

Original Research Article

Cost-conscious comparison of dynamic condylar screw versus locking compression plate fixation in distal femur fractures: a comprehensive functional and physiotherapy-oriented evaluation

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ABSTRACT

Background: Distal femur fractures are complex injuries associated with substantial morbidity, particularly in comminuted and intra-articular patterns. Locking Compression Plates (LCP) provide angular stability and facilitate early mobilization, whereas Dynamic Condylar Screws (DCS) remain a cost-effective option in resource-limited settings. This study compared radiological, functional, rehabilitation and economic outcomes between LCP and DCS fixation under a standardized physiotherapy protocol.

Methods: A retrospective-prospective observational cohort study was conducted from January 2018 to December 2021 involving 33 adults with AO/OTA 33-A or 33-C distal femur fractures. Eighteen patients underwent distal femur LCP fixation and 15 underwent DCS fixation. All patients followed a structured continuous passive motion (CPM)-assisted rehabilitation program. Outcomes assessed included radiological union, knee range of motion, functional scores, complications, and treatment cost.

Results: The LCP group demonstrated earlier radiological union (approximately 16 to 17 weeks vs. 19 weeks in the DCS group) and superior knee flexion throughout rehabilitation. Final knee flexion ranged from 105° to 122° in the LCP cohort compared with 95° to 112° in the DCS cohort. Functional outcomes, including Knee Society Score, Lysholm score, Neer's grading, and Timed Up and Go performance, favoured LCP fixation. Varus malalignment and non-union were more frequent in the DCS group. However, LCP fixation incurred 35% to 45% higher direct treatment costs.

Conclusions: LCP fixation provides earlier union, improved range of motion, and superior functional recovery compared with DCS fixation, particularly in comminuted and osteoporotic fractures. Despite higher costs, LCP with structured CPM-assisted rehabilitation may offer better outcomes in selected high-demand patients, while DCS remains a cost-effective option for simpler fracture patterns.

Keywords: Continuous passive motion, Distal femur fracture, Dynamic condylar screw, Functional outcome, Locking compression plate, Radiological union

INTRODUCTION

Distal femur fractures constitute a relatively small proportion of all femoral fractures; however, they are associated with significant morbidity owing to metaphyseal comminution, intra-articular extension, and associated soft-tissue injury.^{1,2} Anatomically, the distal femur is characterized by a broad metaphyseal flare, thin cortical bone, and a wide medullary canal, all of which make stable fixation technically challenging.³ In developing countries such as India, these fractures commonly result from high-energy road traffic accidents and predominantly affect middle-aged, economically productive individuals, thereby contributing to considerable functional and socioeconomic burden.⁴ Consequently, successful management depends not only on achieving fracture union but also on restoring knee function and mobility through effective rehabilitation protocols.

Historically, several fixation methods have been employed for distal femur fractures, including angled blade plates, condylar buttress plates, and fixed-angle devices such as the Dynamic Condylar Screw (DCS).⁵ The DCS has remained widely utilized, particularly in resource-limited settings, because of its lower cost, technical familiarity, and ability to provide fixed-angle compression across the femoral condyles.^{5,6} Nevertheless, DCS fixation often requires extensive surgical exposure and soft-tissue stripping, and its effectiveness may be limited in osteoporotic bone or highly comminuted metaphyseal fractures, where complications such as varus collapse and delayed mobilization have been reported.^{6,7}

The introduction of locking plate technology, particularly the distal femur Locking Compression Plate (LCP), has addressed several of these limitations by providing angular stability, multiplanar screw fixation, and reduced dependence on bone quality.^{4,7} In addition, LCP systems can frequently be applied using minimally invasive techniques that preserve periosteal blood supply and soft-tissue integrity. Biomechanical studies have demonstrated superior construct stiffness and fatigue resistance with locking plates compared with DCS constructs, particularly in unstable metaphyseal fracture models, where locked plates tolerate higher cyclic loading with reduced subsidence.⁸ Clinically, these advantages may facilitate earlier mobilization, improved maintenance of reduction, and superior functional recovery, especially in osteoporotic or comminuted fracture patterns.^{2,4,7}

Despite these biomechanical and clinical advantages, the substantially higher cost of LCP implants remains a major limitation in low- and middle-income countries, where financial constraints significantly influence treatment decisions.^{9,10} As a result, DCS fixation continues to serve as a cost-effective alternative in many tertiary care and government-funded institutions. However, limited literature exists comparing how implant selection influences postoperative rehabilitation outcomes,

particularly when combined with structured physiotherapy and continuous passive motion (CPM)-assisted mobilization. The relationship between fixation stability, progression of knee range of motion, functional recovery, complication profile, and overall treatment cost remains insufficiently explored in real-world resource-constrained settings.^{2,3,6} Therefore, the present study aims to compare distal femur Locking Compression Plate (LCP) fixation with Dynamic Condylar Screw (DCS) fixation for distal femur fractures in a tertiary care centre in India. The study specifically evaluates radiological union, CPM-assisted rehabilitation and range-of-motion progression, functional outcomes, complications, and cost-effectiveness under a standardized postoperative physiotherapy protocol, with the objective of guiding implant selection in settings where both biomechanical performance and economic feasibility must be carefully balanced.

METHODS

This retrospective-prospective observational cohort study was conducted at a tertiary-level trauma centre between January 2018 and December 2021 after Institutional Ethics Committee approval and written informed consent from all participants in accordance with the Declaration of Helsinki. Adult patients aged 18 to 70 years with closed distal femur fractures classified as AO/OTA 33-A or 33-C were included. Eligible patients had isolated femoral injuries and were willing to participate in structured rehabilitation and follow-up. Exclusion criteria included open fractures (Gustilo-Anderson grade II or higher), pathological fractures, polytrauma limiting rehabilitation, pre-existing neurological deficits affecting lower limb function and inability to provide informed consent.

All patients underwent open reduction and internal fixation using either a distal femur LCP or a DCS. Implant selection was based on surgeon preference, fracture configuration, and patient affordability, reflecting routine practice in a resource-constrained setting. LCP fixation utilized pre-contoured locking plates with distal fixed-angle screws inserted through minimally invasive or limited open techniques according to fracture morphology. DCS fixation was performed using a standard lateral approach with insertion of a 95° lag screw across the condyles followed by side-plate fixation along the femoral shaft. Operative duration, blood loss and intraoperative complications were recorded.

All patients followed a standardized postoperative physiotherapy protocol supervised by the institutional rehabilitation team. Early CPM-assisted mobilization, quadriceps strengthening and range-of-motion exercises were initiated during the first postoperative week once wound condition permitted. Progressive active-assisted mobilization, strengthening exercises, gait training, proprioceptive rehabilitation and functional training were subsequently introduced in a phased manner over 3 to 6 months. Partial weight-bearing was generally initiated earlier in the LCP group (2 to 3 weeks) compared with the

DCS group (4 to 6 weeks), based on clinical and radiological assessment. Physiotherapists documented CPM-assisted knee flexion, pain scores using the Visual Analogue Scale (VAS) and rehabilitation-related complications at predefined follow-up intervals.

Primary outcome measures included radiological union time and knee flexion range of motion measured using goniometer during follow-up. Secondary outcomes included functional scores (Knee Society Score, Lysholm score, or Neer's score depending on dataset selection), Timed Up and Go (TUG) test performance where applicable, complication rates, and overall treatment cost including implant expenditure, hospitalization, surgery and physiotherapy sessions. Radiological union was defined as bridging callus across at least three cortices on radiographs with painless full weight-bearing. Functional and radiological assessments were performed at 3 months, 6 months and a minimum of 12 months postoperatively.

Statistics was performed using SPSS Version 28 software. Continuous variables were expressed as mean $\pm$ standard deviation, while categorical variables were summarized as frequencies and percentages. Between-group comparisons (LCP versus DCS) were performed using Student's t-test for continuous variables and chi-square test or Fisher's exact test for categorical variables after assessment of normality assumptions. A p-value of <0.05 was considered statistically significant. Statistical analysis was performed using standard statistical software.

RESULTS

A total of 33 patients fulfilled the inclusion criteria and completed follow-up, including 18 patients treated with distal femur LCP fixation and 15 treated with DCS fixation. The cohort demonstrated a male predominance with a mean age in the mid-40s and road traffic accidents were the most common mechanism of injury followed by falls. AO/OTA type 33-C fractures constituted the majority of cases. Comminuted and osteoporotic fractures were more commonly managed with LCP fixation, whereas relatively simpler extra-articular fracture patterns were frequently treated using DCS. Baseline demographic and clinical characteristics of the overall study cohort are summarized in Table 1.

The mean operative duration was shorter in the LCP group (approximately 95 to 100 minutes) compared with the DCS group (approximately 110 minutes), with the difference reaching statistical significance. Intraoperative blood loss was marginally lower in the LCP cohort, although this difference was not statistically significant. No intraoperative neurovascular complications were encountered in either group. Postoperative complications were infrequent overall. In the LCP group, one patient developed superficial wound infection and one patient experienced delayed union. In the DCS group, two patients developed varus malalignment and one patient progressed

to non-union requiring revision fixation. No cases of deep infection or implant failure were observed in either cohort.

Radiological union occurred earlier in patients treated with LCP fixation, with a mean union time of approximately 16 to 17 weeks compared with nearly 19 weeks in the DCS group, demonstrating a statistically significant difference. All patients except one in the DCS cohort achieved fracture union by 24 weeks, while the remaining patient required revision surgery.

Table 1: Demographic and clinical characteristics of the study cohort (n=33).

Variable	Value
Age (years), mean (range)	44.7 (19-82)
Sex, N (%)	
Male	22 (66.7)
Female	11 (33.3)
Group allocation, N (%)	
LCP fixation	18 (54.5)
DCS fixation	15 (45.5)
Mechanism of injury, N (%)	
Road traffic accident	26 (78.8)
Fall from height	5 (15.2)
Low-energy (osteoporotic) fall	2 (6.1)
AO/OTA fracture classification, N (%)	
Type 33-C (complex articular)	21 (63.6)
Type 33-A (extra-articular)	12 (36.4)
Comorbidities, N (%)	
Diabetes mellitus	6 (18.2)
Clinical osteoporosis	4 (12.1)

LCP=Locking Compression Plate; DCS=Dynamic Condylar Screw

CPM-assisted knee flexion improved progressively in both groups throughout follow-up; however, the LCP cohort consistently demonstrated superior range of motion at all assessment intervals. On postoperative day 5, mean knee flexion was approximately 60° in the LCP group compared with 40° in the DCS group. By week 3, flexion improved to nearly 90° versus 70° , and by week 6 reached approximately 100° to 118° in the LCP cohort compared with 85° to 104° in the DCS cohort. At final follow-up, mean knee flexion ranged from 105° to 122° in the LCP group and 95° to 112° in the DCS group, with statistically significant differences observed at key rehabilitation milestones (Figure 1).

Functional outcomes at final follow-up favoured LCP fixation. Mean Knee Society Scores and Lysholm scores were higher in the LCP cohort, while TUG test performance was superior with shorter completion times compared with the DCS group. Similarly, Neer's functional grading demonstrated a higher proportion of excellent and good outcomes among LCP-treated patients. Compliance with the standardized physiotherapy and CPM rehabilitation protocol remained high in both groups.

Cost analysis demonstrated substantially higher expenditure associated with LCP fixation. Average implant cost for LCP ranged from approximately INR 28,000 to 45,000 compared with INR 8,000 to 12,000 for DCS. Total treatment expenditure, including surgery, hospitalization, medications and physiotherapy, averaged approximately INR 75,000 to 92,000 for LCP fixation versus INR 38,000 to 52,000 for DCS fixation, corresponding to an estimated 35% to 45% reduction in direct treatment cost with DCS. Indirect costs such as wage loss and transportation expenses were comparable between the two groups because hospital stay duration and follow-up schedules were largely similar (Figure 2).

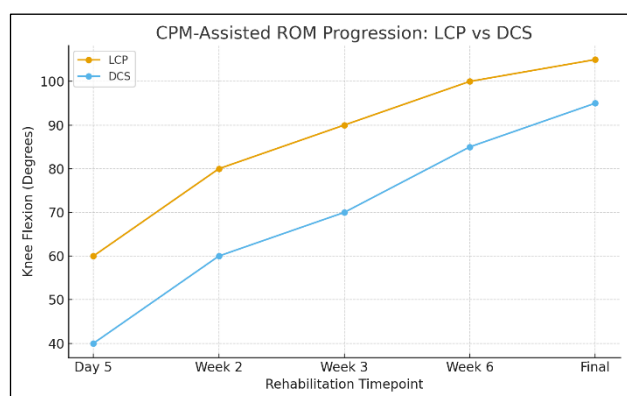


Figure 1: CPM-assisted postoperative knee ROM progression following distal femur fixation with LCP and DCS.

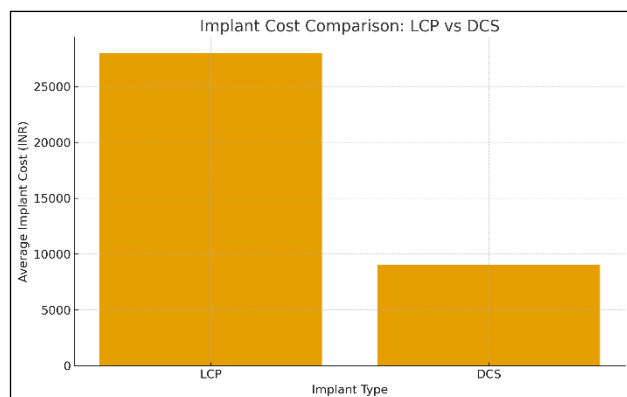


Figure 2: Comparison of implant cost between LCP and DCS fixation.

DISCUSSION

The present cohort predominantly consisted of middle-aged male patients who sustained distal femur fractures following high-energy road traffic accidents, with AO/OTA 33-C intra-articular and metaphyseal region comminuted fractures representing the majority of injury patterns. These findings are consistent with contemporary Indian literature reporting that distal femur fractures account for approximately 4% to 6% of all femoral fractures and are increasingly observed in young and

middle-aged males following high-velocity trauma mechanisms.^{1,11} Similar demographic trends have been reported from other Indian and Nepalese trauma centres, where road traffic accidents and fall-from-height injuries remain the leading causes, particularly among economically active individuals.^{2,7,11} The fracture distribution observed in our study also parallels previous reports demonstrating a predominance of AO/OTA 33-A and 33-C fracture patterns in tertiary-care trauma settings.^{2,11} Importantly, our cohort comprised relatively homogeneous cases of closed, isolated distal femur fractures suitable for definitive internal fixation and structured postoperative rehabilitation. This is clinically relevant because several recent studies have emphasized that successful outcomes following distal femur fixation depend not only on radiological union but also on restoration of knee function through early mobilization and supervised physiotherapy protocols.^{2,7,11} Our findings are comparable to a recent Indian series involving 70 distal femur fractures treated with locking plate fixation, which reported a mean patient age of 47.5 years, male predominance, and a similar distribution of AO/OTA 33-A and 33-C fractures, along with favourable functional outcomes associated with early rehabilitation compliance.^{7,11} Although our sample size was comparatively smaller, the demographic characteristics and fracture morphology closely mirrored these contemporary cohorts. Furthermore, unlike many previous studies that evaluated a single implant system, the present study provides a direct comparison between LCP and DCS fixation within a standardized rehabilitation framework. Consequently, the epidemiological and injury characteristics observed in our cohort likely reflect real-world distal femur fracture practice in resource-constrained tertiary-care settings, thereby supporting the broader applicability of our implant-specific findings.

Implant selection in the present study was primarily influenced by fracture morphology, bone quality, surgeon preference and patient affordability. Comminuted intra-articular and osteoporotic distal femur fractures were more frequently treated using distal femur LCP, whereas relatively simpler extra-articular fracture patterns were commonly managed with DCS fixation. This approach is consistent with contemporary Indian and international literature recommending locking plate constructs for AO/OTA 33-C fractures and osteoporotic metaphyseal bone because of their superior angular stability and multiplanar fixation capabilities.^{3,10,12} In contrast, DCS fixation continues to remain a technically familiar and cost-effective option for less complex metaphyseal-diaphyseal fracture patterns.^{3,5,8} The implant allocation pattern observed in our study reflects real-world orthopaedic practice in many low- and middle-income countries, where implant selection is often guided by balancing biomechanical requirements with economic constraints rather than adherence to rigid treatment algorithms.^{3,4} Similar findings have been reported in recent comparative Indian studies evaluating DCS and distal femur locking plate fixation, where both implants

demonstrated satisfactory overall outcomes, although locking plates were preferentially utilized for comminuted fractures while DCS fixation was favoured for simpler AO/OTA 33-A patterns.^{5,12} Our observations closely parallel these previous reports, with LCP fixation predominantly employed in comminuted and osteoporotic fractures and DCS used for relatively simpler configurations. However, unlike earlier mixed-implant studies, the present study additionally evaluates radiological union, CPM-assisted range-of-motion progression, functional recovery, and cost-effectiveness within a standardized rehabilitation protocol, thereby providing a more comprehensive assessment of implant performance in routine clinical practice.^{4,8,12}

The LCP group demonstrated a shorter operative duration compared with the DCS cohort, despite the use of pre-contoured locking plates and minimally invasive or limited-exposure techniques. This finding is consistent with recent Indian studies reporting that distal femoral locking plates can provide stable fixation with operative times comparable to or shorter than DCS constructs.^{6,10,12} The slightly lower intraoperative blood loss observed in the LCP group, although not statistically significant, also aligns with previous reports suggesting that locking plates may reduce soft-tissue dissection; however, both fixation methods still require adequate exposure for fracture reduction and condylar alignment, thereby limiting major differences in intraoperative haemorrhage.^{3,10,12} Importantly, no intraoperative neurovascular complications were encountered in either group, supporting existing literature demonstrating that both LCP and DCS fixation are safe and technically reliable procedures when performed by experienced surgeons using standard surgical approaches and fluoroscopic guidance.^{8,12,13} Similar observations have been reported in recent comparative Indian studies evaluating distal femur fractures managed with DCS and LCP fixation, where mean operative durations ranged between 90 and 110 minutes with marginally shorter operative times in the locking plate cohort and no reported vascular or nerve injuries despite moderate blood loss.^{3,6} Our findings further reinforce these results by demonstrating that LCP fixation can achieve efficient operative performance and acceptable intraoperative safety while facilitating early rehabilitation within a standardized postoperative mobilization protocol.^{6,8,10}

The overall postoperative complication rate in our cohort was low, with only one superficial wound infection and one delayed union in the LCP group, while the DCS cohort demonstrated two cases of varus malalignment and one non-union requiring revision fixation. These findings are consistent with recent Indian and Pakistani studies reporting acceptable complication profiles for both distal femoral LCP and DCS fixation when utilized in appropriately selected patients.^{10,12,14} Previous DCS-based series have reported higher rates of malalignment, delayed union and non-union in osteoporotic or highly comminuted metaphyseal fractures, whereas locking plate

cohorts generally demonstrate fewer mechanical complications because of improved angular stability and multiplanar fixation.^{10,14,15} Our findings similarly suggest that although both implants are safe and clinically effective, DCS fixation may be more vulnerable to secondary displacement and varus collapse in complex fracture patterns, while LCP constructs provide better maintenance of alignment and rotational stability.^{8,12,14} Comparable observations have been reported in recent comparative studies. A randomized trial evaluating DCS versus distal femoral LCP fixation in 78 patients demonstrated shorter union times and lower malalignment rates in the LCP group despite similar superficial infection rates, paralleling our findings of improved radiological outcomes with locking plate fixation.^{8,10} Likewise, a recent Indian series involving 33 distal femur fractures reported delayed union and non-union predominantly in the DCS cohort, whereas most LCP-treated fractures achieved uncomplicated healing.^{6,12} Collectively, these findings support the growing evidence that although both DCS and LCP fixation are technically feasible and generally safe, distal femur locking plates may offer a more favourable complication profile and improved maintenance of alignment in unstable, comminuted or osteoporotic distal femur fractures, particularly during the early and intermediate follow-up period.

The significantly earlier radiological union observed in the LCP group (16 to 17 weeks) compared with the DCS group (approximately 19 weeks) is consistent with recent Indian prospective studies reporting mean union times of 15.3 to 16.4 weeks following distal femoral locking plate fixation, whereas DCS constructs frequently demonstrate union closer to 18 to 20 weeks, particularly in comminuted or osteoporotic fractures.¹⁴⁻¹⁶ A recent prospective observational study evaluating distal femoral LCP fixation in 60 patients reported fracture union in 96.6% of cases at a mean duration of 15.3 weeks, supporting the concept that angular-stable constructs facilitate earlier callus formation and progressive weight-bearing when combined with structured rehabilitation protocols.^{2,16} Contemporary studies involving AO/OTA 33-A, 33-B and 33-C fractures treated with locking plates similarly report mean union times ranging from 16 to 18 weeks and emphasize the importance of stable fixation, preservation of soft-tissue biology, and early mobilization in promoting successful healing outcomes.^{17,18} These principles were incorporated into our treatment protocol and likely contributed to the favourable union rates observed in the LCP cohort. In contrast, DCS-based series have reported comparatively longer healing intervals along with higher rates of delayed union and malalignment in metaphyseally comminuted fracture patterns.^{9,17,18} Our findings parallel these observations, with the DCS group demonstrating longer mean union times and one case progressing to delayed union requiring revision surgery. Similar comparative Indian studies have also shown that locking plates provide more reliable fixation and lower rates of secondary displacement in complex distal femur fractures.^{17,18} Collectively, the present findings suggest that distal femur

LCP fixation may offer advantages in terms of faster and more predictable radiological union, particularly in comminuted and osteoporotic fractures. These benefits are especially relevant in resource-constrained settings where consistent follow-up and prolonged protected mobilization may be difficult to maintain, thereby increasing the clinical importance of stable fixation constructs that support earlier rehabilitation and reduce revision-prone scenarios.^{2,9,16}

The more rapid progression of knee flexion observed in the LCP group, with significantly greater range of motion at all assessed follow-up intervals, is consistent with contemporary studies demonstrating that angular-stable distal femoral locking constructs permit earlier and more aggressive CPM-assisted rehabilitation.^{9,16,19} Recent cohort studies evaluating distal femur fractures treated with locking plates have reported improvement in knee flexion from approximately 70° at 2 weeks to nearly 100° to 110° by 6 weeks, findings comparable to the progression observed in our LCP cohort, where flexion improved from nearly 60° by postoperative day 5 to 90° to 118° by week 6.¹⁶ Current rehabilitation-focused literature emphasizes that early CPM-assisted mobilization, combined with quadriceps strengthening and progressive weight-bearing, reduces postoperative stiffness and improves functional recovery following distal femur fixation.^{19,20} The favourable flexion outcomes observed in our study likely reflect the combined effect of stable fixation provided by LCP constructs and the ability to safely initiate early structured rehabilitation. Similar findings have been reported in recent Indian prospective studies, where distal femur fractures managed with locking plates and early CPM achieved final knee flexion ranging between 110° and 120° at medium-term follow-up, closely paralleling the 105° to 122° achieved in our LCP cohort. In contrast, studies utilizing delayed or less intensive mobilization protocols have reported lower final flexion outcomes, often limited to 90° to 105°.¹⁶ Furthermore, recent physiotherapy-oriented case series have demonstrated that early CPM initiation combined with progressive active-assisted mobilization and gait training significantly improves range of motion and reduces postoperative pain within the first 4 to 6 weeks.^{19,20} Our findings support these observations and suggest that the biomechanical stability afforded by LCP fixation facilitates more effective rehabilitation progression, ultimately translating into clinically meaningful improvements in knee flexion and early functional recovery.

The superior functional outcomes observed in the LCP group, including higher Knee Society scores, Lysholm scores, improved TUG performance and a greater proportion of excellent or good Neer's grading outcomes, are consistent with recent Indian studies reporting favourable functional recovery following distal femoral locking plate fixation.^{2,16,21} A recent prospective study evaluating lateral distal femoral locking plates demonstrated excellent or good functional outcomes in more than 80% of patients at 12 months, with progressive improvement in knee-specific functional scores, findings

that closely parallel the outcomes observed in our LCP cohort.^{16,22} Contemporary studies involving AO/OTA 33-C distal femur fractures treated with distal femoral locking plates have similarly emphasized that stable fixation combined with early mobilization and supervised physiotherapy contributes significantly to improved knee function, pain reduction and gait performance.^{2,20,21} The superior TUG performance and overall functional recovery seen in our LCP group likely reflect the combined benefits of enhanced biomechanical stability and the ability to safely initiate earlier rehabilitation and partial weight-bearing. In contrast, older comparative studies and DCS-focused cohorts have reported comparatively lower functional scores and a higher proportion of fair or poor outcomes, particularly in comminuted intra-articular or osteoporotic fractures.^{12,21} Similar trends were observed in our study, where the DCS cohort demonstrated lower mean functional scores and greater variability in outcomes compared with the LCP group. Recent Indian series evaluating locking plate fixation have reported mean Lysholm scores within the "good" range and predominantly excellent or good Neer's outcomes, findings that closely resemble the functional profile observed in our LCP-treated patients.^{16,22} Collectively, these findings suggest that distal femoral LCP fixation, when combined with structured CPM-assisted rehabilitation and early mobilization, may provide superior patient-centered functional recovery, particularly in active middle-aged individuals with higher functional demands.^{16,20,21}

The significantly higher treatment expenditure associated with LCP fixation, with approximately 35% to 45% greater direct costs compared with DCS, is consistent with recent Indian and Pakistani studies demonstrating that distal femoral locking plates are substantially more expensive than DCS-based constructs.^{10,23,24} Contemporary cost analyses have identified implant pricing as the principal contributor to this difference, while operative duration, hospital stay, and physiotherapy-related expenses generally remain comparable between fixation methods.^{10,15,23} In resource-constrained healthcare systems, these financial considerations strongly influence implant selection. Consequently, locking plates are frequently reserved for comminuted intra-articular or osteoporotic fractures requiring greater biomechanical stability, whereas DCS fixation continues to serve as a cost-effective alternative for relatively simpler metaphyseal-diaphyseal fracture patterns.^{2,15,24} Despite the higher initial expenditure, several recent studies suggest that the superior stability provided by LCP fixation may reduce rates of secondary displacement, delayed union, non-union and revision surgery, thereby potentially decreasing long-term treatment burden and indirect socioeconomic costs related to prolonged disability.^{2,10,20} Similar findings have been reported in comparative Indian cohorts, where LCP fixation was associated with higher implant costs but improved radiological and functional outcomes, particularly in comminuted fractures, closely paralleling the observations of our study.^{2,23} Recent

narrative reviews on distal femur fracture management further emphasize that implant selection in low- and middle-income countries should balance biomechanical performance, complication risk, functional recovery, and economic feasibility rather than focusing solely on upfront implant cost.^{20,24} Within this context, our findings suggest that although LCP fixation carries a greater financial burden, its superior union rates, range-of-motion recovery, and functional outcomes may justify its use in selected high-demand or complex fracture patterns, while DCS remains a valuable and economically viable option for appropriately selected patients.

The present study has several limitations. First, the retrospective-prospective observational design introduces the possibility of selection and performance bias, as implant choice (LCP versus DCS) was based on surgeon preference, fracture morphology, and patient affordability rather than randomization. Consequently, associations between implant type and outcomes such as union time, range of motion, and functional recovery should be interpreted cautiously. Second, the relatively small sample size limits statistical power and reduces the ability to detect smaller but clinically meaningful differences in complication rates and functional outcomes. In addition, subgroup analyses based on fracture subtype, osteoporosis, or associated comorbidities could not be performed. Third, the study included only closed, isolated distal femur fractures and excluded open fractures, polytrauma, and pathological fractures. While this improved cohort homogeneity, it limits the generalizability of the findings to more complex trauma populations. Furthermore, follow-up duration was sufficient for assessment of radiological union and intermediate-term functional outcomes but did not permit evaluation of long-term complications such as post-traumatic osteoarthritis, implant-related issues, or late revision procedures. Finally, although cost analysis was performed, the evaluation primarily focused on direct medical expenditure and did not comprehensively assess long-term indirect socioeconomic costs such as prolonged wage loss, caregiver burden, and transportation expenses. Therefore, the cost-effectiveness conclusions of the present study remain largely descriptive and warrant further validation through larger prospective and health-economic studies.

CONCLUSION

Distal femur LCP fixation demonstrated earlier radiological union, superior knee range of motion, improved functional outcomes, and lower rates of malalignment compared with DCS fixation, particularly in comminuted and osteoporotic fractures. Early CPM-assisted rehabilitation further enhanced postoperative recovery and functional mobility. Although LCP fixation was associated with significantly higher treatment costs, its biomechanical stability and improved clinical outcomes may justify its use in complex fracture patterns. DCS remains a cost-effective and clinically acceptable

alternative for selected simpler distal femur fractures in resource-constrained settings.

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