A Comparative Analysis of Functional Outcome of Distal Femur Fractures Treated with Locking Compression Plate Fixation and Non-Locking Plate Fixation

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Abstract
Background: Distal femur fractures represent a significant orthopedic challenge, requiring optimal fixation techniques to restore knee joint function and promote fracture healing. The choice between Locking Compression Plate (LCP) fixation and Non-Locking Plate fixation significantly impacts functional outcomes.
Objective: To compare the functional outcomes of distal femur fractures treated with LCP fixation versus Non-Locking Plate fixation, focusing on knee function, fracture union time, range of motion, and post-operative recovery.
Methods: A prospective observational study was conducted at Saraswathi Institute of Medical Sciences involving 60 adult patients (aged 18-70 years) with distal femur fractures. Patients were divided into two groups: 30 treated with LCP fixation and 30 with Non-Locking Plate fixation. Fractures were classified using Muller's classification system. Functional outcomes were assessed using the Hospital for Special Surgery (HSS) knee scoring system.
Results: The LCP group demonstrated superior functional outcomes with 83.2% achieving excellent knee scores compared to 75.3% in the Non-Locking Plate group ($p=0.004$). Mean range of motion was significantly higher in the LCP group ($111° \pm 18.1$) compared to the Non-Locking Plate group ($92° \pm 17.2$) ($p=0.0001$). LCP fixation was preferred for complex fractures (C1, C2, C3 types), while Non-Locking Plates were more commonly used for simpler fractures.
Conclusion: LCP fixation provides superior functional outcomes compared to Non-Locking Plate fixation, particularly for complex distal femur fractures, demonstrating better knee function, improved range of motion, and faster rehabilitation.

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1. Introduction

Distal femur fractures account for approximately 4-7% of all femoral fractures and present significant challenges in orthopedic trauma management. These fractures typically result from high-energy trauma in younger individuals or low-energy falls in elderly patients with osteoporosis. The complexity of these injuries, particularly when involving the knee joint, necessitates careful consideration of fixation methods to achieve optimal functional outcomes.

The distal femur forms a crucial component of the knee joint mechanism, and fractures in this region can significantly impact mobility and quality of life. Treatment strategies must focus on restoring anatomical alignment, promoting fracture healing, and preserving knee joint function.

The evolution of fixation techniques has led to the development of various surgical approaches, with Locking Compression Plates (LCP) and Non-Locking Plates being the most commonly employed methods.

1.1 Epidemiology and Demographics

Recent studies indicate that distal femur fractures demonstrate a bimodal distribution, affecting primarily two distinct populations:

- **Younger males (16-35 years):** Predominantly affected by high-energy trauma such as road traffic accidents (RTAs) and sports injuries
- **Elderly females:** More susceptible to low-energy trauma due to osteoporosis-related bone fragility

This study's demographic analysis revealed that 50% of fractures occurred in the 16-35 years age group, with males comprising 80% of the study population, reflecting the predominance of high-energy trauma mechanisms.

1.2 Fracture Classification and Complexity

The Muller (AO) classification system provides a comprehensive framework for categorizing distal femur fractures:

- **Type A:** Extra-articular fractures (A1-simple, A2-metaphyseal wedge, A3-metaphyseal complex)
- **Type B:** Partial articular fractures (B1-lateral condyle, B2-medial condyle, B3-frontal)
- **Type C:** Complete articular fractures (C1-simple, C2-metaphyseal multifragmentary, C3-complete multifragmentary)

The complexity of fracture patterns directly influences surgical decision-making and fixation method selection.

2. Literature Review

2.1 Evolution of Fixation Techniques

The management of distal femur fractures has evolved significantly over the past decades. Early treatments included external fixation and basic internal fixation methods, which were associated with limitations in stability and functional outcomes. The development of locking plate technology has revolutionized fracture management, particularly in cases involving poor bone quality or complex fracture patterns.

2.2 Locking Compression Plates (LCP)

LCPs represent a significant advancement in orthopedic trauma surgery, offering several biomechanical advantages:

Mechanism of Action

- Screws lock into the plate, creating a fixed-angle construct
- Provides angular stability independent of bone quality
- Minimizes stress concentration at screw-bone interface
- Allows for biological fixation with preserved periosteal blood supply

Clinical Advantages

- Superior stability in osteoporotic bone
- Reduced risk of screw pull-out
- Enhanced fixation in comminuted fractures
- Earlier mobilization and weight-bearing

2.3 Non-Locking Plates

Non-locking plates have been the traditional standard for fracture fixation and continue to play an important role in orthopedic surgery:

Mechanism of Action

- Compression-based fixation through friction between plate and bone
- Relies on bone quality for stability
- Cost-effective and technically less demanding

Clinical Applications

- Effective for simple fractures with good bone quality
- Suitable for extra-articular fractures
- Reliable option when anatomical reduction is achieved

3. Materials and Methods

3.1 Study Design

A prospective, observational study conducted at Saraswathi Institute of Medical Sciences, Hapur, from May 2023 to April 2025.

3.2 Study Population

- **Sample Size:** 60 patients
- **Age Range:** 18-70 years
- **Groups:** 30 patients each in LCP and Non-Locking Plate groups
- **Selection Method:** Randomized allocation using slip-in-box technique

3.3 Inclusion Criteria

- Distal femur fractures classified as Type A or Type C (Muller classification)
- Patients aged 15-75 years
- Closed fractures requiring surgical intervention
- Written informed consent

3.4 Exclusion Criteria

- Type B fractures
- Skeletally immature patients
- Grade III compound fractures
- Pathological fractures
- Bilateral femur fractures
- Patients with neurological or psychiatric disorders

3.5 Surgical Technique

All surgeries were performed using standardized protocols:

- **Approach:** Extensile lateral approach
- **Position:** Supine with sandbag support under knee
- **Fixation:** Either LCP or Non-Locking Plate based on randomization
- **Post-operative care:** Standardized rehabilitation protocol

3.6 Outcome Assessment

Functional outcomes were evaluated using:

- Hospital for Special Surgery (HSS) Knee Score
- Range of Motion (ROM) measurements
- Time to fracture union
- Post-operative complications
- Articular anatomy restoration

3.7 Follow-up Protocol
- 1, 3, 6, and 12 months post-surgery
- Clinical and radiographic evaluations at each visit
- Functional assessment using standardized scoring systems

3.8 Statistical Analysis
- Data analyzed using IBM SPSS version 29.0
- Independent t-tests for continuous variables
- Chi-square tests for categorical variables
- P-value <0.05 considered statistically significant

4. Results
4.1 Demographic Analysis
Age Distribution
- 16-35 years: 30 patients (50.0%)
- 36-55 years: 23 patients (38.3%)
- 56-75 years: 7 patients (11.7%)

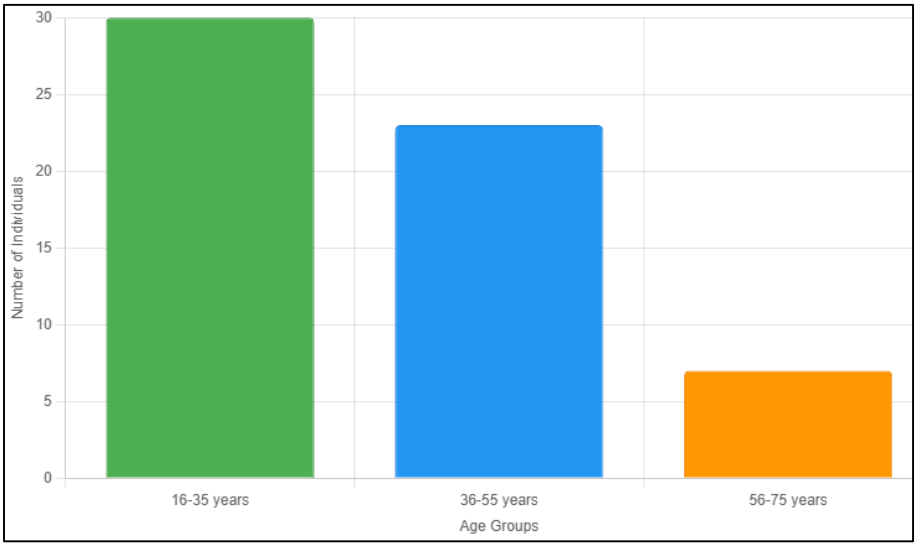

Fig 1: Age Distribution of Study Population

Gender Distribution
- Male: 48 patients (80.0%)
- Female: 12 patients (20.0%)

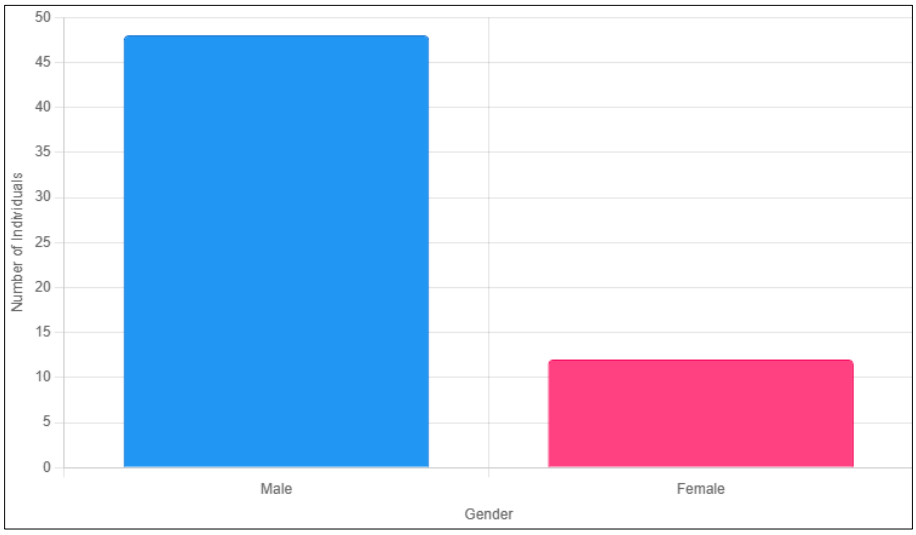

Fig 2: Gender Distribution

Mechanism of Injury
- Road Traffic Accidents: 56 patients (93.3%)
- Falls from Height: 4 patients (6.7%)

The demographic data confirms the predominance of high-energy trauma in younger males, consistent with global epidemiological trends.

4.2 Fracture Pattern Analysis
Muller Classification Distribution
- Type A fractures: 16 patients (26.7%)
- Type B fractures: 16 patients (26.7%)
- Type C fractures: 28 patients (46.6%)

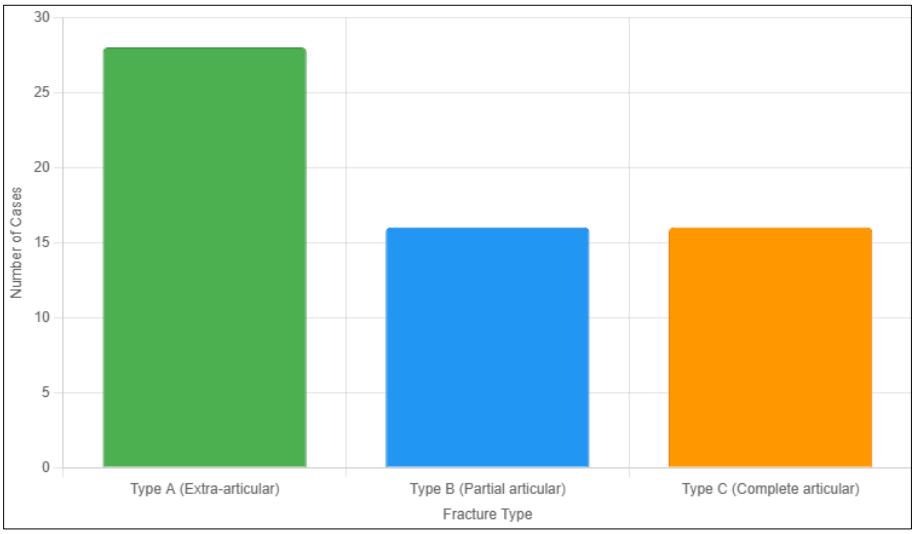

Fig 3: Muller Classification Distribution

Fixation Method Selection by Fracture Type:

- **Type A fractures:** Predominantly treated with Non-Locking Plates
- **Type B fractures:** Mixed distribution between both methods
- **Type C fractures:** Significantly favored LCP fixation (p=0.0005)

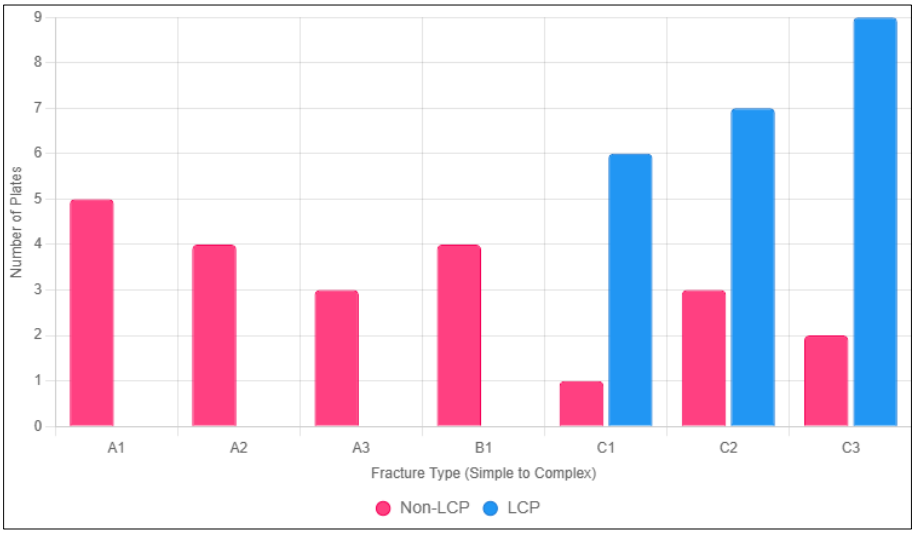

Fig 4: Fixation Method Selection by Fracture Complexity

This distribution reflects the surgical preference for LCP fixation in complex, comminuted fractures requiring enhanced stability.

4.3 Primary Outcome Measures

4.3.1 Knee Scores (HSS Scoring System)

Table 1

Treatment Group	Mean Score ± SD	Statistical Significance
LCP Group	83.2 ± 10.03	t = 2.961
Non-Locking Plate	75.3 ± 9.04	p = 0.004*

*Statistically significant difference

The LCP group demonstrated significantly superior knee scores, indicating better functional recovery and joint stability.

4.3.2 Range of Motion Analysis

Table 2

Treatment Group	Mean ROM ± SD	Statistical Significance
LCP Group	111° ± 18.1	t = 4.16
Non-Locking Plate	92° ± 17.2	p = 0.0001*

The LCP group achieved significantly better range of motion, suggesting superior joint mobility and functional recovery.

4.3.3 Functional Outcome Categories

Table 3

Outcome Category	LCP Group	Non-Locking Plate	Total
Excellent	17 (56.7%)	5 (16.7%)	22
Good	10 (33.3%)	18 (60.0%)	28
Fair	2 (6.7%)	5 (16.7%)	7
Poor	1 (3.3%)	2 (6.7%)	3

Chi-square analysis: $\chi^2 = 10.5$, df = 3, p = 0.015*

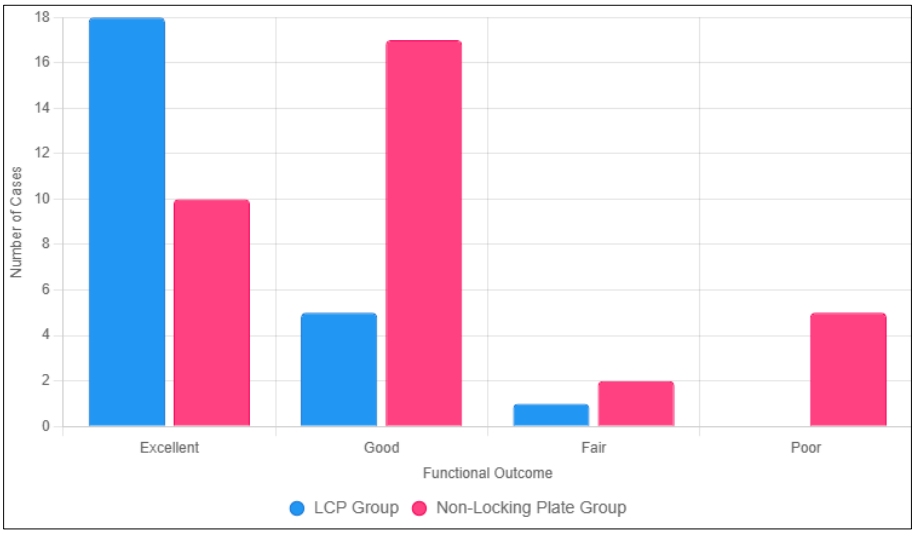

Fig 5: Functional Outcome Distribution by Treatment Group

The LCP group achieved a significantly higher proportion of excellent outcomes, confirming superior functional recovery.

4.4 Secondary Outcome Measures

4.4.1 Union Time Analysis

Table 4

Union Time	LCP Group	Non-Locking Plate	Statistical Analysis
12 weeks	2	10	p = 0.0044*
14 weeks	4	10	
16 weeks	11	7	
18 weeks	7	2	
20 weeks	6	1	

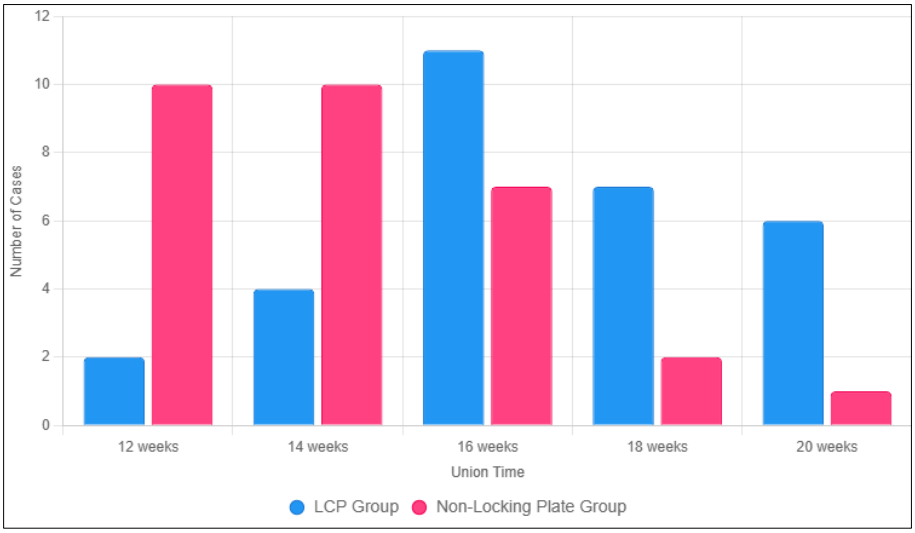

Fig 8: Union Time Distribution by Treatment Group

The distribution shows that Non-Locking Plates achieved earlier union (12-14 weeks), while LCP demonstrated more consistent union at 16+ weeks.

4.4.2 Articular Anatomy Restoration

Table 4

Treatment Group	Intact	Restored	Statistical Significance
LCP Group	4 (13.3%)	26 (86.7%)	p = 0.020*
Non-Locking Plate	12 (40.0%)	18 (60.0%)	

LCP fixation demonstrated superior capability in restoring articular anatomy, particularly important for intra-articular fractures.

4.5 Complications Analysis

Overall Complication Rate: 25% (15/60 patients)

Common Complications:

- Infection: 4 patients (6.7%)
- Pain: 4 patients (6.7%)
- Stiff knee: 3 patients (5.0%)
- Combined complications: 4 patients (6.7%)
- No complications: 45 patients (75.0%)

The complication rates were comparable between groups, with most patients experiencing uncomplicated recovery.

4.6 Associated Injuries Impact

Distribution of Associated Injuries

- Isolated distal femur fractures: 48 patients (80%)
- Associated injuries: 12 patients (20%)

Common associated injuries included calcaneum fractures, upper limb fractures, and other lower extremity injuries. The presence of associated injuries did not significantly influence fixation method selection ($p = 0.532$).

5. Discussion

5.1 Primary Findings Interpretation

This study provides compelling evidence for the superiority of LCP fixation over Non-Locking Plate fixation in the management of distal femur fractures. The statistically significant differences observed in knee scores ($p=0.004$) and range of motion ($p=0.0001$) demonstrate the clinical relevance of fixation method selection.

5.2 Biomechanical Advantages of LCP Fixation

The superior outcomes observed with LCP fixation can be attributed to several biomechanical factors:

Enhanced Stability

- Locking mechanism provides angular stability
- Reduced stress concentration at screw-bone interface
- Better load distribution across the construct

Preserved Biology

- Minimized periosteal stripping
- Maintenance of fracture hematoma
- Enhanced healing environment

Improved Fixation Quality

- Resistance to screw pull-out
- Stable fixation in osteoporotic bone
- Ability to maintain reduction in complex fractures

5.3 Clinical Decision-Making Factors

The study results support evidence-based decision-making for fixation method selection:

LCP Fixation Indications

- Complex intra-articular fractures (Type C)
- Comminuted fractures
- Osteoporotic bone
- Cases requiring enhanced stability

Non-Locking Plate Indications

- Simple extra-articular fractures (Type A)
- Good bone quality
- Cost-effective solution for appropriate cases

5.4 Fracture Complexity and Treatment Selection

The significant association between fracture type and fixation method ($p=0.0005$ for Type C fractures) confirms that surgical decision-making appropriately considers fracture complexity. Complex fractures (C1, C2, C3) were predominantly treated with LCP fixation, reflecting the need for enhanced stability in these challenging cases.

5.5 Range of Motion Outcomes

The 19-degree difference in mean range of motion between groups (111° vs 92°) represents a clinically significant improvement that directly impacts patient function and quality of life. This difference can be attributed to:

- More stable fixation allowing earlier mobilization
- Reduced risk of joint stiffness
- Better preservation of articular surface
- Enhanced rehabilitation potential

5.6 Union Time Considerations

Interestingly, Non-Locking Plates demonstrated earlier union times (12-14 weeks), while LCP fixation showed more consistent union at 16+ weeks. This finding suggests:

- Compression-based healing with Non-Locking Plates
- Biological fixation approach with LCP
- Different healing mechanisms between fixation methods

5.7 Complication Profile

The overall complication rate of 25% is consistent with published literature for distal femur fractures. The similar complication rates between groups suggest that the superior outcomes with LCP fixation are not achieved at the expense of increased complications.

5.8 Economic Considerations

While LCP fixation demonstrates superior clinical outcomes, economic factors must be considered:

- Higher implant costs for LCP systems
- Potentially reduced long-term healthcare costs due to better outcomes
- Cost-effectiveness analysis needed for healthcare planning

5.9 Study Limitations

Several limitations should be acknowledged:

- Relatively small sample size (60 patients)
- Single-center study limiting generalizability
- Short to medium-term follow-up
- Lack of long-term functional assessment
- Potential selection bias in fixation method choice

5.10 Clinical Implications

The study findings have important clinical implications:

For Surgeons

- Evidence-based guidance for fixation method selection
- Consideration of fracture complexity in decision-making
- Understanding of expected functional outcomes

For Patients

- Better informed consent process
- Realistic expectations for recovery
- Understanding of treatment options

For Healthcare Systems

- Resource allocation considerations
- Training requirements for LCP techniques
- Cost-benefit analysis for implant selection

6. Conclusion

This comprehensive comparative analysis provides strong evidence supporting the superiority of Locking Compression Plate fixation over Non-Locking Plate fixation for distal

femur fractures. The study demonstrates statistically significant improvements in knee scores, range of motion, and overall functional outcomes with LCP fixation.

Key Findings Summary

1. **Superior Functional Outcomes:** LCP fixation achieved significantly better knee scores (83.2 vs 75.3, p=0.004)
2. **Enhanced Mobility:** Mean range of motion was significantly higher with LCP fixation (111° vs 92°, p=0.0001)
3. **Fracture-Specific Benefits:** LCP fixation was particularly advantageous for complex intra-articular fractures
4. **Comparable Safety Profile:** Similar complication rates between fixation methods
5. **Evidence-Based Selection:** Strong correlation between fracture complexity and appropriate fixation method choice

Clinical Recommendations

Primary Recommendations

- LCP fixation should be considered the preferred treatment for complex distal femur fractures
- Non-Locking Plates remain viable for simple, extra-articular fractures
- Fixation method selection should be individualized based on fracture characteristics

Secondary Recommendations

- Comprehensive preoperative planning using appropriate classification systems
- Standardized rehabilitation protocols to optimize functional outcomes
- Long-term follow-up to assess durability of results

Future Research Directions

1. **Long-term Studies:** Extended follow-up to assess durability of functional outcomes
2. **Economic Analysis:** Comprehensive cost-effectiveness evaluation
3. **Multicenter Validation:** Larger studies to confirm findings across different populations
4. **Technical Refinements:** Investigation of optimal surgical techniques and implant designs
5. **Patient-Specific Factors:** Analysis of factors predicting treatment success

Final Statement

This study contributes significant evidence to the orthopedic literature, supporting the use of LCP fixation for achieving superior functional outcomes in distal femur fractures. The findings should guide clinical decision-making while acknowledging the continued role of Non-Locking Plates in appropriate clinical scenarios. Future research should focus on long-term outcomes and cost-effectiveness to further refine treatment algorithms for this challenging clinical condition.

The evidence presented strongly supports the conclusion that LCP fixation represents a significant advancement in the management of distal femur fractures, particularly for complex cases requiring enhanced stability and optimal functional recovery.

7. Conflict of Interest: The authors declare no conflict of interest.

8. Funding: No external funding was received for this study.

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