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CLINICAL, FUNCTIONAL, AND RADIOLOGICAL OUTCOMES OF LOCKING COMPRESSION PLATE FIXATION FOR DISTAL FEMORAL FRACTURES IN ADULTS

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ABSTRACT **Background-** Distal femoral fractures present significant challenges in orthopedic trauma due to their complex anatomy, high rate of comminution, and frequent intra-articular extension. This study evaluates the clinical, functional, and radiological outcomes of adult patients sustaining distal femoral fractures treated via open reduction and internal fixation (ORIF) with a distal femoral locking compression plate (DF-LCP). **Materials and Methods-**A prospective clinical study was conducted over a two-year period at a tertiary care teaching hospital involving 60 adult patients presenting with acute distal femoral fractures. Patients underwent definitive fixation using a DF-LCP. Postoperative management emphasized early, non-weight-bearing mobilization. Routine clinical and radiological evaluations were completed to track fracture union, complications, and structural alignment, while final functional outcomes were measured utilizing the Neer scoring system. **Results-**The study cohort comprised 42 males (70%) and 18 females (30%) with a mean age peak in the 31–50 years demographic (53.3%). Road traffic accidents (RTA) were the predominant mechanism of injury (66.7%). AO/OTA Type C2 and C3 complex intra-articular fractures constituted 53.4% of the cases. The average time from injury to surgery was 4.2 days, and the mean duration for radiological union was 18.2 weeks. Complications included superficial surgical site infections (3.3%), delayed union (6.7%), and non-union (3.3%). The mean knee flexion achieved at final follow-up was 108°. Based on the Neer scoring system, 80% of patients achieved excellent (56.7%) or good (23.3%) functional outcomes. **Conclusion-**DF-LCP fixation provides highly reliable mechanical stability, preserves local fracture biology, and allows for early knee rehabilitation. It remains an effective and dependable treatment option for complex, comminuted, and intra-articular distal femoral fractures in adults.

KEYWORDS : Distal Femoral Fracture, Locking Compression Plate, AO/OTA Classification, Neer Score

INTRODUCTION

Distal femoral fractures represent a challenging subset of orthopaedic injuries because of their complex anatomy, frequent intra-articular involvement, and the high incidence of associated complications. Management of these fractures requires restoration of limb alignment, joint congruity, and stable fixation to achieve satisfactory functional outcomes.

The increasing prevalence of high-speed transportation, urbanization, and industrial development has contributed to a rise in trauma-related injuries, particularly road traffic accidents. Consequently, distal femur fractures are increasingly encountered among the younger population following high-energy trauma. Conversely, elderly individuals commonly sustain these fractures following low-energy falls due to osteoporosis and diminished bone quality.

The reported incidence of distal femoral fractures is approximately 37 cases per 100,000 person-years. These injuries demonstrate a bimodal age distribution, affecting young adults exposed to high-energy trauma and elderly patients with osteoporotic bone. High-energy mechanisms frequently result in comminution, metaphyseal bone loss, soft-tissue injury, and intra-articular extension, whereas low-energy mechanisms are commonly associated with fragility fractures and periprosthetic injuries.

Surgical treatment is generally considered the standard of care for displaced distal femur fractures. Conservative management is associated with prolonged immobilization, joint stiffness, malunion, and delayed functional recovery. Various operative techniques have been developed to provide stable fixation and facilitate early mobilization. These include dynamic condylar screw fixation, condylar buttress plating, blade plating, retrograde intramedullary nailing, external fixation, and locking plate systems.

Among the available fixation methods, the distal femoral locking compression plate (DF-LCP) has gained widespread acceptance because of its favourable biomechanical characteristics. The locking plate functions as an internal fixator, creating a fixed-angle construct that enhances stability, particularly in osteoporotic and comminuted fractures. Unlike conventional plating systems that rely on friction between the plate and bone, locking plates provide angular stability through screw-plate locking mechanisms.

The biological advantages of DF-LCP fixation include preservation of periosteal blood supply, minimal disruption of fracture hematoma, and promotion of secondary bone healing through callus formation. When inserted using minimally invasive surgical techniques, locking compression plates further reduce soft tissue trauma, decrease infection rates, and facilitate fracture union.

Given these advantages, the present study was undertaken to evaluate the clinical, functional, and radiological outcomes of distal femoral fractures treated with locking compression plate fixation in adult patients.

MATERIALS AND METHODS

This study was conducted in the Department of Orthopaedics at a tertiary care teaching hospital over a period of two years. Adult patients presenting with distal femoral fractures and fulfilling the eligibility criteria were enrolled consecutively after obtaining informed written consent.

A detailed history was obtained from each patient, including demographic information, mechanism of injury, associated comorbidities, and time elapsed between injury and hospital presentation. A comprehensive clinical examination was performed to assess both local and systemic injuries.

Initial management focused on hemodynamic stabilization according to trauma care protocols. Patients underwent thorough evaluation for associated head, thoracic, abdominal, spinal, pelvic, and musculoskeletal injuries. Neurovascular status of the affected limb was carefully documented.

Radiographic assessment included standard anteroposterior and lateral radiographs of the distal femur and knee joint. Fractures were classified based on their anatomical characteristics and extent of articular involvement.

Relevant demographic and clinical parameters recorded included: Age ,Sex ,Mechanism of injury ,Side involved ,Fracture classification ,Associated injuries ,Time from injury to surgery All eligible patients underwent open reduction and internal fixation using a distal femoral locking compression plate. Postoperative follow-up consisted of regular clinical and radiological evaluations to assess fracture union, implant integrity, alignment, range of motion, and functional recovery.

INCLUSION CRITERIA

Patients fulfilling the following criteria were included in the study:
1. Adult patients aged 18 years and above.
2. Distal femoral fractures involving the metaphyseal or metaphyseodiaphyseal region.
3. Fractures with or without intra-articular extension.
4. Patients medically fit for surgical intervention.
5. Patients willing to participate and provide informed consent.

EXCLUSION CRITERIA

Patients meeting any of the following criteria were excluded from the study:
1. Age below 18 years.
2. Pathological fractures other than those related to osteoporosis.
3. Fractures associated with major neurovascular injury.
4. Patients unfit for surgery due to severe medical illness.
5. Patients unwilling to participate or unavailable for follow-up.

SURGICAL TECHNIQUE

All surgical procedures were performed under appropriate anesthesia with the patient positioned supine on a radiolucent operating table. Intravenous prophylactic antibiotics were administered before skin incision.

A standard lateral approach to the distal femur was utilized. Fracture reduction was achieved through a combination of manual traction and direct visualization. Particular attention was paid to restoring limb length, coronal alignment, sagittal alignment, and rotational orientation.

In fractures with intercondylar extension, the condylar fragments were first reduced anatomically and temporarily stabilized using Kirschner wires. Once articular congruity had been restored, the fracture was converted into a single distal fragment for definitive fixation.

A suitably sized distal femoral locking compression plate was selected and positioned laterally. Plate placement and fracture reduction were verified using fluoroscopic guidance. Locking screws were inserted into the distal fragment to establish angular stability, while proximal fixation was achieved using locking and/or cortical screws as required. Whenever feasible, minimally invasive plate osteosynthesis techniques were employed to minimize soft tissue disruption and preserve periosteal vascularity. Intraoperative assessment included verification of fracture reduction, implant positioning, limb alignment, knee stability, and range of motion.

Following satisfactory fixation, thorough irrigation was performed and hemostasis achieved. The wound was closed in layers and sterile dressing applied.

POSTOPERATIVE PROTOCOL

Postoperative rehabilitation was initiated at the earliest opportunity. Static quadriceps exercises were started on the first postoperative day. Active-assisted and active knee range-of-motion exercises, along with quadriceps and hamstring strengthening exercises, were gradually introduced as tolerated.

Suture removal was performed approximately 10–14 days after surgery. Patients were initially mobilized with non-weight-bearing ambulation using assistive devices. Progressive weight bearing was permitted based on clinical and radiological evidence of fracture healing.

Patients were reviewed periodically at scheduled follow-up visits. Clinical evaluation included assessment of pain, range of motion, limb alignment, and functional status. Radiological union was determined by the presence of bridging callus across at least three cortices on anteroposterior and lateral radiographs. Clinical union was defined as the absence of tenderness at the fracture site and painless functional activity.

Functional outcomes were assessed using the **Neer scoring system**, which evaluates pain, walking ability, range of motion, work capacity, and anatomical alignment.

RESULTS

A total of **60 patients** with distal femoral fractures were included in the study and followed until radiological union and functional assessment. All fractures were acute injuries presenting within **1 to 10 days** of trauma. The study population comprised **42 males (70%) and 18 females (30%)**, with ages ranging from **21 to 78 years**. The highest incidence of fractures was observed in the **31–50 years age group**, accounting for **32 patients (53.3%)**.

The predominant mechanism of injury was **road traffic accidents (RTA)**, observed in **40 patients (66.7%)**, followed by **fall from standing height or slip and fall injuries in 20 patients (33.3%)**. High-energy trauma was more common among younger male patients, whereas low-energy injuries were predominantly seen in elderly females with osteoporotic bone.

Regarding laterality, **34 patients (56.7%)** sustained fractures of the **right distal femur**, while **26 patients (43.3%)** had involvement of the **left side**.

According to the **AO/OTA (Müller) classification**, the fracture distribution was as follows:
- **Type A1:** 6 patients (10.0%)
- **Type A2:** 8 patients (13.3%)
- **Type C1:** 14 patients (23.3%)
- **Type C2:** 16 patients (26.7%)
- **Type C3:** 16 patients (26.7%)

Complex intra-articular fractures (Type C2 and C3) constituted the majority of cases, representing **53.4%** of the study population.

The mean interval between injury and surgical intervention was **4.2 days** (range: 1–10 days). The average duration of radiological union was **18.2 weeks**, with most fractures uniting between **16 and 22 weeks**.

Associated injuries were identified in **9 patients (15%)**. These included:
- Patellar fractures – 3 cases
- Proximal tibial fractures – 2 cases
- Ipsilateral tibial shaft fracture – 2 cases
- Distal radius fracture – 1 case
- Shoulder dislocation – 1 case

Postoperative complications were encountered in a small number of patients. **Superficial surgical site infection** developed in **2 patients (3.3%)**, both of whom responded well to antibiotic therapy and regular wound care. **Delayed union** was observed in **4 patients (6.7%)**, while **non-union** occurred in **2 patients (3.3%)**. One patient experienced implant loosening requiring revision fixation with bone grafting, whereas the other achieved union following autologous cancellous bone grafting.

Limb-length discrepancy of less than 2 cm was noted in **3 patients (5%)**, primarily in highly comminuted fractures. **Varus malalignment** was observed in **4 patients (6.7%)**, although none reported significant functional impairment during follow-up.

The mean knee flexion achieved at final follow-up was **108°** (range: 65°–130°). A satisfactory range of motion greater than **90°** was obtained in **46 patients (76.7%)**, whereas **5 patients (8.3%)** demonstrated knee flexion less than **75°**.

Functional outcomes were evaluated using the **Neer scoring system** at the final follow-up. **Excellent results** were achieved in **34 patients (56.7%)**, **good results** in **14 patients (23.3%)**, **fair results** in **7 patients (11.7%)**, and **poor results** in **5 patients (8.3%)**. Thus, **80% of patients achieved excellent to good functional outcomes**, indicating favorable results with distal femoral locking compression plate fixation.

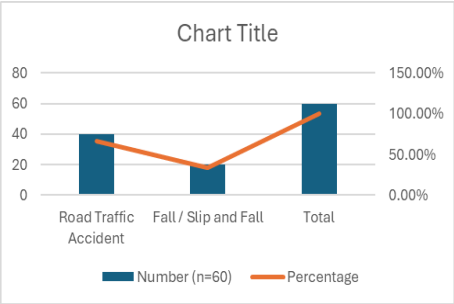
Table 1: Mode of Injury

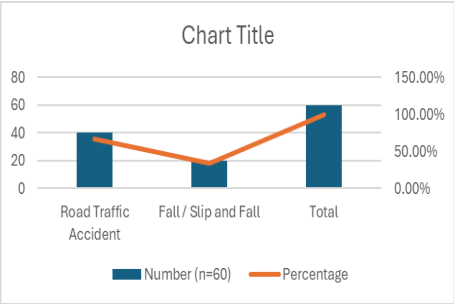
Mode of Injury	Number (n=60)	Percentage
Road Traffic Accident	40	66.7%
Fall / Slip and Fall	20	33.3%
Total	60	100%

Table 2: Functional Outcome (Neer Score)

Outcome	Number (n=60)	Percentage
Excellent	34	56.7%
Good	14	23.3%
Fair	7	11.7%

Poor	5	8.3%
Total	60	100%





Overall, fixation of distal femoral fractures using locking compression plates provided reliable fracture union, satisfactory knee mobility, and good functional outcomes in the majority of patients, with a relatively low complication rate.

DISCUSSION

Distal femoral fractures remain among the most challenging injuries encountered in orthopedic trauma practice because of their proximity to the knee joint, frequent intra-articular extension, comminution, and associated soft-tissue damage. The primary objectives of treatment are restoration of anatomical alignment, achievement of stable fixation, early mobilization, and prevention of complications such as non-union, malunion, and knee stiffness. The advent of locking compression plate (LCP) technology has significantly improved the management of these fractures, particularly in osteoporotic bone and complex fracture patterns.

In the present study, 60 adult patients with distal femoral fractures were managed using distal femoral locking compression plates and were evaluated clinically, functionally, and radiologically. The majority of patients belonged to the economically productive age group of 31–50 years (53.3%), with a male predominance (70%). Similar demographic findings have been reported by Elsoe et al. and Hierholzer et al., who observed that distal femur fractures commonly occur in young males following high-energy trauma and in elderly females following low-energy falls.

Road traffic accidents accounted for 66.7% of injuries in the present study, making them the most common mechanism of trauma. This observation is comparable to the findings of Yeap and Deepak and Nayak et al., who reported that high-energy vehicular accidents remain the leading cause of distal femur fractures in developing countries. The predominance of road traffic accidents among younger patients reflects increasing urbanization, motorization, and occupational exposure to high-energy trauma.

According to the AO/OTA classification, Type C2 and C3 fractures constituted more than half of all cases (53.4%). These fracture patterns are associated with extensive articular involvement and metaphyseal comminution, making stable fixation technically demanding. Similar distributions have been reported by Henderson et al. and Rodriguez et al., emphasizing that locking plate systems are particularly advantageous in managing these complex fracture configurations.

The mean interval between injury and surgery in our study was 4.2 days. Early surgical stabilization facilitates pain relief, allows early mobilization, and reduces complications associated with prolonged immobilization. Previous studies have demonstrated that timely fixation contributes to improved functional outcomes and reduced hospital stay.

The average radiological union time observed in our study was 18.2 weeks. This finding is comparable to the union times reported by Kregor et al.(16–20 weeks) and Vallier et al.(approximately 18 weeks). The preservation of periosteal blood supply and maintenance of biological fracture healing through bridge plating principles likely contributed to the satisfactory union rates observed. Locking compression plates function as internal fixators, reducing disruption of fracture biology and promoting secondary bone healing through callus formation.

Associated injuries were identified in 15% of patients, reflecting the high-energy nature of many distal femur fractures. Similar rates of associated musculoskeletal injuries have been documented in previous studies, highlighting the importance of comprehensive trauma evaluation and multidisciplinary management.

The overall complication rate in the present study was relatively low. Superficial infection occurred in 3.3% of patients and responded to conservative treatment. This rate compares favorably with reported infection rates ranging from 2% to 8% in contemporary literature. The low incidence may be attributed to meticulous surgical technique, perioperative antibiotic prophylaxis, and careful soft-tissue handling.

Non-union was observed in 3.3% of patients, while delayed union occurred in 6.7%. These findings are lower than those reported in earlier studies using conventional plating systems. Henderson et al. identified non-union rates between 5% and 10% following distal femur fixation. The fixed-angle stability provided by locking plates improves construct rigidity and reduces the risk of fixation failure, particularly in osteoporotic bone and comminuted fractures.

Varus malalignment occurred in 6.7% of cases, while limb-length discrepancy was noted in 5%. These complications were primarily associated with severely comminuted fracture patterns. Similar findings have been reported by Stoffel et al., who emphasized the importance of achieving accurate reduction and maintaining mechanical alignment during fixation. Despite radiographic malalignment in a few patients, significant functional impairment was not observed during follow-up.

Restoration of knee motion remains an important determinant of functional outcome following distal femur fracture fixation. In the present study, the mean knee flexion achieved was 108°, and 76.7% of patients attained more than 90° of flexion. Comparable results have been reported by Markmiller et al. and Kregor et al., who documented average postoperative knee flexion ranging between 100° and 115°. Early initiation of rehabilitation and stable internal fixation likely contributed to the favorable range of motion observed.

Functional assessment using the Neer scoring system demonstrated excellent results in 56.7% of patients and good results in 23.3%, yielding an overall satisfactory outcome rate of 80%. These results are consistent with those reported by Yeap and Deepak, who observed excellent-to-good outcomes in approximately 82% of patients treated with locking compression plates. Similar success rates have also been documented by Schandelmaier et al. and Vallier et al.. The favorable outcomes observed in the present study support the effectiveness of locking compression plate fixation in providing stable fixation and facilitating functional recovery.

The strengths of this study include prospective data collection, standardized surgical technique, and consistent follow-up. However, certain limitations should be acknowledged. The study was conducted at a single center with a relatively limited sample size and lacked a comparative control group using alternative fixation methods such as retrograde intramedullary nailing or dynamic condylar screw fixation. Longer follow-up periods and randomized comparative studies would provide further insight into the long-term efficacy of locking compression plate fixation.

CONCLUSION

Distal femoral fractures are complex injuries that require stable fixation and early mobilization to achieve optimal outcomes. The distal femoral locking compression plate provides a reliable fixation method by combining angular stability with preservation of fracture biology.

In the present study, locking compression plate fixation resulted in satisfactory fracture union, good functional recovery, and acceptable complication rates. The mean union time was 18.2 weeks, and 80% of patients achieved excellent to good functional outcomes according to the Neer scoring system. The incidence of infection, non-union, and malalignment was low, and most patients regained a functional range of knee motion.

The findings of this study suggest that distal femoral locking compression plate fixation is an effective and dependable treatment modality for distal femoral fractures, particularly in comminuted, intra-articular, and osteoporotic fractures. Adherence to sound surgical principles, accurate reduction, stable fixation, and early rehabilitation are essential for achieving favorable clinical and functional outcomes.

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