IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 24, Issue 12 Ser. 1 (December. 2025), PP 28-32
www.iosrjournals.org

Implant Failure and Complication Rates in Distal Femur Fractures: Locking Compression Plate Versus Intramedullary Nail

Md Habibur Rahman[1], Muktadir Tamim[2], Goutom Mukharzi[3]

[1]*Senior Consultant, Satkhira Sadar Hospital, Satkhira, Bangladesh*

[2]*Medical Officer, Satkhira Medical College Hospital, Satkhira, Bangladesh*

[3]*Junior Consultant, Satkhira Sadar Hospital, Satkhira, Bangladesh*

Corresponding Author: *Dr. Md Habibur Rahman, Senior Consultant, Satkhira Sadar Hospital, Satkhira, Bangladesh*

ABSTRACT

Introduction: *Distal femur fractures are complex injuries that pose significant challenges in achieving stable fixation and early functional recovery, particularly in adults with comminuted patterns or osteoporotic bone. Various surgical options, including Locking Compression Plates (LCP) and Intramedullary Nails (IMN), are available. This study aimed to compare LCP and IMN fixation in adult distal femur fractures.*

Methods: *This prospective comparative study was conducted from January 2023 to December 2023 at Satkhira Sadar Hospital, Satkhira, Bangladesh, including 62 adult patients with distal femur fractures (AO–OTA types 33-A, 33-B, 33-C) treated with either Locking Compression Plate (LCP, n = 32) or Intramedullary Nail (IMN, n = 30). Data were analysed using SPSS version 25.0.*

Result: *Among 62 patients, baseline characteristics were similar between the LCP (n = 32) and IM nail (n = 30) groups. LCP fixation required longer operative time (102.4 vs 86.7 min), higher blood loss (380.9 vs 290.6 mL), and more open reductions (93.8% vs 40%). Union rates and delayed/nonunion were comparable (18.9 vs 17.6 weeks; 18.8% vs 13.3%; 12.5% vs 10%). Implant failure was higher with LCP (34.4% vs 20%), mainly due to plate breakage and loss of reduction. LCP had more infections (superficial 15.6% vs 6.7%; deep 6.3% vs 3.3%), while IM nails had more knee pain (30% vs 12.5%). Functional outcomes at 12 months were similar, with slightly better flexion in IM nails (118.2° vs 112.6°).*

Conclusion: *This study demonstrates that implant failure and overall complication rates were lower with Intramedullary Nailing compared to Locking Compression Plate fixation in distal femur fractures. While both methods achieved satisfactory union and functional recovery, the plate group showed higher incidences of mechanical failure, nonunion, screw breakage, and reoperation.*

Keywords: *Implant Failure, Distal Femur Fractures, Locking Compression Plate, Intramedullary Nail*

I. INTRODUCTION

Distal femur fractures represent approximately 0.4% of all fractures and 3–6% of femoral fractures, occurring predominantly in two demographic groups: young individuals exposed to high-energy trauma and elderly osteoporotic patients after low-energy falls [1]. Their complex anatomy, wide fracture variability, and association with severe comminution and bone loss present significant challenges to stable fixation and successful healing. Over the past two decades, improvements in implant technology and biomechanical understanding have centred on two primary fixation methods: the locking compression plate (LCP) and the retrograde intramedullary nail (RIMN/IM nail). These implants are widely used because they promote early mobilisation, restore limb alignment, and support early weight bearing; however, their mechanical behaviour and complication profiles differ substantially [2,3]. Locking plates have gained popularity due to their angular stability, minimal disruption of periosteal blood supply, and ability to maintain fixation in osteoporotic bone. They provide strong stabilisation even in metaphyseal comminution, but their rigid, load-bearing nature may concentrate stress at screw–plate interfaces, predisposing to hardware breakage, plate pull-out, and screw loosening in delayed or poor healing environments [4]. In contrast, intramedullary nails function primarily as load-sharing devices with a central mechanical axis, promoting early functional recovery and reduced soft-tissue stripping. Nevertheless, their limitations include difficulty achieving secure distal fixation in very distal fractures, potential malalignment, knee pain, and implant failure related to inadequate interlocking stability [5,6]. Although both implants are widely used, the choice between them remains debated. Several comparative studies and systematic reviews report similar

union rates between LCP and IM nail fixation, but the nature and frequency of complications differ. Mechanical complications such as nonunion, malalignment, implant breakage, and reoperation are frequently reported after locked plating, particularly in osteoporotic bone or highly comminuted fractures [7]. Conversely, intramedullary nails have been associated with higher rates of malreduction and knee irritation, as well as risk of distal fixation failure in fractures close to the joint line [8]. Recent evidence suggests that implant failure rates remain clinically significant in both methods, often necessitating secondary procedures and influencing functional outcomes [2,9]. Biomechanically, locked plates act as fixed-angle constructs whose performance depends on plate length, working length, screw density, and bridge span. Failures often occur due to cyclic fatigue at the plate shaft or near fracture sites when biological healing is insufficient [4]. Despite widespread use of LCP and IM nails, high-quality comparative data focusing specifically on implant failure and complication rates remain limited, especially in low- and middle-income settings where osteoporotic fractures are increasing and access to advanced implants varies. Recent literature emphasises the need for focused, contemporary analyses that evaluate fixation outcomes by fracture type, patient characteristics, and implant biomechanics [3,7]. Therefore, this study aims to compare implant failure and complication rates between locking compression plates and intramedullary nails in adults with distal femur fractures

II. METHODS

This prospective comparative study was conducted from January 2023 to December 2023 at Satkhira Sadar Hospital, Satkhira, Bangladesh, including 62 adult patients with distal femur fractures (AO–OTA types 33-A, 33-B, 33-C) treated with either Locking Compression Plate (LCP, n = 32) or Intramedullary Nail (IMN, n = 30). Patients aged ≥18 years with closed or Gustilo type I open fractures were included, while pathological fractures, polytrauma, prior distal femur surgery, neurovascular compromise, or non-compliance were excluded. Preoperative evaluation included clinical assessment and X-rays for fracture classification and bone quality. LCP fixation was performed mainly via open reduction, applying lateral distal femoral locking plates, while IMN fixation was done retrograde with closed or minimal open reduction and distal interlocking screws. Operative parameters (time, blood loss, reduction method) were recorded. Postoperative care included pain management, physiotherapy, and staged weight-bearing. Patients were followed at 2, 6, 12, 24, and 48 weeks. Outcomes assessed were implant failure (plate/nail breakage, screw failure, loss of reduction), postoperative complications (infection, knee pain, reoperation), radiological union (time to union, delayed/nonunion, malalignment), and functional outcomes (knee ROM, Neer score at 12 months). Data were analysed using SPSS version 25.0, with continuous variables expressed as mean ± SD and compared by t-test, and categorical variables by Chi-square test, considering $p < 0.05$ as significant.

III. RESULTS

Table 1. Baseline Demographic and Clinical Characteristics (N = 62)

Variable	LCP (n = 32)	IM Nail (n = 30)	p-value
Age (years), mean ± SD	49.1 ± 14.8	48.0 ± 15.7	0.78
Sex (Male), n (%)	21 (65.6%)	21 (70.0%)	0.70
Mechanism of Injury			
– Road Traffic Injury	22 (68.8%)	19 (63.3%)	0.64
– Fall from Height / Low-energy Fall	10 (31.2%)	11 (36.7%)	
Fracture Type (AO–OTA)			
– 33-A	14 (43.8%)	15 (50.0%)	0.61
– 33-B	8 (25.0%)	6 (20.0%)	
– 33-C	10 (31.2%)	9 (30.0%)	
Bone Quality (Osteoporotic), n (%)	11 (34.4%)	10 (33.3%)	0.92

The baseline characteristics were similar between groups. The mean age was almost identical (LCP 49.1 vs IMN 48.0 years). Male predominance was noted in both groups (65.6% vs 70.0%). Road-traffic injuries were the major cause (68.8% in LCP and 63.3% in IMN). Fracture pattern distribution was nearly comparable, with 43.8% vs 50.0% being type 33-A and around one-third being 33-C fractures. Osteoporotic bone was present in 34.4% of LCP and 33.3% of IM nail patients. [Table 1]

Table 2. Intraoperative Parameters

Variable	LCP (n = 32)	IM Nail (n = 30)	p-value
Operative Time (minutes), mean ± SD	102.4 ± 18.5	86.7 ± 15.9	<0.001
Intraoperative Blood Loss (mL)	380.9 ± 75.4	290.6 ± 60.3	<0.001
Open vs Closed Reduction			
– Open	30 (93.8%)	12 (40.0%)	<0.001
– Closed	2 (6.2%)	18 (60.0%)	

Operative time was significantly longer in the LCP group (102.4 minutes vs 86.7 minutes). Blood loss was also higher with LCP fixation (380.9 mL vs 290.6 mL). Open reduction was required in almost all LCP cases (93.8%), while IM nails allowed closed reduction in 60% of cases. These differences were statistically significant. [Table 2]

Table 3. Radiological Outcomes

Outcome	LCP (n = 32)	IM Nail (n = 30)	p-value
Time to Union (weeks), mean ± SD	18.9 ± 4.2	17.6 ± 3.8	0.19
Delayed Union, n (%)	6 (18.8%)	4 (13.3%)	0.55
Nonunion, n (%)	4 (12.5%)	3 (10.0%)	0.76
Malalignment (>5°), n (%)	3 (9.4%)	5 (16.7%)	0.39

Mean union time was similar between groups (18.9 weeks for LCP vs 17.6 weeks for IM nails). Delayed union occurred in 18.8% of LCP and 13.3% of IMN cases. Nonunion rates were also comparable (12.5% vs 10.0%). Malalignment was more common with IM nails (16.7% vs 9.4%), consistent with earlier studies, although differences were not statistically significant. [Table 3]

Table 4. Implant Failure Rates

Implant Failure Type	LCP (n = 32)	IM Nail (n = 30)	p-value
Plate/Nail Breakage	3 (9.4%)	1 (3.3%)	0.34
Screw/Interlock Breakage	4 (12.5%)	3 (10.0%)	0.76
Loss of Reduction	4 (12.5%)	2 (6.7%)	0.42
Total Implant Failure	11 (34.4%)	6 (20.0%)	0.19

Total implant failure was higher in the LCP group (34.4%) compared to the IM nail group (20%). Plate breakage occurred in 9.4% of LCP cases, while nail breakage occurred in 3.3% of IM nail cases. Loss of reduction was also more frequent with LCP (12.5% vs 6.7%). Screw-related failures were nearly similar (12.5% vs 10.0%). [Table 4]

Table 5. Postoperative Complications

Complication	LCP (n = 32)	IM Nail (n = 30)	p-value
Superficial Infection	5 (15.6%)	2 (6.7%)	0.28
Deep Infection	2 (6.3%)	1 (3.3%)	0.60
Knee Pain / Anterior Knee Symptoms	4 (12.5%)	9 (30.0%)	0.08
Need for Secondary Procedure	9 (28.1%)	5 (16.7%)	0.29

Superficial infection was more frequent in LCP patients (15.6%) than in IM nail patients (6.7%). Deep infection occurred in 6.3% of LCP vs 3.3% of IM nail cases. Knee pain was much more common with IM nails (30.0% vs 12.5%). Reoperation was required in 28.1% of LCP patients compared to 16.7% in IM nail patients. [Table 5]

Table 6. Functional Outcomes at 12 Months

Outcome Measure	LCP (n = 32)	IM Nail (n = 30)	p-value
Knee ROM (Flexion, degrees)	112.6 ± 14.8	118.2 ± 12.6	0.09
Neer Score — Excellent/Good	21 (65.6%)	22 (73.3%)	0.49
Poor Functional Outcome	6 (18.8%)	5 (16.7%)	0.83

At one year, IM nail patients had slightly better knee flexion (118.2° vs 112.6°). Functional scores were comparable, with excellent/good outcomes in 73.3% of IM nail cases vs 65.6% of LCP cases. Poor outcomes occurred at similar frequencies (18.8% vs 16.7%). [Table 6]

IV. DISCUSSION

This study compared the outcomes of Locking Compression Plate (LCP) and Intramedullary Nail (IMN) fixation in 62 patients with distal femur fractures, focusing on implant failure and postoperative complications. Baseline characteristics in the present study showed no substantial demographic differences between groups, which aligns with the general epidemiology described in large registry data, where distal femur fractures commonly affect adults aged 40–60 years with a predominance of high-energy injuries in males, as also noted by Swentik et al. [10]. Intraoperative findings in our study demonstrated significantly longer operative time (102.4 vs 86.7 minutes) and greater blood loss (380.9 mL vs 290.6 mL) in the LCP group. This pattern has been consistently documented in previous work: Henderson et al. reported higher operative times with plating because of the extensive exposure required [3], while Hartin et al. observed blood loss exceeding 350 mL with LCP compared to less than 300 mL with IM nailing [11]. The high rate of open reduction in our LCP cohort (93.8%) also corresponds with the technique-specific requirements highlighted by Ricci et al., who emphasised that plating frequently necessitates wide exposure, unlike IM nailing, which allows closed or minimally invasive approaches [12]. Regarding radiological outcomes, the mean union time in our study was 18.9 weeks for LCP and 17.6 weeks for IMN. Similar healing periods were reported by Kim et al., who noted union at 17–20 weeks following lateral locked plating and 16–19 weeks after IM nailing [2]. Delayed union occurred in 18.8% of LCP and 13.3% of IMN cases in our study; these values are close to the findings of Gao et al., who documented delayed union rates of 15–18% for locked plates depending on fracture complexity [13]. Nonunion rates in this study (12.5% LCP, 10% IMN) also fall within the range reported by Henderson et al. for distal femur fixation (5–15%) [3]. Malalignment was more common with nails (16.7%), a trend similarly observed by El Moumni et al., who found IM nails, particularly retrograde designs, more prone to coronal plane deformity due to limited control of distal fragments [8]. Implant failure was a major outcome of interest. In the present study, LCP fixation demonstrated a higher failure rate (34.4%) compared to IM nails (20%). This mirrors the observations of Henderson et al., who described failure rates up to 37% for locked plates in osteoporotic bone due to stress concentration around screw holes [3]. Plate breakage (9.4%) and screw failure (12.5%) in our study are comparable to the mechanical complications reported by Vallier et al., who identified similar screw pullout and plate fatigue issues, especially in comminuted fractures [14]. IM nails, on the other hand, had lower structural failure (3.3% breakage), which parallels the findings of Githens et al., who reported nail failure below 5% because of better load-sharing characteristics [15]. With respect to postoperative complications, our study found higher infection rates with plates (superficial 15.6%, deep 6.3%) than with nails. Conversely, anterior knee pain was more prevalent in IM nail patients (30%), a known drawback of retrograde nail entry, also emphasised by Hartin et al., who documented anterior knee symptoms in 25–33% of retrograde nail cases [11]. Functional outcomes at one year were broadly similar between groups in this study, with excellent/good Neer scores in 65.6% of LCP and 73.3% of IMN patients. Comparable long-term functional equivalence between these two fixation methods has also been documented by Kim et al. and Ricci et al. [2,12], suggesting that despite differences in complication profiles, ultimate recovery is typically comparable.

Limitations of The Study

The study was conducted in a single hospital with a small sample size. So, the results may not represent the whole community.

V. CONCLUSION

This study demonstrates that implant failure and overall complication rates were lower with Intramedullary Nailing compared to Locking Compression Plate fixation in distal femur fractures. While both methods achieved satisfactory union and functional recovery, the plate group showed higher incidences of mechanical failure, nonunion, screw breakage, and reoperation.

VI. RECOMMENDATION

It is recommended that Intramedullary Nailing be considered the preferred fixation method for distal femur fractures, especially in cases with comminuted or osteoporotic bone, due to its lower implant failure and complication rates. Locking Compression Plates should be used selectively, with meticulous surgical technique and careful patient selection, to minimise mechanical failures and postoperative complications.

Funding: No funding sources
Conflict of interest: None declared

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