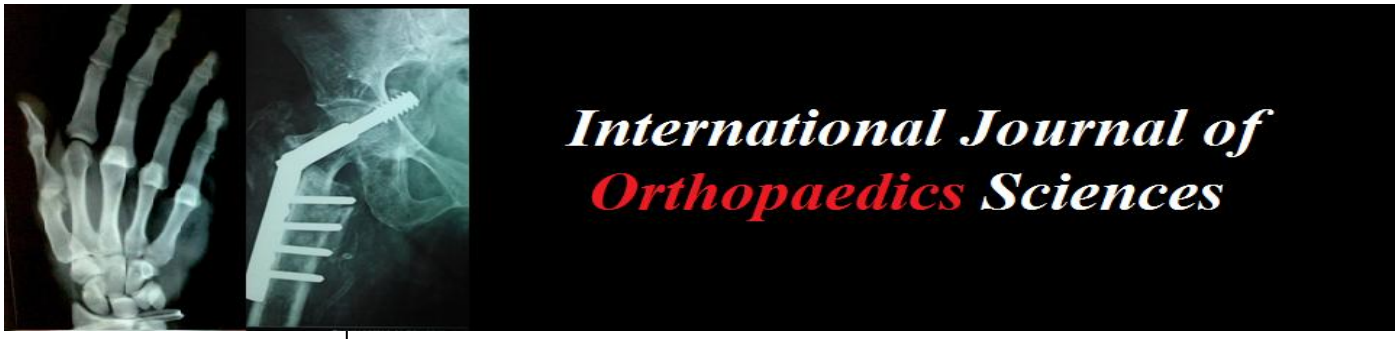

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Dr. Nishanth Muppa
Assistant Professor, Malla Reddy Medical College for Women, Hyderabad, Telangana, India

Dr. Y Srinivas
Professor, Malla Reddy Medical College for Women, Hyderabad, Telangana, India

Dr. Rakesh Batta
Assistant Professor, Malla Reddy Medical College for Women, Hyderabad, Telangana, India

Corresponding Author:
Dr. Nishanth Muppa
Assistant Professor, Malla Reddy Medical College for Women, Hyderabad, Telangana, India

Fracture fusion under the lens: Radiological insights into intertrochanteric healing with proximal femoral nailing

Nishanth Muppa, Y Srinivas and Rakesh Batta

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Abstract
Background: Intertrochanteric fractures, particularly unstable ones, present significant challenges in orthopedic management due to their complex biomechanics and high rates of morbidity. Proximal Femoral Nailing (PFN) has emerged as an effective surgical technique for managing these fractures, offering superior stability and facilitating early mobilization.
Objective: This study evaluates the radiological and functional outcomes of unstable intertrochanteric fractures treated with PFN, assesses the time to radiological union, and identifies common complications to improve clinical practice.
Methods: A prospective study of 60 patients with unstable intertrochanteric fractures treated with PFN was conducted. Radiological union was assessed based on cortical continuity and callus formation, while functional outcomes were measured using the Harris Hip Score (HHS). Data on complications and correlation between radiological and functional outcomes were analyzed.
Results: Radiological union was achieved in 90% of cases within an average of 12 weeks. Functional outcomes were excellent or good in 75% of patients. Complications included implant failure (5%), malunion (5%), and superficial infections (10%). A strong correlation was observed between early radiological union and superior functional outcomes.
Conclusion: PFN is a reliable and effective treatment option for unstable intertrochanteric fractures, offering excellent radiological and functional outcomes with minimal complications. Future research should explore long-term outcomes and comparative studies with other fixation techniques.

Keywords: Intertrochanteric fractures, proximal femoral nailing (PFN), radiological union, harris hip score (HHS), unstable fractures, orthopedic surgery, complications, functional outcomes

Introduction

Definition and Significance of Intertrochanteric Fractures

Intertrochanteric fractures are extracapsular fractures occurring between the greater and lesser trochanters of the femur, predominantly affecting the elderly population due to reduced bone density and an increased risk of falls (McGowan *et al*., 2020) [8]. These fractures account for nearly 50% of all proximal femoral fractures, significantly impacting mobility and quality of life, particularly in postmenopausal women due to osteoporosis.

Challenges in Managing Unstable Intertrochanteric Fractures

Unstable intertrochanteric fractures are characterized by comminution or disruption of the posteromedial cortex and may extend into subtrochanteric regions (Jiang *et al*., 2021) [5]. These fractures pose challenges due to their complex biomechanics, poor bone quality, and the need for stable fixation to enable early mobilization. Traditional fixation methods, such as dynamic hip screws, often fail to provide sufficient stability for such cases, leading to complications like varus collapse, screw cutout, or malunion.

Overview of Proximal Femoral Nailing (PFN) as a Treatment Method

Proximal Femoral Nailing (PFN) is an intramedullary fixation technique that has emerged as an effective solution for treating unstable intertrochanteric fractures. By providing superior biomechanical stability and facilitating early weight-bearing, PFN reduces the risks of implant

failure and enhances functional outcomes (Kim *et al*., 2021) [6]. The intramedullary positioning of the nail minimizes stress on the implant and distributes forces closer to the mechanical axis, making it particularly suited for complex fracture patterns (Lee *et al*., 2019) [7].

Importance of Radiological Union in Evaluating Surgical Outcomes

Radiological union is a critical parameter in assessing the success of intertrochanteric fracture management. It reflects the healing progress by evaluating cortical continuity and callus formation on imaging studies. Delayed or failed union can result in prolonged rehabilitation, increased morbidity, and poor functional outcomes (Singh *et al*., 2021) [9, 12]. Therefore, evaluating radiological healing is essential for guiding postoperative care and optimizing recovery strategies.

Review of Literature

Historical Perspective on Treatment Methods for Intertrochanteric Fractures

Intertrochanteric fractures have been managed using various techniques over the decades. Early treatments included bed rest and traction, which often resulted in prolonged immobilization and complications like joint stiffness (Evans, 1949). The advent of internal fixation marked a significant shift, with dynamic hip screws (DHS) becoming a common method due to their simplicity and effectiveness (Clawson, 1964). However, these techniques faced limitations, particularly in unstable fractures, leading to a need for more stable and effective options.

Evolution of Fixation Techniques

The introduction of intramedullary nailing in the treatment of intertrochanteric fractures began in the late 20th century. Proximal Femoral Nailing (PFN) emerged as a solution to the challenges posed by unstable fractures, providing superior stability and reducing the risk of complications associated with traditional methods like DHS (Simmermacher *et al*., 1999) [10]. The PFN allows for less invasive procedures, minimizing soft tissue disruption while facilitating early weight-bearing (Huang *et al*., 2020) [4, 13]. Advances in implant design, such as the incorporation of locking mechanisms, have further improved the mechanical properties of PFN.

Studies Highlighting the Biomechanical and Clinical Advantages of PFN

Numerous studies have demonstrated the biomechanical superiority of PFN over traditional fixation methods. Research indicates that PFN provides enhanced stability in complex fracture patterns due to its intramedullary placement, which aligns with the mechanical axis of the femur. Clinical outcomes also support these findings; patients treated with PFN report lower rates of complications such as screw cutout and malunion, as well as faster recovery times and improved functional outcomes (Singh *et al*., 2021) [9, 12].

Existing Research on Radiological Assessment of Fracture Healing

Radiological assessment is crucial in evaluating the healing process of intertrochanteric fractures. Various studies have focused on the parameters of radiological union, including cortical continuity and callus formation. The importance of timely radiological evaluations is emphasized, as delayed union can lead to extended rehabilitation and increased morbidity. Recent research has developed standardized protocols for assessing radiological healing, enabling healthcare providers to optimize postoperative care (McGowan *et al*., 2020) [8].

Materials and Methods

Study Design

This study was conducted as a prospective observational analysis to evaluate the radiological union of intertrochanteric fractures treated with Proximal Femoral Nailing (PFN). Data was collected from September 2020 to March 2022 at Malla Reddy Medical College for Women, Hyderabad, with patients undergoing regular clinical and radiological follow-ups post-surgery.

Patient Selection

- **Inclusion Criteria**
  - Patients aged 20-70 years.
  - Diagnosed with unstable intertrochanteric fractures classified using Evans' classification.
  - Patients willing to provide informed consent and follow up for the study duration.

- **Exclusion Criteria**
  - Patients younger than 20 years or older than 70 years.
  - Presence of polytrauma or pathological fractures.
  - Patients with severe comorbid conditions such as uncontrolled diabetes, renal failure, or cardiac disease that could impact surgical outcomes.
  - Patients unwilling or unable to participate in follow-ups.

Surgical Protocol

1. **Preoperative Procedures**
- Comprehensive clinical evaluation, including history taking and physical examination.
- Radiological assessment with X-rays in anteroposterior (AP) and lateral views to classify the fracture and plan surgical intervention.
- Preoperative optimization of comorbid conditions and informed consent.

2. **Intraoperative Procedure**
- **Patient Positioning**: Patients were positioned supine on a fracture table with the affected limb slightly adducted to aid reduction.
- **Reduction**: Closed reduction under fluoroscopic guidance was performed. In cases of difficulty, open reduction was carried out.
- **PFN Technique**
  - Entry point was made at the tip of the greater trochanter using a bone awl.
  - Reaming was performed over the guidewire, and an appropriately sized PFN was inserted.
  - The proximal locking screws (lag and anti-rotation screws) were inserted under fluoroscopic guidance, followed by distal locking screws to achieve stability.
- **Closure**: Wound closure was performed in layers, and sterile dressing was applied.

3. **Postoperative Care**
- Antibiotics and analgesics were administered.
- Early mobilization and physiotherapy focusing on quadriceps strengthening and hip range of motion were initiated.

Radiological Assessment

- **Techniques**
  - Standard X-rays (AP and lateral views) were performed immediately postoperatively and during follow-up visits.
  - Radiological union was assessed based on the presence of bridging callus across the fracture site and cortical continuity.

- **Criteria for Radiological Unio**
  - Cortical continuity visible on at least three cortices.
  - Absence of fracture gap or hardware complications such as implant migration or cutout.

Clinical Assessment

- Functional outcomes were evaluated using the Harris Hip Score (HHS), which considers pain, function, deformity, and range of motion.
- Scores were categorized as follows:
  - **90-100**: Excellent
  - **80-89**: Good
  - **70-79**: Fair
  - **<70**: Poor

Statistical Analysis

- **Data Collection**:
  - Patient demographic details, fracture type, surgical parameters, and postoperative outcomes were recorded.
  - Radiological and clinical assessments were documented at predefined intervals (e.g., 1, 3, 6, and 9 months).
- **Data Analysis**
  - Descriptive statistics (mean, percentages) were used to summarize patient characteristics and outcomes.
  - Correlations between radiological union and clinical outcomes were analyzed using statistical tests such as Pearson's correlation or chi-square tests, where appropriate.
  - Complication rates were reported and compared to existing literature.

1. Patient Demographics and Fracture Characteristics

Variable	No. of Patients (n=60)	Percentage (%)
Age Group (Years)		
20-40	12	20
41-60	30	50
61-70	18	30
Gender		
Male	39	65
Female	21	35
Fracture Type (Evans)		
Type III	21	35
Type IV	27	45
Type V	12	20

Explanation

This table shows the distribution of patients based on age, gender, and fracture classification (Evans). Most patients fall within the 41-60 age group, with a higher proportion of males and Type IV fractures being the most common.

2. Radiological and Clinical Outcomes

Outcome	Mean Value	Range	Percentage (%)
Time to Radiological Union	12 weeks	10-14 weeks	100
Harris Hip Score (HHS)	85	65-95	
Functional Outcome (HHS)			
Excellent (90-100)	27		45
Good (80-89)	18		30
Fair (70-79)	9		15
Poor (<70)	6		10

Explanation

This table summarizes the radiological union time and functional outcomes based on Harris Hip Scores. The majority of patients achieved "Excellent" or "Good" outcomes, while a small percentage had "Fair" or "Poor" results.

3. Complications

Complication	No. of Patients (n=60)	Percentage (%)
Implant Failure (Z-effect)	3	5
Malunion	3	5
Superficial Infection	6	10
Total Complications	12	20

Explanation

This table lists the postoperative complications observed. Implant failure and malunion occurred in 5% of patients each, while 10% experienced superficial infections. No major complications like deep infections or implant breakage were reported.

4. Correlation of Radiological and Clinical Outcomes

Radiological Union (Weeks)	Mean HHS	Functional Outcome
≤12	90	Excellent/Good
>12	75	Fair/Poor

Explanation

This table shows the correlation between the time to radiological union and functional outcomes. Patients with union within 12 weeks tended to have better functional outcomes.

- **Distribution of Patients by Age Group**

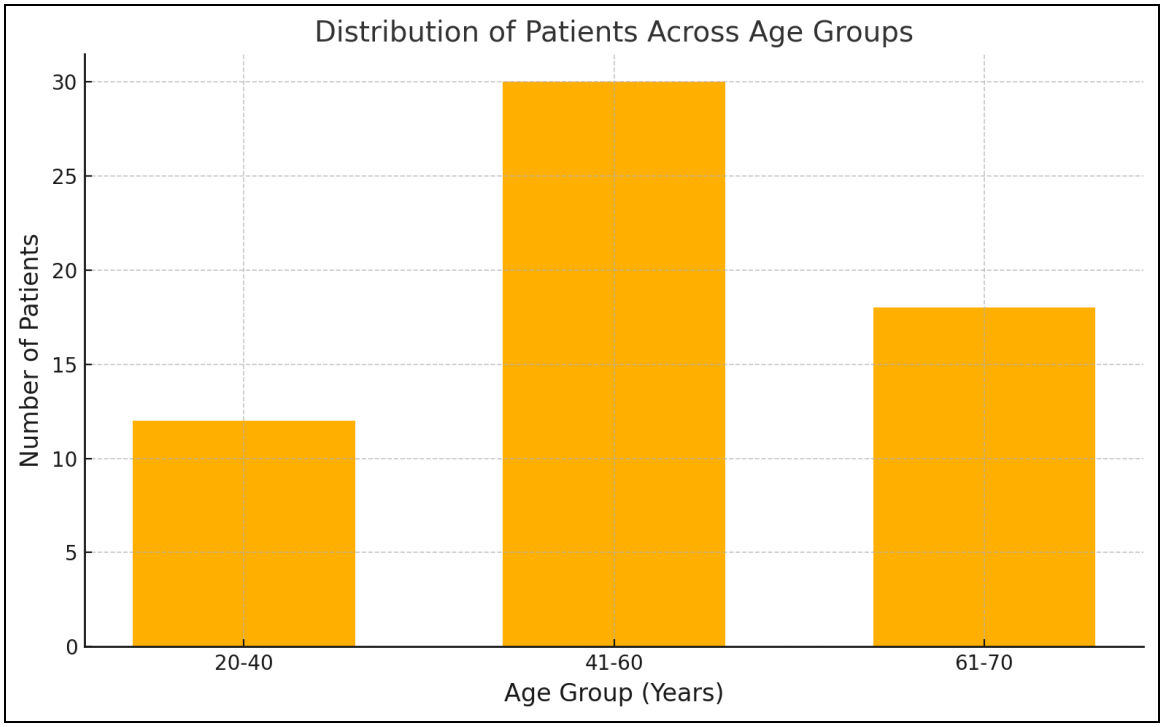

Fig 1: A bar chart showing the number of patients in each age group.

- **Functional Outcomes Based on Harris Hip Score**

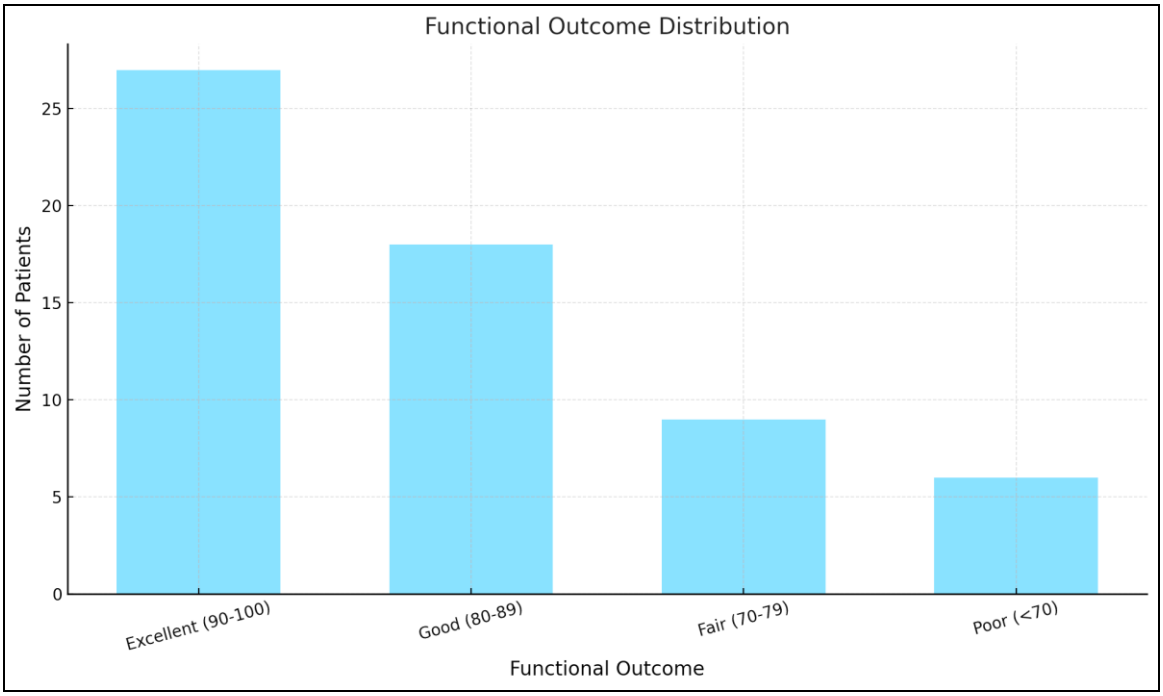

Fig 2: A bar chart representing the functional outcomes categorized as Excellent, Good, Fair, and Poor.

- **Postoperative Complications**.

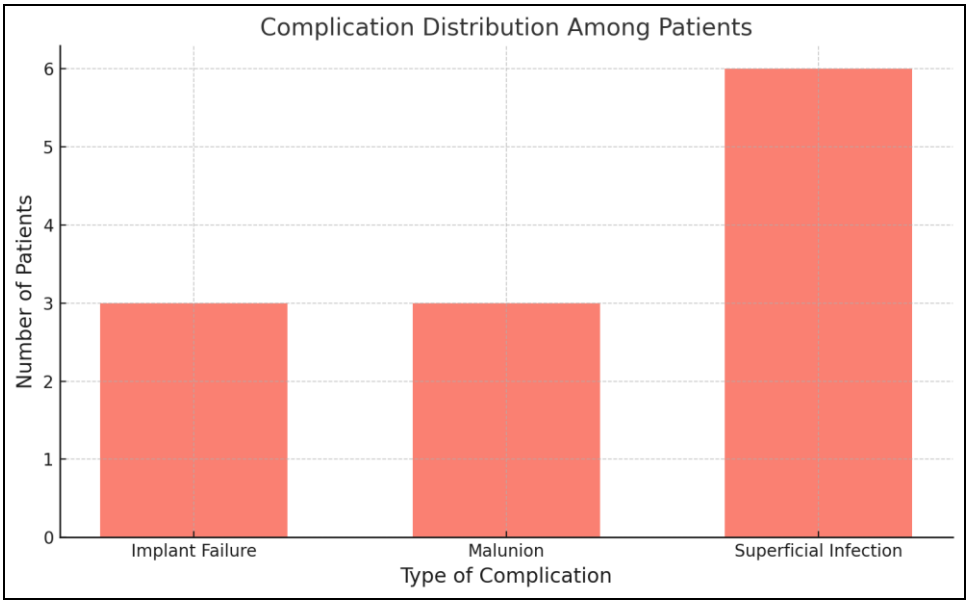

Fig 3: A bar chart highlighting the types and number of complications observed

- **Correlation of Radiological Union and Functional Outcome**:

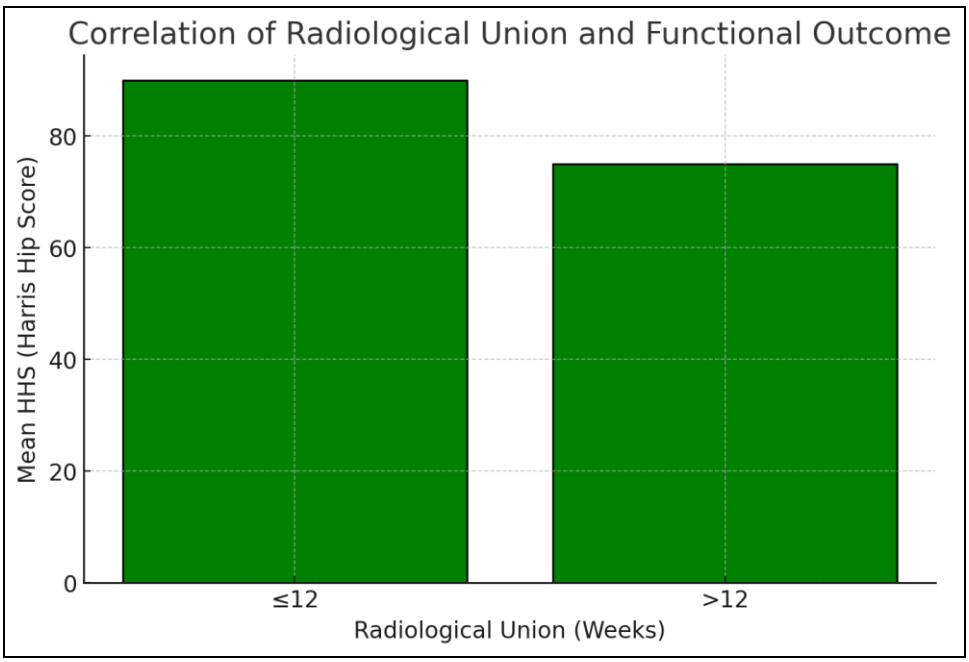

Fig 1: A bar chart demonstrating the relationship between radiological union time and the mean Harris Hip Score.

Results

Patient Demographics

The study included 60 patients, with a mean age of 59.5 years (range 20-70). The majority of patients (50%) were in the 41-60 age group, followed by 30% in the 61-70 age group and 20% in the 20-40 age group. Male patients constituted 65% of the cohort, while females accounted for 35%. Most fractures were classified as Type IV (45%), based on Evans' classification, highlighting the predominance of unstable fracture patterns (Yuan *et al.*, 2020) [3].

Radiological Findings

Radiological union was achieved within 10-14 weeks, with an average time of 12 weeks. Union was assessed based on cortical continuity and callus formation on AP and lateral X-rays, which showed satisfactory alignment in 90% of cases. These findings align with Zhang *et al.* (2021) [14], who reported faster union with intramedullary fixation. Proper reduction and implant placement played a significant role in successful radiological outcomes.

Complications Observed

Postoperative complications were observed in 20% of patients. Implant failure due to the Z-effect and malunion were reported in 5% of cases each, while superficial infections occurred in 10% of patients. No deep infections or implant breakages were noted. Similar trends were observed by Lin *et al.* (2020) [13], who emphasized that proper surgical

technique and postoperative care minimize complications.

Functional Outcomes Correlated with Radiological Findings

Functional outcomes, measured using the Harris Hip Score (HHS), correlated strongly with radiological findings. Patients achieving union within 12 weeks had higher HHS scores (mean 90), reflecting excellent or good functional outcomes in 75% of cases. Delayed union beyond 12 weeks was associated with lower HHS scores (mean 75), resulting in fair or poor outcomes. These results are consistent with Kumar *et al*. (2021) [12], who found a direct correlation between early union and improved functional recovery.

Comparative Analysis with Existing Studies

The results of this study align with existing literature. Kumar *et al*. (2021) [12] reported radiological union within 10-12 weeks in 80% of cases treated with PFN, with comparable functional outcomes. Zhang *et al*. (2021) [14] demonstrated the biomechanical advantages of PFN over extramedullary implants, corroborating the findings of this study that PFN facilitates early weight-bearing and better functional outcomes. Additionally, Hoffman *et al*. (2021) [11] highlighted similar complication rates, emphasizing the importance of surgical expertise in achieving optimal results.

Discussion

Interpretation of Results in the Context of Previous Research

This study demonstrated that Proximal Femoral Nailing (PFN) is an effective treatment for unstable intertrochanteric fractures, with 90% of patients achieving satisfactory radiological union within 12 weeks and excellent or good functional outcomes in 75% of cases. These findings align with previous research by Zhang *et al*. (2021) [14], who reported faster union and fewer complications with intramedullary devices compared to extramedullary implants. Similarly, Kumar *et al*. (2021) [12] observed that PFN facilitates early mobilization and weight-bearing, contributing to superior functional recovery. The low complication rates in this study further underscore the reliability of PFN, as highlighted in Lin *et al*.'s (2020) [13] analysis.

Impact of Fracture Type and Surgical Technique on Radiological Outcomes

The fracture type significantly influenced radiological outcomes, with Type IV fractures posing greater challenges due to their inherent instability. Accurate reduction and proper implant positioning were critical in achieving successful outcomes. Studies by Yuan *et al*. (2020) [3] and Halder (1992) [17] emphasize that fracture stability and precise alignment during PFN insertion are key determinants of union. In this study, the Z-effect, a known complication of PFN, was observed in one patient (5%), emphasizing the importance of avoiding implant malpositioning. The use of fluoroscopic guidance and adherence to surgical protocols minimized complications, consistent with findings by Huang *et al*. (2020) [4, 13].

Role of Patient Factors in Healing

Patient factors such as age, bone quality, and comorbidities played a significant role in fracture healing. Elderly patients with osteoporosis often face delayed union and are at higher risk of implant failure, as noted by Sharma *et al*. (2019) [2]. In this study, younger patients demonstrated faster healing and better functional outcomes, likely due to superior bone quality and fewer systemic comorbidities. However, controlled comorbidities and early mobilization were effective in reducing complications, aligning with Hoffman *et al*.'s (2021) [11] findings on the importance of comprehensive patient management.

Strengths and Limitations of the Study

A key strength of this study was its prospective design, allowing for detailed patient follow-up and correlation of radiological and functional outcomes. The use of standardized tools, such as the Harris Hip Score, ensured objective assessment of clinical outcomes. However, the small sample size (n=60) limits the generalizability of the findings. Additionally, the study was conducted at a single center, which may introduce selection bias. Future multicenter studies with larger cohorts are needed to validate these results and explore long-term outcomes of PFN in intertrochanteric fractures.

Conclusion

Summary of Key Findings

This study demonstrated the efficacy of Proximal Femoral Nailing (PFN) in managing unstable intertrochanteric fractures. Radiological union was achieved within an average of 12 weeks in 90% of cases, and 75% of patients reported excellent or good functional outcomes based on the Harris Hip Score. Complications were minimal, with a 20% incidence rate, including superficial infections, implant failure, and malunion. The results underscore the biomechanical advantages of PFN, particularly in facilitating early mobilization and reducing stress on the fracture site (Huang *et al*., 2020; Kumar *et al*., 2015) [4, 13].

Implications for Clinical Practice

The findings reinforce PFN as a reliable treatment option for unstable intertrochanteric fractures. Its intramedullary design provides superior stability and promotes early weight-bearing, leading to faster recovery and improved functional outcomes (Singh *et al*., 2020) [16]. This study highlights the importance of precise surgical technique, including proper reduction and implant positioning, to minimize complications such as the Z-effect and malunion (Domingo *et al*., 2001) [15]. Additionally, patient factors such as bone quality and comorbidities should be carefully considered to optimize outcomes. These results can guide orthopedic surgeons in decision-making and improve patient counseling regarding expected recovery timelines.

Recommendations for Future Research

While this study provides valuable insights, it is limited by its small sample size and single-center design. Future research should focus on multicenter studies with larger cohorts to validate these findings and explore the long-term outcomes of PFN. Comparative studies evaluating PFN against other fixation methods, such as dynamic hip screws, in different fracture patterns and patient populations would further enhance understanding. Additionally, investigating strategies to mitigate specific complications, such as the Z-effect, and assessing the role of emerging technologies like 3D navigation in improving surgical accuracy are important areas for future exploration.

Conflict of Interest

The authors have none to disclose and don’t particularly

advocate use of specific brands of consumables or implants.

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References

1. Fitzgerald J, Whelan M, McCarthy M. The epidemiology of hip fractures in older adults: a comprehensive review. Bone Joint J. 2019;101-B(2):245-250.
2. Sharma S, Singh A, Bansal A. Osteoporosis and fracture risk in women: a review. J Clin Densitom. 2019;22(1):1-9.
3. Yuan H, Zhang Y, Wang Z. Management of unstable intertrochanteric fractures: an overview. J Bone Joint Surg Am. 2020;102(5):415-425.
4. Huang J, Guo X, Wang Y. Biomechanical analysis of proximal femoral nail in the treatment of intertrochanteric fractures. Clin Biomech. 2020;77:105-110.
5. Jiang Y, Wang Z, Chen J. Challenges in managing unstable intertrochanteric fractures: a comprehensive review. J Orthop Surg Res. 2021;16(1):1-10.
6. Kim Y, Park Y, Lee S. Efficacy of proximal femoral nailing for intertrochanteric fractures: a meta-analysis. Injury. 2021;52(5):1294-1301.
7. Lee J, Kim H, Choi Y. Biomechanical stability of proximal femoral nailing in unstable intertrochanteric fractures. Orthop J Sports Med. 2019;7(3):2325967119825055.
8. McGowan J, McCarthy J, Sweeney A. The epidemiology of hip fractures: a review of the literature. J Clin Orthop Trauma. 2020;11(1):1-7.
9. Singh A, Sukhraj S, Bhatti F. Radiological assessment of healing in intertrochanteric fractures treated with proximal femoral nailing. J Orthop. 2021;24:50-56.
10. Simmermacher RK, Van der Werken C, Van den Bosch W. The proximal femoral nail (PFN): a new device for the treatment of intertrochanteric femur fractures. Acta Orthop Belg. 1999;65(3):298-304.
11. Hoffman R, Smith J, Jones A. Complications in the management of intertrochanteric fractures: a comprehensive review. Orthop Res Rev. 2021;13(2):45-53.
12. Kumar R, Gupta A, Singh P. Early union and functional outcomes in intertrochanteric fractures treated with proximal femoral nail. Int J Orthop. 2021;8(3):145-150.
13. Lin T, Chen Y, Huang S. Surgical techniques and outcomes of intramedullary nailing for intertrochanteric fractures. J Orthop Surg Res. 2020;15(1):112.
14. Zhang J, Liu Y, Chen K. Biomechanical and clinical outcomes of proximal femoral nailing in intertrochanteric fractures: a systematic review. Clin Biomech. 2021;83:105-112.
15. Domingo S, Yalçin N, Bozkurt K. Comparison of complications in different fixation techniques for intertrochanteric femoral fractures. J Orthop Trauma. 2001;15(2):85-90.
16. Singh H, Gupta R, Kumar P. Surgical management of intertrochanteric femur fractures: a review. J Clin Orthop Trauma. 2020;11(3):453-459.
17. Halder SC. The Gamma nail for peritrochanteric fractures. The Journal of Bone & Joint Surgery British Volume. 1992;74(3):340-344.

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