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Comparison of Functional Outcome of Femur Intertrochanteric Fracture Fixation with Hemiarthroplasty and Proximal Femoral Nail Systems

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Patients, Comparative, Hemiarthroplasty, intertrochanteric

ABSTRACT:
Intertrochanteric femur fractures represent a significant health challenge in the elderly population, associated with considerable morbidity, mortality, and socioeconomic burden. While proximal femoral nail (PFN) systems are widely accepted as the standard treatment for these fractures, hemiarthroplasty has emerged as an alternative approach, particularly for elderly patients with osteoporotic bone. Despite ongoing debate regarding the optimal management strategy, comparative studies evaluating functional outcomes between these two approaches remain limited. This study aimed to compare the functional outcomes, pain control, and rehabilitation milestones between hemiarthroplasty and PFN for the treatment of intertrochanteric femur fractures in elderly patients.

Methods:

This prospective comparative study included 50 patients with intertrochanteric femur fractures, divided equally between hemiarthroplasty (n=25) and PFN (n=25) groups. Demographic data, operative parameters, and hospital stay duration were recorded. Functional outcomes were assessed using the Harris Hip Score at 1, 3, and 6 months postoperatively. Pain was evaluated using the Visual Analog Scale (VAS) at the same intervals. Time to fully weight-bearing was documented for all patients. Statistical analysis was performed using appropriate tests with significance set at $p<0.05$.

Results:

The groups were comparable regarding age, gender distribution, comorbidities, and BMI. Operative time was significantly shorter in the PFN group (71.6±13.9 vs. 81.3±12.6 minutes, $p=0.01$), while hospital stay was similar between groups. The PFN group demonstrated significantly lower pain scores at all follow-up intervals ($p<0.05$). At 1 month, functional outcomes favored hemiarthroplasty, with all patients achieving fair Harris Hip Scores compared to poor scores in the PFN group. However, by 3 months, the PFN group showed better improvement ($p=0.02$), and at 6 months, the PFN group demonstrated superior outcomes with 56% achieving excellent scores versus 24% in the hemiarthroplasty group ($p=0.006$). Patients in the hemiarthroplasty group achieved fully weight-bearing status significantly earlier than those in the PFN group (7.28±1.79 vs. 9.32±1.95 weeks, $p<0.001$).

Conclusion:

While hemiarthroplasty offers advantages in terms of earlier weight-bearing and better initial functional scores, PFN provides superior outcomes in terms of operative efficiency, pain control, and mid-term functional recovery. The optimal treatment approach should be individualized based on patient characteristics, fracture pattern, and rehabilitation potential. For patients with good rehabilitation potential and reasonable life expectancy, PFN may offer better overall functional outcomes despite delayed weight-bearing.

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Introduction

Intertrochanteric femur fractures represent one of the most common and devastating injuries in the elderly population, with significant implications for both individual health outcomes and healthcare systems worldwide. These fractures occur in the region between the greater and lesser trochanters of the proximal femur and account for approximately 45% of all hip fractures, with an increasing incidence due to the aging global population and the prevalence of osteoporosis. [1] The global incidence of hip fractures is projected to reach 6.3 million by 2050, with intertrochanteric fractures comprising a substantial proportion of this burden. [2] These fractures are associated with high mortality rates, ranging from 15-30% in the first year following injury, while survivors often experience significant functional decline, loss of independence, and reduced quality of life. [3] Underscoring the importance of optimizing treatment approaches to enhance functional outcomes and reduce the associated morbidity and mortality.

The management of intertrochanteric fractures has evolved significantly over the past decades, transitioning from predominantly conservative approaches to surgical intervention as the standard of care. This paradigm shift has been driven by the recognition that early surgical fixation facilitates more rapid mobilization, reduces complications associated with prolonged immobilization, and improves overall functional recovery. [4] Despite this consensus regarding the necessity of surgical intervention, considerable debate persists regarding the optimal fixation method for these fractures, particularly in the elderly population with osteoporotic bone. The ideal fixation method should provide stable construct that allows early weight-bearing, minimizes the risk of fixation failure, and optimizes functional recovery while considering the patient's physiological age, bone quality, fracture pattern, and comorbidities. The two predominant surgical approaches that have emerged in contemporary practice are internal fixation using proximal femoral nail systems and replacement arthroplasty procedures, specifically hemiarthroplasty, each with distinct biomechanical principles, technical considerations, and outcome profiles that warrant comprehensive comparative analysis.

Proximal femoral nail (PFN) systems represent an evolution in the internal fixation paradigm for intertrochanteric fractures, designed to address the biomechanical limitations of earlier fixation devices. These intramedullary devices function as internal splints that share load with the femoral shaft, providing a shorter lever arm compared to extramedullary devices, thereby theoretically reducing the bending forces at the implant-bone interface. [5] The development of various intramedullary nail designs, including those with helical blades, integrated lag screws, and anatomical configurations, has aimed to enhance rotational stability, prevent cut-out complications, and accommodate diverse fracture patterns. The purported advantages of PFN systems include the potential for minimally invasive insertion through smaller incisions, reduced operative blood loss, preservation of the fracture hematoma, which may facilitate biological healing, and mechanical advantages in load-sharing that may permit earlier weight-bearing. However, challenges in achieving optimal reduction and proper implant positioning, along with complications such as cut-out, implant failure, non-union, and malunion, particularly in severely comminuted fractures or those with poor bone quality, have prompted consideration of alternative approaches for specific patient populations.

Hemiarthroplasty, involving the replacement of the femoral head and neck with a prosthesis while retaining the native acetabulum, represents an alternative surgical strategy that has gained traction for the management of unstable intertrochanteric fractures in elderly patients with poor bone quality. The fundamental principle underlying this approach is the elimination of the fracture site as a problem, circumventing concerns regarding fracture reduction, bone healing, and implant-related complications associated with internal fixation. [6] By replacing the damaged proximal femur with a prosthesis, hemiarthroplasty theoretically permits immediate full weight-bearing, eliminates the risk of fixation failure in osteoporotic bone, and potentially expedites functional recovery-considerations of paramount importance in frail elderly patients for whom prolonged immobilization or restricted weight-bearing may precipitate a cascade of adverse outcomes. Contemporary hemiarthroplasty prostheses, including both unipolar and bipolar designs, coupled with the option for cemented or uncemented fixation, provide surgeons with versatility in addressing individual patient needs. Nevertheless, concerns regarding increased surgical invasiveness, higher blood loss, potential acetabular erosion, prosthetic dislocation, and periprosthetic infection have tempered enthusiasm for the universal application of this approach.

The decision-making process regarding the optimal surgical approach for intertrochanteric fractures

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necessitates a nuanced consideration of multiple variables, including patient factors (age, functional status, bone quality, comorbidities), fracture characteristics (stability, comminution, extension), surgeon expertise, and healthcare resource availability. While both PFN systems and hemiarthroplasty have demonstrated efficacy in appropriate clinical scenarios, the comparative effectiveness of these modalities across various outcome dimensions remains incompletely characterized, with existing literature yielding heterogeneous results. Several studies have suggested potential benefits of hemiarthroplasty in unstable fracture patterns and severely osteoporotic bone, highlighting improved early weight-bearing capability, reduced reoperation rates, and enhanced early functional outcomes. [7] Conversely, other investigations have demonstrated comparable or superior results with properly executed PFN fixation, emphasizing the importance of appropriate surgical technique, optimal implant selection, and careful patient selection. [8] These divergent findings underscore the need for rigorous comparative analysis to elucidate the relative merits and limitations of each approach, particularly as they relate to functional recovery-the ultimate determinant of successful intervention from the patient perspective.

The assessment of functional outcomes following intertrochanteric fracture treatment presents methodological challenges that have contributed to the uncertainty regarding optimal management. Functional recovery encompasses multiple domains, including mobility, activities of daily living, pain, and overall quality of life, necessitating comprehensive and standardized evaluation instruments. The Harris Hip Score, Parker Mobility Score, modified Barthel Index, and health-related quality of life measures such as the SF-36 and EQ-5D have emerged as validated tools for quantifying functional outcomes in this population. [9] However, heterogeneity in outcome measures, assessment timepoints, and follow-up durations across studies has complicated direct comparisons between treatment modalities. Moreover, the interaction between treatment-related factors and patient characteristics, such as pre-fracture functional status, cognitive function, and social support, introduces complexity in interpreting observed outcomes. A methodologically robust comparison of functional outcomes between PFN systems and hemiarthroplasty must account for these confounding variables to provide clinically meaningful insights that can guide evidence-based decision-making.

Recent meta-analyses and systematic reviews have attempted to synthesize the available evidence comparing internal fixation and arthroplasty for intertrochanteric fractures, but have been limited by the heterogeneity of included studies, methodological constraints, and the evolution of implant designs and surgical techniques over time. [10]

The economic implications of treatment selection for intertrochanteric fractures cannot be overlooked in an era of healthcare resource constraints and value-based care initiatives. While the initial costs of implants and surgical procedures constitute important considerations, the comprehensive economic evaluation must encompass downstream expenditures related to complications, reoperations, rehabilitation, and long-term care requirements. Limited evidence suggests potential economic advantages of primary arthroplasty in specific patient subgroups due to reduced reoperation rates and earlier functional recovery, despite higher initial costs compared to internal fixation. However, robust cost-effectiveness analyses comparing contemporary PFN systems and hemiarthroplasty, particularly those incorporating quality-adjusted life years and accounting for indirect costs, remain scarce. Such economic evaluations, integrated with clinical outcome assessments, would provide valuable insights for healthcare policy formulation and resource allocation decisions.

The evolution of surgical approaches for intertrochanteric fractures continues unabated, with emerging technologies and techniques potentially reshaping the treatment landscape. Innovations in implant design, including augmentation techniques for enhancing fixation in osteoporotic bone, patient-specific instrumentation, and advanced biomaterials with enhanced osseointegration properties, may address current limitations of both internal fixation and arthroplasty approaches. Concurrently, the development of enhanced recovery protocols, multimodal pain management strategies, and comprehensive rehabilitation programs offers opportunities for optimizing perioperative care and functional recovery, regardless of the selected surgical approach. The integration of these evolving modalities with appropriate patient selection criteria based on comprehensive pre-operative assessment may ultimately transcend the dichotomous debate between fixation and replacement, fostering a more nuanced, patient-centered approach to intertrochanteric fracture management.

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The persistent controversy surrounding the optimal management strategy for intertrochanteric fractures, particularly in the elderly population, underscores the need for rigorous comparative investigation of functional outcomes between PFN systems and hemiarthroplasty. While both approaches have demonstrated efficacy in appropriate clinical scenarios, the relative impact on functional recovery, complication profiles, and cost-effectiveness across diverse patient populations and fracture patterns remains incompletely characterized. This knowledge gap impedes evidence-based clinical decision-making and potentially compromises patient outcomes. The present study aims to address this critical need through a comprehensive comparative analysis of functional outcomes following intertrochanteric fracture fixation with hemiarthroplasty versus PFN systems, employing validated assessment instruments, standardized evaluation timepoints, and rigorous methodological approaches. By elucidating the relative merits and limitations of these surgical modalities across multiple outcome dimensions, this investigation seeks to inform clinical practice guidelines, refine patient selection criteria, and ultimately enhance the quality of care provided to this vulnerable patient population. The findings will contribute to the ongoing evolution of intertrochanteric fracture management, potentially influencing surgical decision-making, implant design, perioperative protocols, and rehabilitation strategies to optimize functional recovery and improve quality of life for affected individuals.

Materials & Methods

Study design: Prospective comparative study

Study area: Department of Orthopedics, BLDE (DEEMED TO BE UNIVERSITY) Shri B. M. Patil's Medical College, Hospital and Research Centre, Vijayapura

Study period: Research study was conducted from January 2023 to January 2025. Below is the work plan.

Sample size: 50

t tests - Means: Difference between two independent means(two groups) Analysis: A priori: Compute required sample size Input: Tail(s)=Two Effect size d = 1.0790862 a err prob = 0.05 Power

(1-P err prob)=0.96 Allocation ratio N2/N1=1

Output: Noncentrality

parameter 5 = 3.8151458 Critical t = 2.0106348

Df = 48

Sample size group 1=25

Sample size group 2=25

Total sample size=50 Actual power = 0.9622813

Sample size:

Using G*power ver 3.1.9.4 software for sample size calculation.

The post operative mobility score fro PFN and bipolar , this study requires a total sample size of 50 (25 cases fro each group assuming equal group size .) So to achieve a power of 96% for detecting a difference in Proportions. 5 % level of significance.

Sample size: 50 (25 cases in each group)

· **Inclusion criteria**: Patients > 55 years of age, Diagnosed with a primary, unilateral, recent INTERTROCHANTERIC fracture by X-RAY/CT scan, Boyd and griffin classification fractures (type 2,3,4) and Able to give informed consent

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Exclusion criteria: Multiple fractures, Immobility or walking difficulties before fracture, Deep vein thrombosis, Infections and Failure of follow up 6 months after surgery.

Methodology

Source of Data

This prospective comparative study was conducted at the Department of Orthopedics in BLDE (Deemed to be University) Shri B.M. Patil Medical College, Hospital and Research Centre, Vijayapura. The study included patients diagnosed with intertrochanteric fractures of the femur who were admitted to the department between August 1, 2022, and January 31, 2024. All patients who met the inclusion criteria were thoroughly informed about all aspects of the study, including the treatment options, potential complications, rehabilitation protocols, and follow-up requirements. Written informed consent was obtained from all participants prior to enrollment in the study. The study protocol was approved by the Institutional Ethics Committee of BLDE University (Reference No. BLDE/IEC/2022-23/OR-05) and was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki.

The study population comprised patients aged 60 years and above who were diagnosed with intertrochanteric fractures of the femur. Patients were assigned to either the hemiarthroplasty group or the proximal femoral nail (PFN) group based on predefined clinical criteria, fracture characteristics, and surgeon's assessment. The assignment to treatment groups was not randomized but was based on clinical judgment considering factors such as age, bone quality, fracture pattern, comorbidities, and pre-fracture functional status. All surgical procedures were performed by experienced orthopedic surgeons who were proficient in both surgical techniques.

Study Design and Patient Selection

A total of 60 patients with intertrochanteric fractures who fulfilled the inclusion criteria were enrolled in the study, with 30 patients allocated to the hemiarthroplasty group and 30 patients to the PFN group. The inclusion criteria encompassed patients aged 60 years and above with acute intertrochanteric fractures (AO/OTA classification 31-A1, 31-A2, and 31-A3), ability to walk independently or with minimal assistance prior to the fracture, and medical fitness for the planned surgical intervention. Patients with pathological fractures, previous ipsilateral hip surgery, polytrauma, open fractures, neuromuscular disorders affecting gait, inability to comprehend instructions for functional assessment, and those who declined to participate were excluded from the study.

Upon admission, a detailed medical history was obtained, including demographic data, mechanism of injury, pre-fracture functional status, and coexisting medical conditions. Each patient underwent a comprehensive clinical examination, which included assessment of vital parameters, systemic examination, local examination of the affected limb for skin condition, neurovascular status, deformities, and associated injuries. The fractures were classified according to the AO/OTA classification system based on the radiographic findings. Preoperative optimization was performed for all patients, which included pain management, thromboprophylaxis, and treatment of medical comorbidities as per standard protocols.

Preoperative Evaluation and Preparation

All patients underwent a standardized preoperative evaluation protocol. Radiological assessment included anteroposterior and lateral radiographs of the affected hip, as well as a radiograph of the pelvis with both hips. In selected cases, computed tomography (CT) scanning was performed to better delineate the fracture pattern and to aid in surgical planning. Laboratory investigations included complete blood count, bleeding time, clotting time, blood glucose levels, blood urea, serum creatinine, liver function tests, serum electrolytes, urinalysis, HIV and HBsAg screening, and blood grouping and Rh typing. Preoperative cardiac evaluation included electrocardiography and echocardiography when indicated. Chest radiographs were obtained to assess cardiopulmonary status.

Anesthetic fitness was assessed by the anesthesiology team, and patients were categorized according to the American Society of Anesthesiologists (ASA) physical status classification system. Preoperative optimization was tailored to individual patient needs, including management of comorbidities, correction of anemia, and electrolyte imbalances. Thromboprophylaxis was initiated as per institutional protocol, typically involving low molecular weight heparin. Prophylactic antibiotics were administered within one hour prior to surgical incision, typically a first-generation cephalosporin, with alternative agents for patients with penicillin allergy. The affected limb was prepared, and skin traction was applied in cases with significant pain or muscle spasm.

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Surgical Procedures

All surgical procedures were performed under either spinal anesthesia or general anesthesia, depending on the anesthesiologist's assessment and patient factors. The choice between hemiarthroplasty and PFN fixation was made based on the patient's age, bone quality, fracture pattern, functional demands, and surgeon's assessment of the optimal treatment approach.

For patients in the hemiarthroplasty group, the procedure was performed through a posterolateral or direct lateral approach with the patient in the lateral decubitus position. After exposing the hip joint, the femoral head and neck were excised, taking care to preserve as much of the calcar as possible. The proximal femoral canal was prepared with graduated reamers and broaches. The prosthesis size was determined based on preoperative templating and intraoperative assessment. The stability of the prosthesis was assessed intraoperatively, and cemented or uncemented fixation was employed based on bone quality and intraoperative findings. In most cases, a modular bipolar prosthesis was utilized. The greater trochanter and calcar fragments were secured to the prosthesis and femoral shaft using stainless steel wires or non-absorbable sutures when necessary. Meticulous soft tissue repair was performed, including capsular repair and reattachment of the external rotators when the posterolateral approach was used.

For patients in the PFN group, the procedure was performed on a fracture table with the patient in the supine position. Closed reduction of the fracture was attempted under fluoroscopic guidance, with open reduction performed when satisfactory closed reduction could not be achieved. A small incision was made proximal to the greater trochanter for nail insertion. After appropriate entry point preparation, a guidewire was inserted, followed by reaming of the proximal femur. The appropriate nail size was selected based on preoperative templating and intraoperative assessment. The nail was inserted, and the position was confirmed under fluoroscopic guidance. The lag screw and anti-rotation screw or blade were inserted into the femoral head, ensuring appropriate positioning in the inferior-central portion of the femoral head on both anteroposterior and lateral views. Distal locking was performed as per the implant design and fracture characteristics. The incisions were closed in layers, and sterile dressings were applied. Intraoperative parameters including surgical time, blood loss, need for blood transfusion, and intraoperative complications were meticulously documented for both groups. Immediate postoperative radiographs were obtained to assess the position of the implant and quality of reduction.

Results

Table 1 reveals a statistically significant difference in the duration of surgery between proximal femoral nailing and hemiarthroplasty with a p-value of 0.39.

Parameters (mean±SD)	Hemiarthroplasty	PFN	p-value
Duration of surgery (minutes)	81.3±12.6	71.6±13.9	0.01
Length of hospital stay (days)	8.04±2.6	8.64±2.2	0.39

Table 1: Comparison of groups according to different parameters

Table 2, 3, 4 and 5 shows The VAS pain scores showed statistically significant differences at all time points: At 1 month: Hemiarthroplasty (4.3 ± 0.97) vs. PFN (3.49 ± 0.75), p-value 0.002, At 3 months: Hemiarthroplasty (3.16 ± 0.63) vs. PFN (1.91 ± 0.45), p-value <0.001 and At 6 months: Hemiarthroplasty (1.6 ± 0.85) vs. PFN (1.08 ± 0.59), p-value 0.02 The PFN group consistently showed lower pain scores, indicating potentially better pain management.

VAS (mean±SD)	Hemiarthroplasty	PFN	p-value
1 month	4.3±0.97	3.49±0.75	0.002
3 months	3.16±0.63	1.91±0.45	<0.001
6 months	1.6±0.85	1.08±0.59	0.02

Table 2: Comparison of groups according to VAS at different intervals

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Harris hip score	Hemiarthroplasty	PFN	p-value
Poor (<70)	-	25 (100%)	-
Fair (70-80)	25 (100%)	-	
Good (80-90)	-	-	
Excellent (90-100)	-	-	
Total	25 (100%)	25 (100%)	

Table 3: : Comparison of groups according to Harris hip score at 1 month

Harris hip score	Hemiarthroplasty	PFN	p-value
Poor (<70)	17 (68%)	9 (36%)	0.02
Fair (70-80)	8 (32%)	16 (64%)	
Good (80-90)	-	-	
Excellent (90-100)	-	-	
Total	25 (100%)	25 (100%)	

Table 4: Comparison of groups according to Harris hip score at 3 months

Harris hip score	Hemiarthroplasty	PFN	p-value
Poor (<70)	-	-	0.006
Fair (70-80)	7 (28%)	0	
Good (80-90)	12 (48%)	11 (44%)	
Excellent (90-100)	6 (24%)	14 (56%)	
Total	25 (100%)	25 (100%)	

Table 5: Comparison of groups according to Harris hip score at 6 months

Table 6 shows the comparison of both the groups return to full weightbearing where Hemiarthroplasty group was 7.28 +/- 1.79 and PFN was 9.32 +/- 1.95.

time to fully weight bearing (weeks)	Hemiarthroplasty	PFN	p-value
mean±SD	7.28±1.79	9.32±1.95	<0.001

Table 6: Comparison of groups according to time to fully weight bearing

Discussion

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Intertrochanteric femur fractures represent one of the most common and devastating injuries in the elderly population, with significant implications for morbidity, mortality, and healthcare expenditure. With the global aging population expanding rapidly, the incidence of these fractures is projected to increase substantially over the coming decades. The management of intertrochanteric fractures has evolved considerably over the years, with current treatment strategies focused not only on fracture stabilization but also on early mobilization and restoration of pre-injury functional status. While internal fixation with proximal femoral nail (PFN) systems has been widely accepted as the standard of care for most intertrochanteric fractures, hemiarthroplasty has emerged as an alternative treatment option, particularly in elderly patients with osteoporotic bone, comminuted fractures, or pre-existing joint disease. The choice between these two modalities remains controversial, with proponents on both sides highlighting various advantages and limitations. Our study aimed to compare the functional outcomes of intertrochanteric fracture fixation with hemiarthroplasty versus PFN systems, evaluating parameters such as pain scores, hip function, time to weight-bearing, and complications. This discussion will contextualize our findings within the existing literature, analyze the factors influencing outcomes with each treatment modality, and provide insights into optimizing management strategies for these challenging fractures.

The mean duration of surgery was significantly shorter in the PFN group compared to the hemiarthroplasty group (71.6±13.9 minutes vs. 81.3±12.6 minutes, p=0.01). This finding is consistent with several previous studies. Choy et al., in their retrospective analysis of 148 patients, reported a mean operative time of 85.5 minutes for hemiarthroplasty compared to 67.2 minutes for PFN, attributing the difference to the additional steps involved in hemiarthroplasty, including femoral head extraction, acetabular preparation, and prosthesis implantation. Similarly, Tang et al. found that the operative time for PFN was approximately 15-20 minutes shorter than for hemiarthroplasty in their comparative study of elderly patients with unstable intertrochanteric fractures. [11]

The shorter operative time with PFN offers several potential advantages, including reduced anesthesia exposure, decreased blood loss, and potentially lower infection risk.

However, it is important to note that operative time can be influenced by various factors, including surgeon experience, case complexity, and institutional protocols. Esen et al. emphasized that the learning curve for PFN is steeper than for hemiarthroplasty, with operative times decreasing significantly after the first 20-25 cases. [12] Experienced surgeons may achieve comparable operative times with either procedure, particularly in straightforward cases.

Despite the difference in operative time, the length of hospital stay was comparable between the hemiarthroplasty and PFN groups in our study (8.04±2.6 days vs. 8.64±2.2 days, p=0.39). This finding contrasts with some previous studies that reported shorter hospital stays with hemiarthroplasty. Shen et al., in their systematic review and meta-analysis comparing arthroplasty with internal fixation for unstable intertrochanteric fractures, found that patients in the arthroplasty group had a mean hospital stay that was 1.8 days shorter than those in the internal fixation group. [13] They attributed this difference to earlier mobilization and weight-bearing in the arthroplasty group, leading to faster rehabilitation and discharge. The comparable hospital stay in our study despite earlier weight-bearing in the hemiarthroplasty group may be due to several factors, including standardized discharge protocols, similar postoperative complications rates, or institutional factors unrelated to the surgical procedure itself.

Pain control is a critical aspect of postoperative management following hip fracture surgery, influencing patient satisfaction, rehabilitation participation, and functional outcomes. Our study employed the Visual Analog Scale (VAS) to assess pain at 1, 3, and 6 months postoperatively. The results demonstrated significantly lower pain scores in the PFN group compared to the hemiarthroplasty group at all time points: 1 month (3.49±0.75 vs. 4.3±0.97, p=0.002), 3 months (1.91±0.45 vs. 3.16±0.63, p<0.001), and 6 months (1.08±0.59 vs. 1.6±0.85, p=0.02).

These findings differ from those reported by Kayali et al., who found comparable pain scores between hemiarthroplasty and PFN groups at 6 and 12 months follow-up in their study of 84 elderly patients with unstable intertrochanteric fractures. [14] However, our results align with the observations of Ju et al., who reported consistently lower pain scores in patients treated with intramedullary nailing compared to those undergoing hemiarthroplasty, particularly in the early postoperative

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period. [15] They attributed this difference to the less invasive nature of intramedullary nailing, which preserves the natural femoral head and involves less soft tissue disruption.

Several factors may contribute to the higher pain scores observed in the hemiarthroplasty group. Firstly, hemiarthroplasty involves more extensive soft tissue dissection and greater periosteal stripping compared to PFN, potentially leading to more postoperative pain. Secondly, the presence of a prosthetic femoral head articulating with the native acetabulum may cause acetabular erosion or impingement, resulting in persistent pain. Thirdly, complications such as prosthesis loosening, subsidence, or periprosthetic fracture, although not specifically analyzed in our pain assessment, may contribute to higher pain scores in the hemiarthroplasty group.

The difference in pain scores, although statistically significant at all time points, showed a decreasing trend over time, with the smallest difference observed at 6 months (1.08±0.59 vs. 1.6±0.85). This convergence of pain scores with time has been noted in other comparative studies. Zhao et al., in their meta-analysis of 8 studies comparing arthroplasty with internal fixation for intertrochanteric fractures, found that while pain scores were higher in the arthroplasty group in the early postoperative period, they became comparable by 12 months. [13] This suggests that the initial pain advantage with PFN may diminish over time as healing progresses and rehabilitation advances.

The Harris Hip Score (HHS) is a widely validated tool for assessing hip function following hip fracture surgery, incorporating parameters such as pain, function, absence of deformity, and range of motion. Our study evaluated HHS at 1, 3, and 6 months postoperatively, revealing distinct patterns of functional recovery in the two groups.

At 1 month, all patients in the hemiarthroplasty group had fair scores (70-80), while all patients in the PFN group had poor scores (<70). This early advantage in the hemiarthroplasty group can be attributed to the immediate stability provided by the prosthesis, allowing earlier weight-bearing and mobilization. Zhou et al. reported similar findings, with significantly higher functional scores in the hemiarthroplasty group at 4 weeks postoperatively compared to the internal fixation group. [16] They emphasized that early mobilization and weight-bearing not only improve functional outcomes but also reduce complications associated with prolonged bed rest, such as pressure sores, deep vein thrombosis, and pneumonia.

By 3 months, a shift in functional outcomes became apparent, with a significantly higher proportion of patients in the PFN group achieving fair scores (64% vs. 32%, p=0.02) and fewer remaining in the poor category (36% vs. 68%). This reversal of the initial advantage suggests that the PFN group experienced more rapid functional improvement between 1 and 3 months. Fichman et al. observed a similar pattern in their prospective study comparing functional outcomes between hemiarthroplasty and intramedullary nailing for unstable intertrochanteric fractures. [17] They attributed this acceleration of recovery in the PFN group to several factors, including preservation of the natural femoral head and neck, maintenance of hip biomechanics, and potentially better proprioception due to the intact hip joint.

The most striking differences in functional outcomes were observed at 6 months, with significantly better results in the PFN group (p=0.006). While both groups showed substantial improvement from the 3-month assessment, with all patients moving out of the poor category, the PFN group had a significantly higher proportion of patients achieving excellent scores (56% vs. 24%) and none remaining in the fair category (0% vs. 28%). The proportion of patients with good scores was comparable between the two groups (44% in PFN vs. 48% in hemiarthroplasty).

The superior functional outcomes in the PFN group at 6 months may be attributed to several factors. Firstly, preservation of the natural femoral head and neck in PFN maintains the normal hip biomechanics and proprioception, potentially allowing for more physiological gait patterns once healing is complete. Secondly, the less invasive nature of PFN preserves the hip abductor mechanism, which is critical for stable gait and prevention of Trendelenburg lurch. Thirdly, the lower pain scores observed in the PFN group may facilitate more active participation in rehabilitation activities, leading to better functional recovery. Finally, the absence of prosthesis-related complications such as acetabular erosion, dislocation, or loosening may contribute to better long-term outcomes with PFN.

The time to fully weight-bearing is a critical parameter in the rehabilitation of patients with hip fractures, influencing hospital stay, functional recovery, and overall outcomes. Our study found that patients in the hemiarthroplasty group achieved fully weight-bearing status significantly

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earlier than those in the PFN group (7.28±1.79 weeks vs. 9.32±1.95 weeks, p<0.001). This finding is consistent with the fundamental difference between the two procedures: hemiarthroplasty provides immediate stability through prosthetic replacement, allowing early weight-bearing, while PFN requires fracture healing before fully weight-bearing can be safely permitted.

The ability to bear weight early after surgery is influenced by multiple factors beyond the surgical technique itself. Patient-related factors such as pre-injury functional status, cognitive function, and comorbidities play important roles. Surgeon-related factors, including confidence in the construct stability and rehabilitation protocols, also significantly impact weight-bearing instructions. Institutional factors such as the availability of physiotherapy services and discharge planning considerations further modulate this parameter.

It is worth noting that despite the earlier achievement of fully weight-bearing status in the hemiarthroplasty group, this did not translate into superior functional outcomes at 3 and 6 months follow-up, as evidenced by the Harris Hip Score results. This observation challenges the conventional wisdom that earlier weight-bearing necessarily leads to better functional outcomes. Several studies have explored this apparent paradox.

The findings of our study have several important clinical implications for the management of intertrochanteric fractures in the elderly population. The comparable demographic profile and baseline characteristics between the two groups in our study suggest that both hemiarthroplasty and PFN are viable options for a similar patient population. However, the distinct advantages and limitations of each approach warrant careful consideration in individualizing treatment decisions.

Hemiarthroplasty offers advantages in terms of shorter time to weight-bearing (7.28±1.79 vs. 9.32±1.95 weeks) and better early functional scores (at 1 month). These characteristics make it potentially beneficial for specific patient subgroups, such as those with limited life expectancy who would benefit most from rapid mobilization, patients with severe osteoporosis where fixation failure risk is high, and those with pre-existing ipsilateral hip arthritis where replacement could address both conditions simultaneously.

Conversely, PFN demonstrates advantages including shorter operative time (71.6±13.9 vs. 81.3±12.6 minutes), lower pain scores at all time points, and superior functional outcomes at 3 and 6 months. These characteristics suggest that PFN might be preferable for relatively younger patients, those with a longer life expectancy, patients with good bone quality, and those without pre-existing hip disease. Jiang et al. recommended intramedullary nailing as the primary treatment for most intertrochanteric fractures, reserving arthroplasty for selected cases with severe comminution, poor bone quality, or pre-existing hip conditions. [18]

The significantly superior functional outcomes with PFN at 6 months, as evidenced by the higher proportion of patients achieving excellent Harris Hip Scores (56% vs. 24%), challenge the traditional preference for hemiarthroplasty in certain elderly patients based solely on the advantage of early weight-bearing. Our findings suggest that for patients with reasonable life expectancy and rehabilitation potential, the long-term functional benefits of PFN may outweigh the short-term advantage of earlier weight-bearing with hemiarthroplasty.

The choice between hemiarthroplasty and PFN should also consider surgeon experience and institutional capabilities. PFN is technically more demanding and has a steeper learning curve, potentially leading to higher complication rates in less experienced hands. Additionally, the availability of appropriate implants, fluoroscopy, and specialized instrumentation may influence treatment decisions in resource-limited settings. Hemiarthroplasty, while requiring different surgical skills, may be more accessible in certain healthcare environments.

Finally, our study highlights the importance of patient-specific factors in treatment decision-making. Factors such as pre-fracture functional status, cognitive function, comorbidities, and social support significantly influence rehabilitation potential and should be carefully considered in selecting the optimal treatment approach. A comprehensive geriatric assessment, including evaluation of cognitive status, functional capacity, nutritional status, and comorbidity burden, can provide valuable information for tailoring treatment strategies to individual patients.

Study Limitations and Future Directions

While our study provides valuable insights into the comparative outcomes of hemiarthroplasty versus PFN for intertrochanteric fractures, several limitations should be acknowledged. Firstly, our sample size of 50 patients (25 in each group) is relatively small, potentially limiting the statistical power to detect differences in secondary outcomes or subgroup analyses. Future studies with larger

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sample sizes would provide more robust evidence, particularly for less common complications or outcomes.

Secondly, our follow-up period of 6 months, while sufficient to assess early and mid-term outcomes, may not capture long-term complications or functional trajectories. Complications such as acetabular erosion with hemiarthroplasty or late fixation failure with PFN typically manifest beyond the 6-month mark. Long-term follow-up studies extending to 2-5 years would provide more comprehensive information about the durability of each approach.

Thirdly, our study did not include a detailed analysis of fracture patterns or bone quality, which could significantly influence outcomes with each treatment modality. The AO/OTA classification of intertrochanteric fractures, particularly the distinction between stable and unstable patterns, has important implications for treatment selection. Future studies incorporating detailed fracture classification and bone density assessment would enhance the specificity of treatment recommendations.

Fourthly, we did not include a comprehensive cost analysis comparing the two approaches. Healthcare costs, including implant costs, operating room time, hospital stay, rehabilitation services, and management of complications, represent an important consideration in treatment selection, particularly in resource-constrained environments. Future studies incorporating cost-effectiveness analyses would provide valuable information for healthcare policy and resource allocation.

Finally, our study did not include patient-reported outcome measures (PROMs) beyond pain assessment, such as quality of life indices, satisfaction scores, or mental health outcomes. These patient-centered outcomes are increasingly recognized as important complements to traditional clinical and radiological measures. Future studies incorporating validated PROMs would provide a more holistic assessment of the impact of each treatment approach on patients' overall well-being.

Additionally, studies exploring the role of advanced rehabilitation protocols, including accelerated weight-bearing programs with PFN or modified surgical techniques to enhance construct stability, could potentially narrow the early mobilization gap between the two approaches. Finally, research on the optimization of perioperative management, including enhanced recovery protocols, pain management strategies, and complication prevention measures, could improve outcomes regardless of the surgical approach selected.

Conclusions

This comparative study of intertrochanteric femur fracture management provides valuable insights into the relative merits of hemiarthroplasty versus proximal femoral nail (PFN) systems. Our findings demonstrate that each approach offers distinct advantages in different phases of treatment and recovery. Hemiarthroplasty allows for earlier weight-bearing and better initial functional scores, advantages that can be particularly beneficial for elderly patients with limited rehabilitation potential or those who require rapid mobilization to prevent complications associated with prolonged bed rest. Conversely, PFN demonstrates superior outcomes in terms of operative efficiency, pain control, and mid-term functional recovery. The significantly shorter operative time with PFN (71.6±13.9 minutes versus 81.3±12.6 minutes) represents a meaningful advantage, potentially reducing anesthesia-related risks in elderly patients with multiple comorbidities. Furthermore, the consistently lower pain scores in the PFN group at all follow-up intervals (1, 3, and 6 months) suggest better patient comfort throughout the recovery process, which may contribute to improved rehabilitation participation and quality of life. Perhaps most notably, our study challenges the conventional wisdom that earlier weight-bearing necessarily translates to superior functional outcomes. Despite the significant advantage in time to fully weight-bearing in the hemiarthroplasty group (7.28±1.79 weeks versus 9.32±1.95 weeks), the PFN group demonstrated progressively better functional outcomes at 3 and 6 months follow-up, with 56% of PFN patients achieving excellent Harris Hip Scores at 6 months compared to only 24% in the hemiarthroplasty group. This suggests that the preservation of natural hip biomechanics and native femoral head with PFN may confer substantial functional advantages once fracture healing is complete, outweighing the initial benefit of earlier weight-bearing with hemiarthroplasty. The optimal treatment approach should be individualized based on patient characteristics, fracture pattern, surgeon expertise, and institutional resources. Hemiarthroplasty may be preferable for patients with severely osteoporotic bone, comminuted fractures, pre-existing hip disease, or very limited life expectancy. PFN represents an excellent option for relatively younger patients within the elderly population, those with adequate bone quality, and those with good rehabilitation potential

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who would benefit from the superior mid-term functional outcomes observed with this approach.

In conclusion, while both hemiarthroplasty and PFN represent viable treatment options for intertrochanteric femur fractures in the elderly, our study suggests that PFN provides better overall outcomes in terms of pain control and functional recovery at 6 months, despite the delayed weight-bearing. These findings contribute to the growing body of evidence guiding treatment decisions for these challenging fractures, ultimately aiming to optimize functional recovery and quality of life for elderly patients.

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