

Clinical and Functional Outcomes of Proximal Femoral Nail Anti-Rotation in Extracapsular Femoral Fractures: A Prospective Cohort Study

Sunil Kumar Dhanger¹, Sanju², Abhishek Bhardwaj³, Mohit Jataywal⁴, Anil⁵

¹Assistant Professor, Department of Orthopaedics, Pt. B.D. Sharma PGIMS, Rohtak, Haryana, India

²Senior Resident, Department of Orthopaedics, Pt. B.D. Sharma PGIMS, Rohtak, Haryana, India

^{3,4,5}Postgraduate, Department of Orthopaedics, Pt. B.D. Sharma PGIMS, Rohtak, Haryana, India

Received: 25-06-2026 / Revised: 23-07-2026 / Accepted: 26-08-2026

Corresponding Author: Dr. Abhishek Bhardwaj

Conflict of interest: Nil

Abstract:

Introduction: Extracapsular fractures of the proximal femur are frequent injuries in older adults and are associated with substantial morbidity, loss of independence, and increased mortality. Early surgical stabilization is essential to restore limb alignment, permit mobilization, and reduce complications of prolonged bed rest. Proximal Femoral Nail Anti-Rotation (PFNA) is an intramedullary implant designed to provide stable fixation, particularly in unstable and osteoporotic fracture patterns.

Materials and Methods: A prospective cohort study was conducted on 72 patients with extracapsular proximal femoral fractures treated with PFNA at the Department of Orthopaedics, Pt. B.D. Sharma PGIMS, Rohtak, between February 2023 and January 2025. Fractures were classified using the AO/OTA system. Surgical outcomes included operative time, blood loss, and hospital stay. Radiological outcomes included time to union, delayed union, and non-union. Functional recovery was assessed using the Harris Hip Score at six months.

Results: The mean age was 69.8 years. Most injuries followed low-energy falls. The average operative time was 68 minutes, and mean blood loss was 165 ml. Fracture union was achieved in 66 of 72 patients (91.7%) by six months, with an average union time of 14.8 weeks. Complications included cut-out (4 cases, 5.6%), superficial infection (3 cases, 4.2%), deep infection (1 case, 1.4%), and implant failure (1 case, 1.4%). The mean Harris Hip Score at six months was 81.4, indicating good functional recovery.

Discussion: PFNA provided stable fixation and satisfactory early outcomes in this series. The helical blade design may improve purchase in osteoporotic bone and reduce rotational instability. Unstable fractures showed slower union and somewhat lower functional scores than stable fractures. Larger comparative studies are needed to determine whether PFNA offers clinically meaningful advantages over other fixation methods.

Keywords: Proximal Femoral Nail Anti-Rotation, extracapsular femoral fracture, intertrochanteric fracture, osteoporosis, intramedullary fixation, Harris Hip Score.

DOI: 10.25258/ijpqa.17.9.38

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.

Introduction

Extracapsular fractures of the proximal femur, including intertrochanteric and subtrochanteric fractures, represent a major burden in orthopaedic trauma. These injuries occur frequently in older adults with reduced bone density, although high-energy trauma can produce similar fractures in younger patients. Pain, immobility, and medical comorbidities may combine to produce prolonged hospitalization, loss of independence, and increased mortality. [1,2,3,4]

Surgical stabilization is the standard of care for most displaced extracapsular fractures. The goals of treatment are to restore alignment, provide stable fixation, allow early mobilization, and minimize complications such as malunion, non-union, and implant failure. Various fixation devices have been

used over time, including extramedullary implants such as the Dynamic Hip Screw and intramedullary nails such as the Gamma Nail and Proximal Femoral Nail Anti-Rotation. [5,6,7,8,9]

PFNA has gained attention because of its helical blade design, which is intended to compact cancellous bone and improve rotational stability. This may be particularly useful in osteoporotic bone, where conventional screw fixation may be weaker [10,11,12]. However, robust clinical data from diverse patient populations remain important to confirm the benefits and limitations of this implant.

The present study evaluated the clinical, radiological, and functional outcomes of PFNA in patients with extracapsular proximal femoral

fractures. A secondary objective was to compare outcomes between stable and unstable fracture patterns.

Materials and Methods

Study design and setting: A prospective cohort study was carried out in the Department of Orthopaedics at Pt. B.D. Sharma Post Graduate Institute of Medical Sciences, Rohtak, and Haryana. Patients were recruited between February 2023 and January 2025. The study included individuals with closed extracapsular fractures of the proximal femur who underwent fixation using PFNA.

Patient selection: Patients were eligible if they were at least 18 years old and had a closed intertrochanteric or subtrochanteric fracture classified within the relevant AO/OTA categories [13,20]. The study included fracture patterns ranging from relatively stable injuries to unstable and comminuted configurations.

Patients with open fractures, pathological fractures, or serious medical conditions that prevented operative treatment were excluded. The study population included both older individuals with low-energy osteoporotic fractures and younger patients who sustained high-energy trauma.

Surgical technique: All procedures were performed by experienced orthopaedic surgeons using a standard PFNA technique. Patients were placed supine on a fracture table. Closed reduction was attempted under fluoroscopic guidance, with care taken to restore the alignment of the proximal femur and avoid excessive varus positioning. After achieving an acceptable reduction, the nail was inserted through the proximal femur. The helical blade was placed in the femoral head with the objective of obtaining firm fixation while maintaining an appropriate tip-apex distance. Distal locking was performed according to the fracture pattern and implant requirements. Intraoperative imaging was used to confirm reduction, nail

position, blade placement, and the absence of joint penetration. Postoperatively, patients were encouraged to begin rehabilitation as early as their medical and fracture condition allowed. Initially, partial weight-bearing was advised in appropriate cases. Progression toward full weight-bearing depended on fracture stability, radiological evidence of healing, muscle control, pain, and the treating surgeon's assessment.

Follow-up and outcome measures: Patients were reviewed at six weeks, 12 weeks, and six months. Follow-up radiographs were used to evaluate alignment, callus formation, implant position, and fracture union. The study recorded:

- Operative duration.
- Estimated intraoperative blood loss.
- Duration of hospital admission.
- Time required for radiological union.
- Delayed union and non-union.
- Implant-related and wound-related complications.
- Mortality during the six-month follow-up period.
- Functional recovery using the Harris Hip Score.

The Harris Hip Score was used to assess pain, walking ability, daily activities, range of movement, and deformity. Scores from 90 to 100 were considered excellent, 80 to 89 good, 70 to 79 fair, and below 70 poor. [13] Data were analysed using SPSS version 26.0. Continuous variables were presented as means and standard deviations, while categorical variables were expressed as numbers and percentages. A p-value below 0.05 was considered statistically significant.

Results

Patient characteristics: The study included 72 patients. The mean age was 69.8 years, with a standard deviation of 11.1 years. Thirty-eight patients were men and 34 were women, giving a male-to-female ratio of approximately 1.1:1.

Table 1: Demographic Characteristics of Patients (N=72)

Characteristic	Value
Mean Age (years)	69.8±11.1
Age Distribution	
<60 years	20
60-80 years	38
>80 years	14
Gender (Male: Female)	38:34(1.1:1)
Side Affected (Right: Left)	41:31(1.3:1)
Mechanism of Injury	
Low-energy fall	58
High-energy trauma	14
Mean bone mineral density(T-score)	-2.9

Most patients were between 60 and 80 years of age. Twenty patients were younger than 60 years, 38

were aged 60–80 years, and 14 were older than 80 years. The right femur was affected in 41 cases and the left in 31 cases.

A low-energy fall was the mechanism of injury in 58 patients, accounting for 80.6% of the cohort.

The remaining 14 patients sustained high-energy trauma. The average bone mineral density T-score

was -2.9 , suggesting that reduced bone strength was an important factor in many cases.

Fracture pattern: According to the AO/OTA classification, 24 patients had 31-A1 fractures, 30 had 31-A2 fractures, and 12 had 31-A3 fractures. Six patients had fractures categorized as 32-A/B. Thus, unstable fracture patterns represented a substantial proportion of the study population.

Table 2: Fracture Classification (AO/OTA)

Fracture Type	Number	Percentage
31-A1	24	33.33
31-A2	30	41.67
31-A3	12	16.67
32-A/B	6	8.33

Operative outcomes: The mean operative time was 68 minutes, with individual procedures ranging from 48 to 98 minutes. Average blood loss was 165 mL, with a recorded range of 90–270 mL. Mean fluoroscopy exposure time was 52 seconds. The average hospital stay was 6.5 days. These findings

suggest that PFNA can be inserted through a relatively efficient surgical procedure, although operative duration may vary according to fracture complexity, reduction difficulty, patient anatomy, and the quality of the available imaging.

Table 3: Surgical Parameters

Parameter	Mean $\pm$ SD	Range
Operative Time (minutes)	68 $\pm$ 14	48-98
Blood Loss (mL)	165 $\pm$ 30	90-270
Fluoroscopy Time (seconds)	52 $\pm$ 12	33-86
Hospital Stay (days)	6.5 $\pm$ 2.2	3-11

Radiological healing: By the six-month assessment, 66 patients had achieved fracture union. This represented a union rate of 91.7%. The average time to union was 14.8 weeks. Four patients experienced delayed union beyond 20 weeks, while two patients developed non-union

during the observation period. The average tip-apex distance was 23.1 mm. In 61 patients, or 84.7% of the cohort, the tip-apex distance was below 25 mm, which is generally considered a desirable radiological target for reducing the risk of femoral-head fixation failure.

Table 4: Radiological Outcomes

Outcome Measure	Result
Mean Time to Union (weeks)	14.8 $\pm$ 2.7
Union Rate at 6 months	66(91.67)
Delayed Union (> 20 weeks)	4(5.55)
Non-union	2(2.76)
Tip-Apex Distance (mm)	23.1 $\pm$ 3.5
Acceptable TAD (< 25 mm)	61 (84.7)



Figure 1: Preoperative Xray



Figure 2: Post op Xray at 6 month



Figure 3: Preoperative Xray

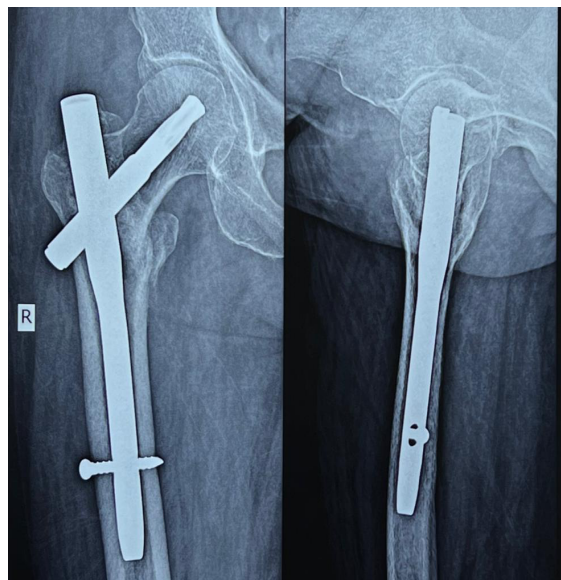


Figure 4: Post op Xray at 6 month

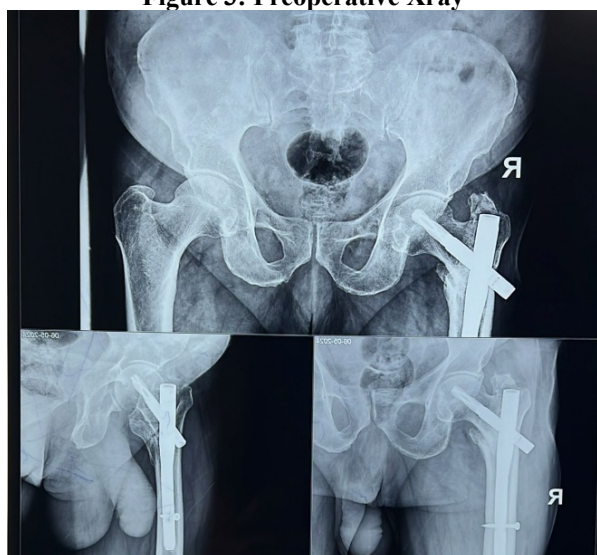


Figure 5: Implant failure



Figure 6: Cut Out of Helical blade

Complications: Four patients developed cut-out of the helical blade, corresponding to 5.6% of the study group. Superficial infection occurred in three patients, while one patient developed a deep infection. Implant failure was reported in one case. No periprosthetic fracture was recorded. Three patients died during the six-month follow-up

period, giving a mortality rate of 4.2%. Because the study was not designed to determine the precise cause of death, this outcome should be interpreted in the context of the advanced age and medical vulnerability commonly associated with hip fractures.

Table 5: Complications

Complication	Number	Percentage
Cut-out	4	5.56
Superficial Infection	3	4.16
Deep Infection	1	0.14
Implant Failure	1	0.14
Periprosthetic Fracture	0	0
Mortality(6-month)	3	4.16

Functional recovery: Functional scores improved progressively during follow-up. At six weeks, the

mean Harris Hip Score was 61.8. At 12 weeks, it increased to 73.9. By six months, the mean score

had reached 81.4. At the six-month evaluation, 11 patients achieved an excellent score, 29 recorded a good score, 20 had a fair result, and 12 had a poor

result. Overall, most patients achieved good or acceptable functional recovery, although not every patient returned to pre-injury mobility.

Table 6: Functional Outcomes (Harris Hip Score)

Time Point	Mean Score $\pm$ SD	Excellent (90-100)	Good (80-89)	Fair (70-79)	Poor (<70)
6 Weeks	61.8	0	6	17	49
12 Weeks	73.9	3	13	34	22
6 Months	81.4	11	29	20	12

Stable and unstable fractures: Patients with stable A1 fractures demonstrated faster healing and better functional scores than those with unstable fracture configurations. The average union time was 13.1 weeks in the stable group compared with 15.6 weeks in the unstable group. This difference was statistically significant (p value -0.007). The mean Harris Hip Score at six months was 85.4 for

stable fractures and 79.6 for unstable fractures, also showing a statistically significant difference (p value -0.002). Cut-out occurred only in the unstable group, where four cases were recorded.

The overall complication rate was higher among unstable fractures, although the difference did not reach statistical significance.

Table 7: Subgroup analysis by fracture stability

Parameter	Stable(A1) (N=24)	Unstable (A2A3,32A/B) (N=48)	P Value
Union rate (Weeks)	13.1 $\pm$ 2.6	15.6 $\pm$ 2.9	0.007
Cut-out rate	0	4	0.29
Mean HHS at 6 Month	85.4 $\pm$ 6.2	79.6 $\pm$ 8.9	0.002
Complication rate	4	5	0.49

Discussion

The findings indicate that PFNA can provide satisfactory fixation for a wide range of extracapsular proximal femoral fractures. In this series, more than nine out of ten fractures united within six months, and the average functional score was within the good-outcome range. These results are clinically important because successful fixation allows patients to begin rehabilitation earlier and may reduce the consequences of prolonged immobilization. The helical blade is a central feature of the PFNA system. In osteoporotic bone, conventional screw fixation may be weakened by poor cancellous bone quality. The helical blade is intended to compact the surrounding bone rather than remove a large volume of it during insertion. This may improve the purchase of the implant and provide additional resistance to rotation. [10,11,12]

However, cut-out remains a clinically relevant complication. It may occur when the femoral-head element migrates through the superior part of the femoral head, particularly when reduction is poor, the blade is positioned incorrectly, or the fracture collapses into varus. In the current series, the cut-out rate was 5.6%. The relatively high proportion of patients with a tip-apex distance below 25 mm may have contributed to the limited number of these failures. [14,15] The operative results were also encouraging. The average operative time of 68 minutes and blood loss of 165 mL suggest that PFNA can be used efficiently in an experienced trauma unit [16,17]. Intramedullary fixation may be advantageous because the implant is positioned close to the femoral axis, which can reduce the

bending moment acting on the construct. This is particularly relevant in unstable patterns with medial or posterolateral cortical disruption. [18,19]

The difference between stable and unstable fractures deserves attention. Patients with unstable fractures took longer to unite and achieved lower functional scores [18,19]. This is not unexpected. Unstable fractures are often more comminuted, have poorer medial support, and are more vulnerable to collapse and limb shortening. They may also require greater surgical effort to achieve and maintain reduction. [13]

These findings highlight that the implant alone does not determine the outcome. PFNA should be regarded as one component of a complete treatment strategy. Accurate preoperative classification, appropriate reduction, correct blade placement, restoration of the medial column where possible, and individualized postoperative weight-bearing are equally important.

The functional results demonstrate gradual improvement rather than immediate recovery. The average Harris Hip Score was only 61.8 at six weeks but rose to 73.9 by 12 weeks and 81.4 at six months. This pattern reflects the time required for fracture healing, muscle strengthening, confidence with walking, and recovery from the physiological stress of surgery.

Despite the favourable results, several limitations must be considered. First, the study was conducted at a single institution and included 72 patients. Second, there was no control group treated with a Dynamic Hip Screw, Gamma Nail, or another

intramedullary device. Therefore, it is not possible to conclude that PFNA is superior to all alternative implants. [20,21,22,23] Third, the follow-up period was limited to six months. Longer follow-up would be useful for evaluating persistent pain, limb-length discrepancy, late implant problems, return to independent walking, and quality of life. Fourth, the study did not provide detailed information regarding rehabilitation compliance, pre-injury functional status, osteoporosis treatment, or the medical causes of mortality.

Future research should include multicenter randomized trials with larger patient populations. Such studies should compare PFNA with other fixation systems and should report patient-centered outcomes, including mobility, independence, pain, quality of life, readmission, and cost. Subgroup analysis according to fracture stability, bone density, age, and comorbidity would also help clinicians select the most appropriate implant for individual patients. [8]

Conclusion

PFNA produced favourable clinical and radiological outcomes in this prospective series of patients with extracapsular proximal femoral fractures. The implant was associated with a 91.7% union rate, an average healing time of 14.8 weeks, and a mean six-month Harris Hip Score of 81.4.

The helical blade design offers a useful method of obtaining femoral-head fixation, particularly in patients with osteoporotic bone. The relatively low frequency of cut-out and implant failure supports the use of PFNA when appropriate surgical principles are followed.

Stable fractures healed more quickly and achieved better functional scores than unstable fractures. This finding emphasizes the influence of fracture morphology on recovery and demonstrates why unstable patterns require careful reduction, secure fixation, and closely supervised rehabilitation.

PFNA should not be considered a universal solution for every proximal femoral fracture. Its effectiveness depends on correct patient selection, accurate fracture reduction, optimal blade placement, attention to the tip-apex distance, and a rehabilitation plan adapted to the patient's medical and functional condition. Larger comparative studies with longer follow-up are required before firm conclusions can be drawn about its superiority over other fixation methods.

References

1. Cummings SR, Melton LJ. Epidemiology and outcomes of osteoporotic fractures. *Lancet*. 2002;359(9319):1761-1767

2. Cooper C, Campion G, Melton LJ 3rd. Hip fractures in the elderly: a world-wide projection. *Osteoporos Int*. 1992;2(6):285-289.
3. Suckel AA, Dietz K, Wuelker N, Helwig P. Evaluation of complications of three different types of proximal extra-articular femur fractures: differences in complications, age, sex and surviving rates. *Int Orthop*. 2007;31(5):689-695.
4. Zuckerman JD. Hip fracture. *N Engl J Med*. 1996; 334(23):1519-1525.
5. Parker MJ, Handoll HH. Gamma and other cephalocondylic intramedullary nails versus extramedullary implants for extracapsular hip fractures in adults. *Cochrane Database Syst Rev*. 2010;(9):CD000093
6. Bhandari M, Schemitsch E, Hanson B, Neary D. Treatment of unstable intertrochanteric and subtrochanteric fractures of the femur. *J Bone Joint Surg Am*. 2005;87(10):2277-2286.
7. Boettner F, Zettl R, Bartl C, Stöckle U, Schneider E, Müller PE. Pertrochanteric femoral fractures: intramedullary nailing compared with the dynamic hip screw. *Int Orthop*. 2005;29(5):279-281.
8. Zlowodzki M, Braberg B, Noordermeer PA, Koval KJ. Evidence-based orthopaedic trauma: what is the optimal treatment of intertrochanteric hip fractures? *J Orthop Trauma*. 2005;19(9):634-641.
9. Queally JM, Harris E, Handoll HH, Parker MJ. Intramedullary nails for extracapsular hip fractures in adults. *Cochrane Database Syst Rev*. 2014;(9):CD004961
10. Geller JA, Saifi A, Mauffrey C, Kummer FJ, Koval KJ. Biomechanical analysis of proximal femoral locking plate and helical blade in osteoporotic bone. *J Orthop Trauma*. 2010;24(10):618-622.
11. . Mereddy P, Kamath S, Ramakrishnan M, Malik H, Donnachie N. The AO/ASIF proximal femoral nail antirotation (PFNA): a new design for the treatment of unstable proximal femoral fractures. *Injury*. 2009;40(4):428-432.
12. . Simmermacher RK, Ljungqvist J, Bail H, et al. The new proximal femoral nail antirotation (PFNA) in daily practice: results of a multicentre clinical study. *Injury*. 2008;39(8):932-939.
13. Matre A, Vinayakumar KP, Arun S. Clinical outcome of AO type A2 and A3 intertrochanteric femoral fractures treated with proximal femoral nail antirotation. *J Orthop Trauma*. 2013;27(11):e263-e267
14. Baumgaertner MR, Collinge CF, Archdeacon M, Koval KJ. Reducing cutout in pertrochanteric hip fractures: the role of the tip-apex distance. *Clin Orthop Relat Res*. 1998;(348):109-116.
15. Baumgaertner MR, Curtin SL, Lindskog DM, Keggi JM. The value of the tip-apex distance

- in predicting failure of fixation of peritrochanteric fractures of the hip. *J Bone Joint Surg Am.* 1995;77(7):1058-1064.
16. Simmermacher R, Dirx J, Hayen K, van der Elst M, van Rietbergen B. The treatment of intertrochanteric femoral fractures: results of PFNA in 105 cases. *Injury.* 2011;42 Suppl 2:S14-S18.
 17. Muckley T, Mourschen C, Lucke M, Hessmann MH. PFNA versus DHS in proximal femoral fractures: a prospective randomized clinical trial. *Injury.* 2010;41 Suppl 2:S16-S20.
 18. Perren SM. Biomechanics of fracture fixation and fracture healing. In: Rockwood and Green's Fractures in Adults. 8th ed. Philadelphia: Lippincott Williams & Wilkins; 2015:291-332
 19. Sternheim A, Oron Y, Sagi A, Ben-Zvi Y, Efrima B, Mosheiff R. Proximal femoral nail antirotation versus dynamic hip screw for unstable trochanteric fractures: a meta-analysis of randomized controlled trials. *J Orthop Trauma.* 2018;32(11):e411-e417.
 20. Chen L, Zhang H, Wang J, Xiang Z. Proximal femoral nail antirotation versus dynamic hip screw for unstable intertrochanteric femur fractures: a systematic review and meta-analysis. *Medicine (Baltimore).* 2017;96(39):e8126.
 21. Kyle RF, Gustilo RB, Premer RF. Analysis of six hundred and twenty-two intertrochanteric hip fractures. *J Bone Joint Surg Am.* 1979;61(2):216-221.
 22. Xu YZ, Geng DL, Yang HL, Zhu XG, Tang J. A comparison of the proximal femoral nail antirotation device and dynamic hip screw in the treatment of unstable pertrochanteric fracture. *J Orthop Sci.* 2010;15(3):340-346.
 23. Xu YZ, Geng DC, Mao HQ, Zhu XS, Yang HL. A comparison of the proximal femoral nail antirotation device and dynamic hip screw in the treatment of unstable pertrochanteric fracture. *J Int Med Res.* 2010;38(4):1266-1275.