Surgical management of proximal femoral fracture with proximal femoral nail in adults

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ABSTRACT

INTRODUCTION

Proximal femoral fracture (PFF), commonly seen in elderly osteoporotic patients, poses difficulties in achieving and maintaining stable fixation. Surgical treatment is essential because of limited role of conservative management. Use of proximal femoral nail (PFN) for these fracture management has advantage of early mobilization, minimum blood loss, minimal infection and malunion rate.

MATERIAL AND METHODS

A prospective observational study was conducted among 50 patients in Orthopedics department at Universal College of Medical Sciences-Teaching Hospital (UCMS-TH) from April 2024 to October 2025. Selected patients with PFF were treated with PFN and they were followed post operatively at 6 weeks, 3 months and 6 months. At 6 months, functional outcomes were assessed by using Kyle's criteria.

RESULTS

Among 50 patients, most fractures were AO/OTA 31-A3 (50%) and Boyd–Griffin type III (42%). In 86% of cases, short PFN was used. The average duration to surgery was 3.12 days and the mean tip apex distance (TAD) difference was of 1.44 mm. The average duration of fracture union was 10.56 weeks. Complications were minimal with lateral migration of screw among 8% cases. At 6 months, 98% of patient had excellent to good functional outcomes. Neck shaft angle was well maintained during 6-month follow-up and the agreement was statistically significant ($p<0.05$), however no significant association was observed between fracture type and functional outcome.

CONCLUSION

Proximal femoral nail is an effective surgical treatment method for PFF with excellent functional outcome and minimal complication. Early postoperative neck shaft alignment strongly predicts long-term angular stability, while fracture classification does not significantly influence functional recovery.

KEYWORDS

Functional outcome, proximal femoral fracture, proximal femoral nail

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INTRODUCTION

Hip fracture is common around 60 to 70 years and PFF, basically intertrochanteric and subtrochanteric fractures, account for more than half of these fractures.[1,2] Due to osteoporosis in these age group, achieving and maintaining stable fixation is very difficult.[3] Surgical treatment is now the recommended mode of treatment which aims to achieve acceptable reduction, stable fixation, immediate mobilization and prompt return to pre-fracture activity levels.[4]

Obtaining a successful stable fixation is the key in elderly patients with PFF because revision surgeries after implant failure are highly morbid procedure and has significant complications. Thus, debate regarding the ideal implant is always a topic of ongoing research.[5] The main challenge with PFF is fracture instability that causes varus deviation as well as lateral rotation of the femoral head.[6] Whether plating device is superior over nailing device remains controversial, particularly after a reduction in complication rate by virtue of surgeon increasing experience.[7] Reoperation rates for mechanical complications (hardware-related fractures, blade cut-out, Z effect etc.) of any type remains as high as 21% which are mainly associated with greater fracture instability and severe osteoporosis.[8]

The dynamic hip screws (DHS), which are considered as an ideal implant for stable fractures, were found to be less appropriate for unstable fractures.[9] For unstable fractures, proximal femoral nail (PFN) have become popular.[10] The PFN, designed by the AO/ASIF (1996), is considered to be a favorable implant in PFF.[11] When compared to plating devices, PFN are considered more stable under loading because of short lever arm (reduced distance between the implant and hip joint), thus reducing significant deforming forces across the implant. Furthermore, PFN reduces the extent of soft tissue dissection, thereby minimizing surgical trauma, intraoperative blood loss, infection, complications, and the incidence of malunion.[12]

Thus, this study was conducted to evaluate the clinical, radiological, and functional outcomes of PFF treated with PFN

MATERIAL AND METHODS

A hospital-based, prospective observational study was conducted in Orthopedics department of UCMS-TH, Bhairahawa, Nepal from April 2024 to October 2025, following ethical clearance from Institutional Review Committee (UCMS/IRC/053/24). Isolated PFF with patient aged more than 20 years were included while patients with head injury, polytrauma, open fractures, neuromuscular disorders, pathological fractures and previous fracture of ipsilateral limb were excluded.

The sample size was calculated using Cochrane formula ($n=Z^2pq/d^2$) where Z= 1.96, is the normal variate at confidence interval of 95%, p = 3%[13] (0.03), q=1-p (1-0.03 = 0.97), d= allowable error (5%). The sample size after calculation was 45. After adding non response rate of 10%, the final sample size was 50.

After detail history and systemic examination, fracture was classified according to AO/ASIF (AO 31-A1 stable pertrochanteric, 31-A2 unstable pertrochanteric, 31-A3 unstable intertrochanteric and subtrochanteric fractures) and Boyd and Griffin classification. Preoperatively, patients were managed with analgesics, anti-swelling agents; and skin or skeletal traction. The operations were performed within 7 days of the trauma targeting closed reduction in majority of cases. Short PFN (240 mm) was used for intertrochanteric fracture and long PFN (320–420 mm) was used for subtrochanteric extension type and subtrochanteric fracture. After nail insertion, the neck screw was inserted in superior half and anti-rotational screw in inferior half of neck on the anteroposterior views; and centrally or slightly posterior on the lateral view. The anti-rotational hip pin should be introduced no further than to a horizontal line through the greater trochanter tip to femoral head center; the length of which measures approximately 10-20 mm shorter than neck screw length (Figure 1-4).

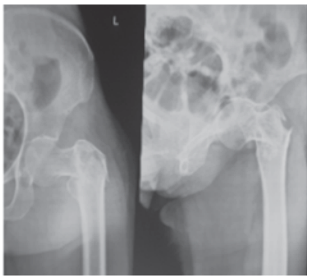

Fig 1. Pre op Xray

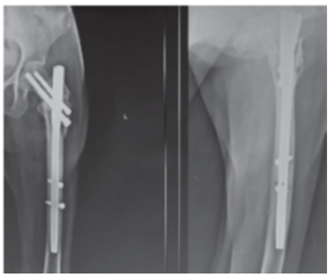

Fig 2. Post op Xray

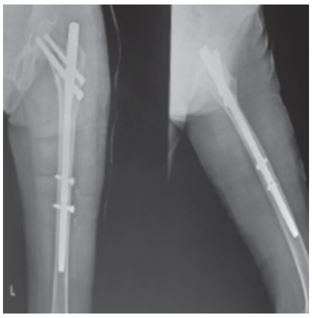

Fig 3. 3 month Xray

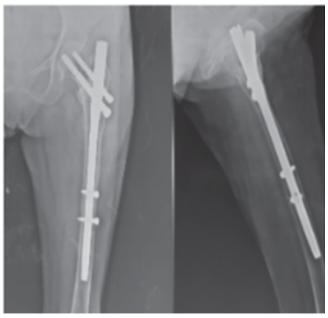

Fig 4. 6 month Xray

Follow ups were regularly done at 6 weeks, 3 months and 6 months; and outcome was evaluated according to Kyle's Criteria.[14] Radiological assessments were done depending on fracture union parameters, tip apex distance (TAD) difference, immediate post-operative and 6 months neck shaft angle, screw cut-out, lateral migration of screws, Z and reverse Z effects, peri-prosthetic fracture, avascular necrosis and nonunion. When there was no radiological visible fracture line, union was considered. Partial weight bearing crutch walking was allowed at 6 weeks while full weight bearing walking without crutches was permitted at 3 months.

Radiological outcomes were assessed based on reduction and fixation quality. Reduction was evaluated by comparing the neck shaft angle of the operated hip with the normal side on the antero-posterior view. A difference of <5° was considered good, 5–10° acceptable, and >10° poor. Fixation quality was assessed using the tip apex distance (TAD).[15] A TAD <25 mm, measured on immediate postoperative radiographs, was considered adequate and protective against screw cut-out.

Functional outcomes were assessed using Kyle's criteria.[14] Results were graded as excellent (no or minimal limp, no pain, rarely uses a cane), good (mild limp, occasional pain, full range of motion, uses a cane), fair (moderate limp, moderate pain, limited range of motion, requires two canes or a walker), and poor (wheelchair-bound, pain in any position, non-ambulatory).

Data were collected using a preformed proforma, including demographic details, clinical history, and clinical and radiological findings, along with management and follow-up information. Data were entered and analyzed using SPSS version 20. Descriptive (frequency, percentage, mean, range, and standard deviation) and inferential statistics (chi-square test and Kappa index) were applied to analyze the data.

RESULTS

Among 50 cases, more commonly affected were females (58%), with a mean age of 68.48±11.38 years. RTA was the most common injury mode (44%), with right side predominance (62%). The common fracture type was AO 31-A3 (50%) and BG type III (42%). The mean time to surgery was 3.12±1.31 days (table 1).

Table 1. Demographic data and general characteristics

Variables	Frequency (n)	Percentage (%)	Mean±SD (Range)
Gender			
Male	21	42	
Female	29	58	
Age(years)			68.48±11.386(45-90)
Side			
Right	31	62	
Left	19	38	
Mode of injury			
RTA	22	44	
Fall from height	11	22	
Slip	17	34	
AO/ASIF Classification			
31A1	6	12.0	
31A2	17	34.0	
31A3	25	50.0	
Subtrochanteric	2	4.0	
BG Classification			
Typ1 I	5	12	
Type II	18	36	
Type III	21	42	
Type IV	5	10	
Interval (days)			3.12±1.319;Range (1-6)

Short PFN (86%) were used among most patients, with a nail of 11-mm diameter (64%). The mean TAD difference was 1.44 ± 0.91 mm. The mean neck shaft angle variation at immediate postoperative x-ray and 6 months x-ray was 3.4±3.26 and 3.3±3.13 degree respectively. Only one patient showed change of 5 degree in neck shaft angle at 6 months. The average fracture union time was 10.56± 1.31weeks. Minimal complications were observed, with lateral screw migration being the most common (8%) (table 2). Excellent to good functional outcomes were achieved in 98% of patient at 6-month follow-up (table 3).

Table 2. Implant characteristics, fracture union and complications

Variables	Frequency (n)	Percentage (%)	Mean±SD (Range)
Nail length			
Short	43	86	
Long	7	14	
Nail Diameter (MM)			
9	2	4	
10	16	32	
11	32	64	
Screw 6.4 mm (Derotation screw)			
65	7	14	
70	21	42	
75	13	26	
80	8	16	
85	1	2	
Screw 8 mm (Neck screw)			
85	7	14	
90	21	42	
95	13	26	
100	8	16	
105	1	2	
TAD Difference mm (Normal Vs Fractured)			
0	8	16	1.44±0.915; Range (0-4)
1	18	36	
2	20	40	
3	2	4	
4	2	4	
Neckshaft angle variation degree (Post operative)			3.4±3.263; Range (0-10)
0	21	42	
5	24	48	
10	5	10	
Neckshaft angle variation degree (6 month)			3.3±3.131; Range (0-10)
0	21	42	
5	25	50	
10	4	8	
Fracture Union (weeks)			10.56± 1.312; Range (9-16)
Complications			
Superficial Infection	1	2.0	
Lateral migration of screw	4	8.0	
Screw cut out	1	2.0	

Table 3. Functional outcome (Kyles criteria)

Variables	Frequency(n)	Percentage (%)
Kyles Criteria (6 months)		
Excellent	34	68
Good	15	30
Fair	1	2

The kappa value (0.296) showed fair agreement in variation of neck shaft angle between immediate postoperative period and six-month follow-up, which was statistically significant, indicating that PFN effectively prevents varus collapse during healing (P<0.05) (table 4).

Table 4. Postoperative neck shaft angle variation Vs neck shaft angle variation at 6 months (Kappa index)

Neck Shaft angle variation-Postoperative (degree)	Neck Shaft angle variation -6 month (degree) 0	5	10	15	Total	Kappa Value	P Value
0	21	0	0	0	21		
5	0	24	0	0	24		
10	0	0	4	1	5	0.296	<0.001
15	0	0	0	0	0		
Total	21	24	4	1	50		

p<0.05 significant

Fracture classification (AO/OTA and BG) showed no statistically significant correlation with functional outcomes (table 5).

Table 5. AO/OTA and BG classification Vs functional outcome (Kyles criteria)

Classification	Types	Functional Outcome (Kyles Criteria) Excellent	Good	Fair	Total (N)	*P* Value
AO/OTA	AO-31-A1	5	1	0	6	0.916
	AO-31-A2	12	5	0	17	
	AO-31-A3	16	8	1	25	
	Sub-Trochanteric	1	1	0	2	
BG	I 5	1	0	6	0.871	
	II 12	6	0	18		
	III 13	7	1	21		
	IV 4	1	0	5		

p<0.05 significant

DISCUSSION

The present study demonstrates that PFN provides excellent clinical and radiological outcomes in the management of PFF, particularly in osteoporotic elderly patients. In our study, excellent or good functional results were achieved in 98% cases at six months according to Kyle's criteria, highlighting PFN as an effective implant for all fracture patterns. This high rate of favorable outcomes correlates with several otherstudies. Patted et al also found excellent as well as good results in approximately 90% of patients treated with PFN.[16] Similarly, Simmermacher et al found PFN to be a biomechanically robust option yet minimally invasive with effective outcomes in unstable fractures.[17] Hence, all these findings collectively support PFN as an effective fixation device across different demographic groups and fracture complexities.

Maintenance of neck shaft angle between immediate postoperative period and six month follow up was our key finding. Our study showed fair agreement in variation of neckshaft angle between immediate postoperative period and six-month follow-up. The intra-medullary placement of PFN offers a significant biomechanical advantage by enabling it to transmit axial loads efficiently along the femur's mechanical axis.This reduces bending stresses and lowers the risk of fixation failure.[12] Baumgaertner et al emphasized that varus collapse and an increased TAD are key predictors of implant failure.[15] The PFN features two proximal screws: a larger lag screw that carries the majority of the load, and a smaller anti-rotational screw that enhances rotational stability.The commonly observed screw cut-out, referred to as the Z-effect, occurs when the anti-rotational screw is longer than the lag screw. In this situation, vertical forces act more on the anti-rotational screw, causing it to migrate medially into the joint while the lag screw shifts laterally. The reported cut-out rate with a PFN ranges from approximately 0.6 to 8%.[18] It has been observed that when the anti-rotational screw is kept 10 mm shorter than the lag screw, it carries only about 8–39% of the total load (mean 21%),[19] which may contribute to a significant reduction in screw cut-out, implant failure, and fracture displacement.[20] In our study, the anti-rotational screw was maintained 15–20 mm shorter than the lag screw, which may have helped prevent the overall cut-out rate in cases treated with the PFN. Moreover, the mean TAD difference remained within acceptable limits, likely contributing to the low incidences of screw cut-out and mechanical complications.

Interestingly, no statistically significant association was found between fracture type (AO/OTA or Boyd–Griffin classification) and functional outcome. This suggests that PFN can achieve satisfactory results across wide range of fracture patterns when principles of good surgical technique are followed. This finding is consistent with observations reported by Kashid et al[21] and Geller et al,[22] who noted that proper implant placement, controlled reduction and an optimal TAD have a greater impact on outcomes than the fracture pattern itself. Similarly Abdel Rahim et al[23] observed that both stable and unstable fractures treated with PFN can achieve satisfactory alignment and functional recovery when technical accuracy is maintained.

The complication rate in our study was low, with only 2% superficial infection, 8% lateral migration of screw, and 2% screw cut-out. Zhang et al[9] found no significant difference in cut-out and reoperation rates between PFN and DHS, though PFN performed better in unstable fractures. Sharma et al[24] further observed that PFN is associated with minimal blood loss, shorter operating time, and fewer soft-tissue complications compared to DHS. These advantages likely arise from the smaller surgical incision, decreased soft-tissue dissection, and more efficient load transfer through the femoral canal. In contrast, extra medullary implants such as DHS, although effective for stable fractures, have been shown to carry a higher risk of lateral wall fractures, excessive sliding, and varus collapse in unstable patterns. Cochrane reviews have confirmed that intramedullary nails, including PFN, are biomechanically superior in unstable trochanteric fractures, offering a reduced risk of fixation failure. Additionally, the intramedullary design of PFN decreases the lever arm, thereby reducing stress on the implant and enhancing stability, particularly important in osteoporotic bone.[25]

Despite these strengths, PFN is not without challenges. Some studies have reported higher rates of fluoroscopic exposure, technical difficulty during distal locking and implant-related complications with earlier PFN designs. However, increasing surgical experiences and advances in implant designhave resulted in better outcomes and reduced complication rates.[17, 24]

The limitation of the study was that a six-month follow up period may not adequately detect late complications such as delayed union, implant fatigue failure, or long-term functional limitations. Additionally, although the sample size was sufficient to detect major differences, further large-scale randomized controlled trials with extended followup are necessary to validate the generalizability of these results.

CONCLUSION

The results of this study reinforce PFN as a safe, biomechanically stable, and clinically effective option for the management of proximal femoral fractures. When performed with meticulous technique, PFN provides excellent functional outcomes, stable radiological alignment, and a low rate of complications. Early postoperative neck shaft alignment strongly predicts long-term angular stability, while fracture classification does not significantly influence functional recovery.

CONFLICT OF INTEREST

None

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None

REFERENCES

1. Evans PJ, McGrory B. Fractures of the proximal femur. Hospital Physician. 2002;38(4):30-8.

2. Ahrengart L, Törnkvist H, Fornander P, Thorngren K-G, Pasanen L, Wahlström P, et al. A randomized study of the compression hip screw and Gamma nail in 426 fractures. Clinical Orthopaedics and Related Research (1976-2007). 2002;401:209-22.

3. Goldhahn J, Suhm N, Goldhahn S, Blauth M, Hanson B. Influence of osteoporosis on fracture fixation-a systematic literature review. Osteoporosis international. 2008;19(6):761-72.

4. Babhulkar SS. Management of trochanteric fractures. Indian J Orthop. 2006;40(4):210-18.

5. Gadegone WM, Salphale YS. Short proximal femoral nail fixation for trochanteric fractures. Journal of orthopaedic surgery. 2010;18(1):39-44.

6. Sommers MB, Roth C, Hall H, Kam BC, Ehmke LW, Krieg JC, et al. A laboratory model to evaluate cutout resistance of implants for pertrochanteric fracture fixation. Journal of orthopaedic trauma. 2004;18(6):361-8.

7. Bhandari M, Schemitsch E, Jönsson A, Zlowodzki M, Haidukewych GJ. Gamma nails revisited: gamma nails versus compression hip screws in the management of intertrochanteric fractures of the hip: a meta-analysis. Journal of orthopaedic trauma. 2009;23(6):460-4.

8. Fogagnolo F, Kfuri M, Paccola C. Intramedullary fixation of pertrochanteric hip fractures with the short AO-ASIF proximal femoral nail. Archives of Orthopaedic and Trauma Surgery. 2004;124(1):31-7.

9. Zhang K, Zhang S, Yang J, Dong W, Wang S, Cheng Y, et al. Proximal femoral nail vs. dynamic hip screw in treatment of intertrochanteric fractures: a meta-analysis. Medical science monitor: international medical journal of experimental and clinical research. 2014;20:1628.

10. Hohendorff B, Meyer P, Menezes D, Meier L, Elke R. Treatment results and complications after PFN osteosynthesis. Der Unfallchirurg. 2005;108(11):938, 40, 41-6 passim.

11. Simmermacher R, Bosch A, Van der Werken C. The AO/ASIF-proximal femoral nail (PFN): a new device for the treatment of unstable proximal femoral fractures. Injury. 1999;30(5):327-32.

12. Domingo L, Cecilia D, Herrera A, Resines C. Trochanteric fractures treated with a proximal femoral nail. International orthopaedics. 2001;25(5):298-301.

13. Bucholz RW, Heckman JD. Charles M Court-Brown. Rockwood and green's fractures in children. 2006; 6(22):896-34.

14. Jain HK, Dhakar S, Sharma M, Jain M, Sharma H. Efficacy of proximal Femoral Nail in peritrochanteric femoral fractures of elderly patients. Int J Biological Med Res. 2012;3(3):1910-13.

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. JBJS. 1995;77(7):1058-64.

16. Patted S HA, Shivashankar T. Functional outcome of intertrochanteric fractures treated with proximal femoral nail. Int J Orthop Sci. 2021;7(3):123–7.

17. Simmermacher RK LJ, Bail H. The Proximal Femoral Nail (PFN): a minimally invasive device for unstable femoral fractures. Injury. 1999;30(4):291–7.

18. Al-yassari G LR, Jones JM, Al-Lami M. The AO/ASIF proximal femoral nail (PFN) for the treatment of unstable trochanteric femoral fracture. Injury 2002;33: 395–9.

19. Schipper IB SE, Castelein RM, van der Heijden FH, den Hoed PT, Kerver AJ. Treatment of unstable trochanteric fractures. Randomised comparison of the gamma nail and the proximal femoral nail. J Bone Joint Surg Br. 2004;86:86–94.

20. Schipper IB BS, Wahl D, Linke B, Van Vugt AB, Schneider E. Biomechanical evaluation of the proximal femoral nail. Clin Orthop Relat Res. 2002;405:277–86.

21. Kashid MR PA, Patil S. Radiological and functional outcome of unstable intertrochanteric fractures treated with PFN. J Clin Diagn Res. 2017;11(8):RC05–RC9.

22. Geller JA SC, Morrison TA, Macaulay W. Tip–apex distance and failure of DHS in trochanteric fractures. Am J Orthop. 2010;39(9):E84–E7.

23. Abdel Rahim M E-BH, El-Sherif E. Comparative outcomes of DHS and PFN in intertrochanteric fractures. Orthop Traumatol Surg Res. 2012;98(3):273–7.

24. Sharma V VT, Tripathi SK. Comparison of PFN and DHS in unstable peritrochanteric fractures. J Clin Orthop Trauma. 2020;11(6):1023–8.

25. Parker MJ HH. Intramedullary nails vs extramedullary implants for extracapsular hip fractures. Cochrane Database Syst Rev. 2010(3).