7% of patients had excellent or good functional outcomes. ***Conclusion:*** Lateral DF-LCP fixation provides reliable fracture union, satisfactory functional recovery, and acceptable complication rates. Optimal outcomes depend on precise reduction, soft-tissue preservation, and structured rehabilitation.

Keywords: ***distal femur fracture, locking compression plate, DF-LCP, biological fixation, functional outcome, knee range of motion.***

Introduction

Distal femur fractures account for approximately 6–7% of all femoral fractures and pose significant challenges due to complex distal femoral anatomy, frequent metaphyseal comminution, and the need to restore an intact articular surface for optimal knee function [1,2,4]. These injuries often result from high-energy trauma in younger adults or low-energy falls in osteoporotic elderly patients, making surgical management technically demanding [5,6].

Historically, non-operative treatment and conventional internal fixation methods were associated with malunion, knee stiffness, and delayed functional recovery [3,4,7]. Locking compression plates (LCPs) provide angular stability independent of plate–bone compression, preserving periosteal blood supply and promoting biological healing [13,14]. Distal femoral LCP (DF-LCP) fixation has been increasingly adopted for complex intra-articular and osteoporotic fractures, yet prospective data evaluating union rates, functional outcomes, and complications across a broad fracture spectrum remain limited [8-11].

This study aims to prospectively assess radiological union, functional recovery using the Knee Society Score (KSS), and complication rates following lateral DF-LCP fixation in AO/OTA type A, B, and C distal femur fractures.

Methods

This prospective observational study was conducted at a tertiary care centre between January 2023 and December 2024. Institutional Ethics Committee approval was obtained, and written informed consent was obtained from all participants. Sixty consecutive skeletally mature patients (≥18 years) with AO/OTA type A, B, or C distal femur fractures, including closed fractures and open fractures up to Gustilo–Anderson Grade III, were included. Exclusion criteria were pathological fractures, polytrauma requiring staged fixation, fractures managed with implants other than lateral DF-LCP, and loss to follow-up before 12 months. Patient demographics, fracture classification, side, mechanism of injury, and wound grade were recorded.

All surgeries were performed by the same orthopaedic trauma team under spinal or combined spinal–epidural anesthesia on a radiolucent table [1,2]. Fractures were fixed using a lateral distal femoral locking compression plate (DF-LCP, Synthes®, Paoli, PA, USA) applied through either standard lateral approach, or minimally invasive percutaneous osteosynthesis (MIPO) [8,22]. Anatomical reduction of the condyles was achieved for intra-articular fractures prior to definitive plate fixation [3,7]. Distal fixation used multiple fixed-angle screws for stable purchase; proximal fixation employed

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locking or cortical screws according to fracture morphology and bone quality [13,14].

Early quadriceps exercises and passive knee mobilization were initiated as tolerated. Weight-bearing was advanced based on clinical and radiographic assessment of healing. Open fractures were managed with intravenous antibiotics, meticulous debridement, and staged soft-tissue coverage when necessary. Radiological union was defined as the presence of bridging callus on at least three cortices on orthogonal radiographs, accompanied by the absence of pain or abnormal motion at the fracture site. Functional outcome was evaluated using the Knee Society Score (KSS) at 1, 3, 6, and 12 months postoperatively. Knee range of motion (ROM) was measured with a standard goniometer at each follow-up visit. All complications, including infections, non-union, implant failure, or knee stiffness, were recorded systematically during follow-up. To ensure consistency and minimize inter-observer variability, all assessments were performed by a single senior orthopaedic surgeon.

Statistical Analysis

Data were analyzed using SPSS v26.0. Continuous variables are reported as mean ± SD, categorical variables as frequency (%). Repeated-measures ANOVA evaluated changes in knee ROM. $p < 0.05$ was considered statistically significant.

Results

The study cohort included 60 patients with distal femur fractures, with a mean (SD) age of 42.9 (16.5) years; 44 were male (73.3%) and 16 female (26.7%). Road traffic accidents accounted for the majority of injuries (95%), and right-sided fractures were slightly more common (56.7%). Half of the fractures were closed, while open fractures were classified as Grade I in 18.3%, Grade II in 18.3%, and Grade III in 13.3% (**Table 1**). According to the AO/OTA classification, 25% of fractures were type A, 20% type B, and 55% type C, with further subclass distribution shown in Table 1.

Radiological union was achieved in 58 patients (96.6%), with a mean (SD) union time of 15.3 (2.4) weeks. Complications occurred in six patients (10%), including two non-unions, two superficial infections, one deep infection, and one case of knee stiffness. Four patients required additional soft-tissue procedures, including three split-thickness skin grafts and one gastrocnemius flap (**Table 2**).

Functional outcomes assessed by the Knee Society Score at one-year follow-up were excellent in 45% of patients, good in 36.7%, fair in 13.3%, and poor in 5% (**Table 2**). Mean (SD) knee flexion improved progressively from 83.3 (8.2)° at one month to 103.3 (7.6)° at 12 months, demonstrating a statistically significant improvement over time ($p < 0.001$). AO type A fractures exhibited the most favorable functional recovery, whereas Grade III open fractures were associated with lower KSS scores.

Overall, the results indicate high union rates, progressive improvement in knee range of motion, satisfactory functional outcomes in the majority of patients, and predictable complications primarily associated with open or complex intra-articular fractures.

Table 1: Demographic and injury characteristics of study population

Variable	Category	Frequency	Percentage (%)
Age (years)	20–40	29	48.3
	41–60	24	40.0
	61–80	5	8.3
	>80	2	3.3
Gender	Male	44	73.3
	Female	16	26.7
Mode of Injury	Road traffic accident	57	95.0
	Fall	3	5.0
Side of Fracture	Right	34	56.7
	Left	26	43.3
Type of Wound	Closed	30	50.0
	Grade I	11	18.3
	Grade II	11	18.3
	Grade III	8	13.3
AO Classification	A1	5	8.3
	A2	5	8.3
	A3	5	8.3
	B1	8	13.3
	B2	4	6.7
	C1	10	16.7
	C2	10	16.7
	C3	13	21.7

Table 2: Radiological Union, Complications, and Functional Outcome

Variable	Category	Frequency	Percentage (%)
Union status (N = 60)	United	58	96.6
	Non-union	2	3.3
Time to union (weeks)	12–16	40	66.7
	17–20	18	30.0
Complications (N = 6)	Non-union	2	3.3
	Superficial infection	2	3.3

	Deep infection	1	1.7
	Knee stiffness	1	1.7
Functional outcome (KSS)	Excellent	27	45.0
	Good	22	36.7
	Fair	8	13.3
	Poor	3	5.0

Discussion

This prospective observational study demonstrates that lateral distal femoral locking compression plate (DF-LCP) fixation provides reliable fracture union, satisfactory functional recovery, and a low overall complication rate in adult patients with AO/OTA type A, B, and C distal femur fractures. Radiological union was achieved in 96.6% of patients, with progressive improvement in knee range of motion and 81.7% of patients achieving excellent or good functional outcomes at one year. High-grade open fractures and complex intra-articular patterns were associated with comparatively lower functional scores, highlighting the influence of fracture morphology and soft-tissue injury on recovery.

Radiological union was achieved in 58 patients (96.6%), with a mean (SD) union time of 15.3 (2.4) weeks, consistent with prior studies reporting union rates of 90-98% following DF-LCP fixation [1,2,8,9,11]. Complications occurred in six patients (10%), including two non-unions, two superficial infections, one deep infection, and one case of knee stiffness, similar to the rates reported by Henderson *et al*. and Dehghan *et al*.[13,14]. Four patients required additional soft-tissue procedures, including three split-thickness skin grafts and one gastrocnemius flap, as also noted in other series emphasizing staged soft-tissue management for open fractures [5,6,10].

Our findings align with previous studies reporting favorable outcomes with DF-LCP fixation. Saini *et al*.[1] and Kumar *et al*.[2] observed union rates above 90% with good-to-excellent functional outcomes, while more recent studies by Nizar *et al*.[8] and Khan *et al*.[9] reported similar union times and functional recovery, confirming the reproducibility of these results in diverse patient populations [1,2,8,9]. Compared to multicenter series documenting non-union rates up to 13%, [13,14] our lower complication rate may reflect the benefits of single-center standardization, meticulous surgical technique, and structured postoperative rehabilitation [13,14].

The biological advantages of locking plates, including angular stability, preservation of periosteal blood supply, and indirect fracture reduction, likely contributed to predictable callus formation and early mobilization. The study also emphasizes the importance of patient selection and augmentation strategies for high-risk fractures, such as medial comminution or severe metaphyseal instability, where dual plating or additional support may optimize outcomes [16-18,23,26].

Limitations of this study include its single-center design and modest sample size, which restricts subgroup statistical analysis and generalizability. The absence of a comparison group limits direct conclusions regarding the superiority of DF-LCP fixation over alternative techniques such as retrograde intramedullary nailing. Additionally, follow-up was limited to one year, which precludes assessment of long-term complications such as post-traumatic osteoarthritis. Nevertheless, the prospective design, standardized surgical technique, uniform rehabilitation protocol, and single-observer assessment strengthen the internal validity of the findings.

In conclusion, lateral DF-LCP fixation is an effective and reliable treatment for distal femur fractures, achieving high union rates, satisfactory functional outcomes, and low complication rates. Careful attention to anatomical reduction, preservation of soft tissue, and structured rehabilitation protocols is essential for optimal recovery, particularly in complex intra-articular or high-grade open fractures. Future multicenter studies with larger cohorts and extended follow-up are warranted to refine fixation strategies, evaluate long-term functional outcomes, and establish guidelines for fracture-specific augmentation techniques.

Disclosure Statements

Acknowledgment

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Conflict of interest

None

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Institutional Ethics Committee approval

Taken

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