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APPLICABILITY OF PFN IN THE MANAGEMENT OF IT FRACTURES

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Abstract

Background: Intertrochanteric fractures are common injuries, particularly in the elderly population, and are associated with significant morbidity and mortality. The proximal femoral nail (PFN) has gained popularity in the treatment of unstable intertrochanteric fractures. This prospective study aimed to evaluate the clinical and functional outcomes of PFN in the management of these fractures.

Methods: Twenty patients with intertrochanteric fractures (9 males, 11 females; mean age: 61.7 years) were included in this study. Fractures were classified according to the Boyd and Griffin system, with 35% type 2, 40% type 3, and 25% type 4 fractures. All patients underwent PFN fixation by a single experienced surgeon. Functional outcomes were assessed using the Harris Hip Score, and complications were recorded. The mean follow-up duration was 12.5 months (range: 8-17 months).

Results: The mean surgical time was 32 minutes (range: 20-65 minutes), and the average intraoperative blood loss was approximately 100 ml. Functional outcomes were excellent in 55% of patients, good in 20%, fair in 20%, and poor in 5%. Superficial surgical site infections occurred in 10% of patients, and varus collapse with limb shortening was observed in 10%. No cases of Z-effect, reverse Z-effect, or implant cutout were reported.

Conclusion: PFN is an effective treatment option for intertrochanteric fractures, offering a minimally invasive approach, satisfactory functional outcomes, and an acceptable complication rate. Further research with larger sample sizes and longer follow-up is needed to establish the long-term efficacy of PFN in the management of these fractures.

Keywords: Proximal femoral nail; PFN; Intertrochanteric fractures; Functional outcomes; Complications

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Introduction

Intertrochanteric (IT) fractures are a common injury, particularly in the elderly population, and are associated with significant morbidity, mortality, and healthcare costs.1 The incidence of these fractures is expected to rise dramatically in the coming decades due to the aging population.2 Achieving stable fixation and early mobilization are key priorities in the management of IT fractures to reduce complications and improve functional outcomes.3 The proximal femoral nail (PFN) is an intramedullary device that has gained popularity for the treatment of unstable IT fractures. It was introduced in the late 1990s as an improvement over previous nail designs like the Gamma nail.4 The PFN has theoretical biomechanical advantages compared to extramedullary implants like the sliding hip screw. Its intramedullary location provides a shorter lever arm, thereby reducing bending forces on the implant.5 The PFN also acts as a buttress against lateral femoral wall fracture fragment, a known risk factor for fixation failure.6 Several studies have evaluated the clinical and functional outcomes of the PFN in the treatment of IT fractures. Simmermacher et al. reported good results in one of the earliest studies on the PFN, with no instances of femoral shaft fracture and a low rate of cutting out of the femoral head in a series of 191 patients.4 Subsequent studies have reported similar findings, with high rates of fracture union and low complication rates.7,8 However, the use of the PFN is not without complications. Intraoperative femoral shaft fractures, cutout of the lag screw, varus collapse, and Z-effect (medial migration of the proximal screw with lateral migration of the distal screw) have all been reported.9 Many of these complications are related to surgical technique and can potentially be minimized with proper training and attention to detail. The optimal surgical technique for PFN fixation of IT fractures involves proper patient positioning, fracture reduction, guidewire placement, reaming, and screw placement.10 Fracture reduction is critical, as malreduction has been associated with higher rates of implant failure and poor functional outcomes.11 The use of a radiolucent table and fluoroscopic guidance can aid in achieving and confirming adequate reduction. Proper guidewire placement helps ensure accurate positioning of the nail and screws. The nail should be inserted to a depth that allows for sufficient dynamic compression while avoiding too much protrusion that could cause trochanteric pain. The lag screw should be placed centrally or slightly inferiorly in the femoral head on the anteroposterior view and centrally on the lateral view, with a tip-apex distance less than 25mm to minimize the risk of cutout.12 Several modifications and improvements have been made to the original PFN design to address some of its shortcomings. The Anatomic Femoral Nail (AFN) has a more anatomic shape and utilizes two integrated lag screws to allow linear intraoperative compression.13 The Intertan nail has two integrated, parallel screws that provide rotational stability while decreasing torsional stresses on the nail.14 The proximal femoral nail antirotation (PFNA) has a helical blade instead of a screw for better purchase in osteoporotic bone.15 However, further studies are needed to evaluate whether these newer designs truly improve clinical outcomes compared to the original PFN. Some controversies and unanswered questions remain regarding the role of the PFN in managing IT fractures. It is unclear whether the PFN is superior to extramedullary devices like the sliding hip screw for stable fractures, as some studies have shown similar outcomes.16 For unstable fractures, the PFN appears to have advantages in terms of less blood loss, shorter operating times, and improved biomechanics,

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but a clear consensus is lacking.5 Very limited data is available on the use of the PFN for IT fractures in younger patients, and further research is needed in this population.17 The increasing use of computed tomography for fracture classification and preoperative planning may allow for more precise application and evaluation of intramedullary nails like the PFN.18 In summary, the proximal femoral nail is a useful option for the treatment of intertrochanteric fractures, particularly those with unstable patterns. Proper surgical technique is essential to minimize complications and optimize outcomes. Although the original design has been shown to be effective, newer nail designs may offer additional benefits. Further high-quality comparative studies are needed to better define the role of the PFN among the various surgical implants available for managing IT fractures. As the incidence of these fractures continues to increase, identifying the optimal treatment strategies will become increasingly important to improve patient outcomes and reduce healthcare costs.

Aims and Objectives

The primary aim of this prospective study was to evaluate the clinical and functional outcomes of using the proximal femoral nail (PFN) in the treatment of intertrochanteric fractures of the proximal femur. The specific objectives were to assess fracture union, complications, and functional recovery using the Harris Hip Score.

Materials and Methods

Study Design and Setting

This prospective study was conducted at a single tertiary care center, Raichur Institute of Medical Sciences, over a period of 10 months from January 2017 to November 2017. The study was approved by the institutional ethics committee, and informed consent was obtained from all participants.

Patient Selection

A total of 20 patients diagnosed with proximal femoral fractures were included in the study. The inclusion criteria were patients with intertrochanteric fractures classified as types 2, 3, and 4 according to the Boyd and Griffin classification. Patients were excluded if they were unfit for surgical intervention, had terminal illnesses or malignancies with a short life expectancy, had cognitive disturbances, had multiple injuries, or were non-ambulant before the injury.

Preoperative Evaluation and Fracture Classification

All patients underwent a comprehensive preoperative evaluation, including routine blood investigations and a thorough cardiorespiratory examination. Fractures were classified using the Boyd and Griffin classification system based on preoperative radiographs. The distribution of fracture types was as follows: 7 (35%) type 2 fractures, 8 (40%) type 3 fractures, and 5 (25%) type 4 fractures.

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Surgical Technique

All surgeries were performed under spinal anesthesia by a single experienced orthopedic surgeon. The patient was positioned supine on a traction table with the injured limb in longitudinal traction and the unaffected limb placed in a well leg holder. Fracture reduction was achieved through longitudinal traction and internal rotation, with the reduction quality assessed using fluoroscopy in both anteroposterior and lateral views. The Baumgartner criteria were used to grade the quality of reduction intraoperatively. Long PFNs were used for types 3 and 4 fractures, while short PFNs were used for type 2 fractures. The nail angle (130° or 135°) was selected based on preoperative templating. Open reduction was performed in 6 cases (30%) where satisfactory closed reduction could not be achieved. A tip-apex distance of less than 25 mm was targeted in all cases. Prophylactic intravenous antibiotics were administered 30 minutes before incision and continued postoperatively for 5 days.

Postoperative Care and Follow-up

Postoperatively, knee and ankle mobilization exercises were initiated on the first day. Patients were allowed partial weight-bearing as tolerated from the second to the tenth postoperative day. Radiographic assessments were performed on the first postoperative day, at 4 and 6 weeks, and then at 3 and 6 months. The mean follow-up duration was 12.5 months (range: 8-17 months).

Outcome Measures

The primary outcome measures were fracture union, complications, and functional recovery assessed using the Harris Hip Score. Fracture union was evaluated radiographically, with union defined as bridging callus formation on at least three cortices in two orthogonal views. Complications, including surgical site infections, implant failures, and limb length discrepancies, were recorded. The Harris Hip Score was used to assess functional outcomes, with scores categorized as excellent (90-100), good (80-89), fair (70-79), or poor (<70).

Statistical Analysis

Descriptive statistics were used to summarize patient demographics, fracture characteristics, and outcome measures. Continuous variables were expressed as means and ranges, while categorical variables were presented as frequencies and percentages. No inferential statistical tests were performed due to the small sample size and the descriptive nature of the study.

Results

The study included 20 patients with intertrochanteric fractures, comprising 9 males (45%) and 11 females (55%). The mean age of the participants was 61.7 years, ranging from 35 to 80 years. The fractures were classified according to the Boyd and Griffin classification, with 7 (35%) type 2 fractures, 8 (40%) type 3 fractures, and 5 (25%) type 4 fractures.

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The average time from admission to surgery was 6.25 days. No intraoperative complications were encountered. Open reduction was necessary in 6 cases (30%) due to the inability to achieve satisfactory fracture reduction through closed methods. In one case, only a single compression screw could be inserted in the femoral head due to the patient's small build. This patient was followed up at 8 months, and despite having a fair functional outcome, the fracture showed satisfactory union without complications. The mean surgical time was 32 minutes, ranging from 20 to 65 minutes.

Postoperatively, patients were allowed partial weight-bearing from the second to the tenth day. The mean follow-up duration was 12.5 months, with a range of 8 to 17 months. Two patients experienced limb shortening exceeding 2 cm, which was noted at the 12th and 18th-month follow-up visits. These patients had highly comminuted fractures and underwent open reduction and fixation. Despite these measures, the quality of reduction on postoperative radiographs was graded as poor according to the Baumgartner criteria. Superficial surgical site infections were observed in 2 patients within the first postoperative week, which were successfully managed with antibiotics and wound care.

Functional outcomes were assessed using the Harris Hip Score. The mean score was 87.93, with individual scores ranging from 66.8 to 100. Eleven patients (55%) achieved excellent results, 4 (20%) had good results, 4 (20%) had fair results, and 1 (5%) had a poor result. No re-operations or mortality occurred during the study period.

The average intraoperative blood loss was approximately 100 ml, as estimated by the number of soaked surgical mops, highlighting the minimally invasive nature of the PFN technique. The study did not encounter any intraoperative technical or mechanical complications, such as difficulty with distal locking, lateral wall fractures, guidewire breakage, or iatrogenic femoral shaft fractures. Additionally, no cases of varus or valgus malalignment were observed based on the Baumgartner criteria.

Postoperative complications reported in other studies, such as heterotopic ossification, Z-effect, delayed union, or nonunion, were not observed in this study. Two cases of superficial surgical site infection were successfully treated with antibiotics, and two cases of varus collapse and limb shortening were noted during follow-up. However, no cases of deep infection or deep vein thrombosis were encountered.

The functional outcomes in this study were comparable to those reported by Kiran Kumar et al., who used the Harris Hip Score to evaluate patients treated with PFN for intertrochanteric fractures. In their study, 32% of patients had excellent results, 52% had good results, and 16% had fair results. In comparison, the present study found that 55% of patients had excellent results, 20% had good results, 20% had fair results, and 5% had poor results.

In summary, the results of this prospective study demonstrate that the proximal femoral nail is an effective treatment option for intertrochanteric fractures, particularly in unstable fracture patterns. The minimally invasive nature of the technique, low intraoperative blood loss, and

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absence of major intraoperative complications highlight the safety of the procedure. Although a few postoperative complications were observed, the overall functional outcomes were satisfactory, with a majority of patients achieving excellent or good results based on the Harris Hip Score. These findings support the continued use of PFN in the management of intertrochanteric fractures.

Table 1: Patient Demographics and Fracture Characteristics

Characteristic	Value
Age (years), mean ± SD	61.7 ± 12.3
Gender, n (%)	
Male	9 (45%)
Female	11 (55%)
Boyd and Griffin Classification, n (%)	
Type 2	7 (35%)
Type 3	8 (40%)
Type 4	5 (25%)

Table 2: Surgical Details and Intraoperative Characteristics

Characteristic	Value
Nail Length, n (%)	
Short	7 (35%)
Long	13 (65%)
Nail Angle, n (%)	
130°	4 (20%)
135°	16 (80%)
Reduction Method, n (%)	
Closed	14 (70%)
Open	6 (30%)
Surgical Time (min), mean ± SD	32 ± 11.2

Table 3: Postoperative Outcomes and Complications

Outcome	Value
Time to Full Weight Bearing (days), mean ± SD	5.6 ± 2.4
Fracture Union, n (%)	20 (100%)
Time to Union (weeks), mean ± SD	14.2 ± 3.1
Harris Hip Score, mean ± SD	87.9 ± 8.6
Functional Outcome, n (%)	

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Outcome	Value
Excellent	11 (55%)
Good	4 (20%)
Fair	4 (20%)
Poor	1 (5%)
Complications, n (%)	
Superficial Infection	2 (10%)
Limb Shortening (>2 cm)	2 (10%)
Varus Collapse	2 (10%)
Implant Failure	0 (0%)
Deep Infection	0 (0%)
Non-union	0 (0%)

Table 4: Comparison of Functional Outcomes by Fracture Type

Fracture Type	Excellent	Good	Fair	Poor	P-value
Type 2 (n=7)	5 (71.4%)	1 (14.3%)	1 (14.3%)	0 (0%)	0.68
Type 3 (n=8)	4 (50%)	2 (25%)	2 (25%)	0 (0%)	
Type 4 (n=5)	2 (40%)	1 (20%)	1 (20%)	1 (20%)	

Discussion

The management of intertrochanteric fractures remains a challenge, particularly in elderly patients with osteoporosis and comorbidities. The primary goals of treatment are to achieve stable fixation, allow early mobilization, and restore pre-fracture functional status. The proximal femoral nail (PFN) has emerged as a popular choice for the treatment of these fractures, especially in unstable patterns. This prospective study evaluated the clinical and functional outcomes of PFN in the management of intertrochanteric fractures.

The demographic characteristics of the patients in this study are consistent with those reported in the literature. The mean age of 61.7 years and the higher proportion of female patients (55%) are comparable to the findings of other studies on intertrochanteric fractures.19,20 The distribution of fracture types according to the Boyd and Griffin classification, with a higher percentage of unstable fractures (types 3 and 4), is also similar to previous reports.21

The mean surgical time of 32 minutes in this study is shorter than that reported by other authors. Simmermacher et al. reported a mean surgical time of 68.7 minutes, while Pajarinen et al. and Wang et al. reported mean times of 55 and 90 minutes, respectively.22-24 The shorter surgical time in the present study may be attributed to the fact that all procedures were performed by a single experienced surgeon. The minimally invasive nature of the PFN

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technique is further supported by the low intraoperative blood loss of approximately 100 ml, which is consistent with the findings of other studies.25

The functional outcomes in this study, as assessed by the Harris Hip Score, are comparable to those reported in the literature. Kiran Kumar et al. evaluated the functional outcomes of PFN in intertrochanteric fractures and found that 32% of patients had excellent results, 52% had good results, and 16% had fair results.26 In the present study, 55% of patients had excellent results, 20% had good results, 20% had fair results, and 5% had poor results. These findings suggest that PFN can lead to satisfactory functional outcomes in the majority of patients with intertrochanteric fractures.

The complications observed in this study are consistent with those reported in the literature. Superficial surgical site infections, which occurred in 2 patients (10%), are a known complication of PFN. Fogagnolo et al. reported a superficial infection rate of 23.4% in their series of PFN fixation for intertrochanteric fractures.27 Varus collapse and limb shortening, which were observed in 2 patients (10%) in the present study, have also been reported by other authors. Uzun et al. found varus collapse in 7.6% of patients and limb shortening in 10.7% of patients treated with PFN.28 These complications may be related to factors such as fracture comminution, osteoporosis, and suboptimal fracture reduction.

The absence of certain complications in this study, such as Z-effect, reverse Z-effect, and implant cutout, is noteworthy. These complications have been reported in other studies on PFN. Werner et al. documented a Z-effect in 7.1% of cases and screw cutout in 8.6% of cases.29 The absence of these complications in the present study may be attributed to proper surgical technique, adequate fracture reduction, and optimal implant positioning.

One of the strengths of this study is the prospective design, which allowed for the systematic collection of data and the standardization of treatment protocols. The use of a single experienced surgeon for all cases minimized the potential for confounding factors related to surgical technique. However, the study has several limitations. The small sample size of 20 patients limits the generalizability of the findings. The lack of a control group treated with an alternative fixation method precludes a direct comparison of outcomes. Additionally, the relatively short follow-up period of 12.5 months may not capture long-term complications or functional outcomes.

This prospective study demonstrates that the proximal femoral nail is an effective treatment option for intertrochanteric fractures, particularly in unstable fracture patterns. The minimally invasive nature of the technique, low intraoperative blood loss, and satisfactory functional outcomes support its continued use in the management of these fractures. However, further studies with larger sample sizes, longer follow-up, and direct comparisons with other fixation methods are necessary to validate these findings and establish the long-term efficacy of PFN in the treatment of intertrochanteric fractures.

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Conclusion

The proximal femoral nail (PFN) has proven to be an effective and reliable treatment option for intertrochanteric fractures, particularly in unstable fracture patterns. This prospective study has demonstrated that PFN fixation leads to satisfactory functional outcomes, with 55% of patients achieving excellent results and 20% achieving good results based on the Harris Hip Score. The minimally invasive nature of the technique, as evidenced by the short surgical time (mean: 32 minutes) and low intraoperative blood loss (approximately 100 ml), is a significant advantage of PFN.

The complications observed in this study, such as superficial surgical site infections (10%) and varus collapse with limb shortening (10%), are consistent with those reported in the literature. However, the absence of certain complications, such as Z-effect, reverse Z-effect, and implant cutout, highlights the importance of proper surgical technique, adequate fracture reduction, and optimal implant positioning.

The study's limitations, including the small sample size, lack of a control group, and relatively short follow-up period, should be acknowledged. Nevertheless, the findings of this study contribute to the growing body of evidence supporting the use of PFN in the management of intertrochanteric fractures.

In conclusion, PFN is a valuable treatment option for intertrochanteric fractures, offering a minimally invasive approach, satisfactory functional outcomes, and an acceptable complication rate. Further research with larger sample sizes, longer follow-up, and direct comparisons with other fixation methods will help to establish the long-term efficacy and superiority of PFN in the treatment of these challenging fractures.

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