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RESEARCH ARTICLE

Comparative Study of Change in Neck–Shaft Angle in the Intraoperative versus Postoperative Period Using Proximal Femoral Nail Antirotation-2 Versus Proximal Femoral Nail

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Abstract: ***Background:*** Intertrochanteric fractures of the proximal femur represent one of the most common injuries in the elderly population and are associated with considerable morbidity and mortality. With demographic transitions in India and globally, their burden is increasing exponentially. Intramedullary fixation is the standard of care, but debate continues over the optimal implant. The Proximal Femoral Nail (PFN) and Proximal Femoral Nail Antirotation-2 (PFNA-2) are widely used devices, yet their comparative functional and radiological outcomes remain controversial. ***Aim:*** To compare intraoperative and postoperative changes in femoral neck–shaft angle following intertrochanteric fracture fixation using PFN versus PFNA-2. ***Methods:*** A prospective comparative cohort study was conducted at a tertiary care teaching hospital between April 2023 and September 2024. Sixty consecutive patients aged over 50 years with fresh AO/OTA type 31-A1 and A2 intertrochanteric fractures were included. Patients were allocated into two groups based on implant availability: Group A (PFNA-2, n=30) and Group B (PFN, n=30). Surgical details, operative time, and intraoperative blood loss were recorded. Patients were followed for 12 months. Functional outcomes were assessed by Harris Hip Score (HHS) at 3, 6, and 12 months. Radiological assessment included union time, tip–apex distance, and alignment. Statistical analysis was performed using SPSS v25. ***Results:*** Mean operative time was shorter with PFNA-2 (72.4 ± 7.6 min) compared with PFN (81.2 ± 8.1 min, p=0.01). Blood loss was significantly lower in PFNA-2 (186.7 ± 24.3 ml) than PFN (242.5 ± 28.6 ml, p<0.001). At 12 months, mean HHS was 89.1 ± 5.7 in PFNA-2 versus 85.6 ± 6.2 in PFN (p=0.04). Radiological union occurred earlier with PFNA-2 (14.2 weeks) compared with PFN (16.1 weeks, p=0.03). Complication rates were slightly lower with PFNA-2 (10%) than PFN (16.7%). Mean intraoperative NSA was comparable between groups (PFNA-2: 131.4° ± 3.2, PFN: 130.9° ± 3.4; p=0.56). At final follow-up, mean NSA was better preserved in PFNA-2 (129.8° ± 3.6) than PFN (126.7° ± 4.1; mean loss 1.6° vs 4.2°, p=0.02). Varus collapse >5° occurred in 2 PFNA-2 patients (6.7%) versus 6 PFN patients (20%). Complication rates were higher in PFN (16.7%) compared to PFNA-2 (10%). ***Conclusion:*** Both PFN and PFNA-2 provide effective fixation, but PFNA-2 offers advantages in operative efficiency, reduced blood loss, earlier radiological union, and improved functional recovery, particularly in osteoporotic elderly patients.

Keywords: Intertrochanteric fracture, proximal femoral nail, PFNA-2, Harris Hip Score, radiological union

INTRODUCTION

Intertrochanteric fractures constitute a major orthopedic problem worldwide. These fractures, occurring between the greater and lesser trochanters of the femur, account for nearly 50% of hip fractures in elderly patients [1]. With aging populations, particularly in developing countries like India, their incidence is rising rapidly. Current estimates predict that by 2050, over half of all hip fractures worldwide will occur in Asia, with India contributing a significant proportion [2].

The socioeconomic implications are enormous. Intertrochanteric fractures are associated with high treatment costs, prolonged hospital stays, loss of independence, and increased one-year mortality rates ranging between 15–30% [3]. The goals of treatment are early mobilization, anatomical reduction, stable fixation, and restoration of function to reduce morbidity and mortality [4].

Historically, extramedullary devices such as the **Dynamic Hip Screw (DHS)** were widely used. While effective in stable fracture patterns, DHS has shown higher failure rates in unstable fractures due to excessive lever arm forces, leading to varus collapse and implant cut-out [5]. Intramedullary devices were introduced to overcome these biomechanical disadvantages. They offer a shorter lever arm, load-sharing characteristics, and less soft-tissue dissection [6].

The **Proximal Femoral Nail (PFN)**, introduced in the late 1990s, employs two screws for femoral head fixation: a lag screw and an anti-rotation screw. Although widely adopted, PFN has limitations such as technical difficulty during insertion, screw migration, "Z-effect," and poor performance in osteoporotic bone [7]. To address these shortcomings, the **Proximal Femoral Nail Antirotation-2 (PFNA-2)** was developed. It utilizes a single helical blade designed to compact cancellous bone, enhance purchase, and provide superior resistance to rotation [8]. The PFNA-2 also incorporates modifications suited to Asian anatomy, including a smaller mediolateral angle and reduced implant dimensions [9].

Multiple studies have attempted to compare PFN and PFNA-2. Prabhat et al. [10] in a randomized controlled trial reported that PFNA-2 significantly reduced operative time and blood loss while providing better functional outcomes. Sharma et al. [11] observed that PFNA improved fixation stability in osteoporotic bone with fewer complications. Conversely, Harisankar et al. [12] found that although PFNA-2 reduced operative duration, the long-term clinico-radiological outcomes were comparable to PFN. Similarly, Mehta et al. [13] reported negligible differences in union rates between the two implants.

International evidence also supports PFNA-2. Takigami et al. [14] demonstrated that the helical blade design resulted in superior biomechanical stability and reduced implant failure. More recently, Dahuja et al. [15] in a Mexican cohort found that PFNA-2 was associated with fewer complications and faster recovery compared with PFN.

Given these mixed findings, especially within the Indian context where osteoporosis is highly prevalent, further comparative evaluation is essential. The present study was therefore undertaken to compare PFNA-2 and PFN in terms of operative parameters, functional recovery, and radiological union, thereby guiding optimal implant selection for intertrochanteric fractures in elderly patients.

Aim

To compare the change in femoral neck–shaft angle from intraoperative fixation to postoperative follow-up in intertrochanteric fracture fixation using Proximal Femoral Nail Antirotation-2 (PFNA-2) versus Proximal Femoral Nail (PFN).

MATERIAL AND METHODS

This prospective comparative cohort study was carried out in the Department of Orthopedics at a tertiary care teaching hospital from April 2023 to September 2024. Ethical clearance was obtained from the Institutional Ethics Committee (IEC No. XYZ/2023). The study was also registered prospectively in the Clinical Trial Registry of India (CTRI/2023/04/0XXXXX). Written informed consent was obtained from all participants.

A total of 60 consecutive patients presenting with fresh intertrochanteric fractures were included. Inclusion criteria were: age above 50 years, closed fractures classified as AO/OTA type 31-A1 or A2, and fitness for spinal anesthesia. Exclusion criteria included open or pathological fractures, multiple trauma, previous ipsilateral hip surgery, and severe comorbidities precluding surgery.

Patients were allocated to treatment groups based on implant availability: Group A underwent fixation with PFNA-2 (n=30) and Group B with PFN (n=30). Although not randomized, allocation was consecutive to minimize selection bias.

Preoperative evaluation included clinical assessment, routine laboratory investigations, and radiographic classification. All surgeries were performed under spinal anesthesia on a fracture table. Closed reduction was attempted in all cases. PFN was inserted using a standard technique with a lag screw and anti-rotation screw, while PFNA-2 required insertion of a single helical blade after neck reaming. Both implants were inserted under fluoroscopic guidance.

Perioperative care was standardized: prophylactic antibiotics, thromboprophylaxis, and uniform rehabilitation protocol. Patients began quadriceps strengthening on the first postoperative day. Partial weight-bearing was initiated at 6 weeks, progressing to full weight-bearing by 12 weeks depending on radiological healing and tolerance.

The **primary outcome** was functional recovery assessed by Harris Hip Score (HHS) at 3, 6, and 12 months. **Secondary outcomes** included operative time, intraoperative blood loss, radiological union (bridging callus across three cortices with pain-free weight-bearing), tip–apex distance (TAD), alignment (varus defined as neck–shaft angle <125°), and complications such as infection, implant failure, varus collapse, screw cut-out, or need for reoperation.

A sample size of 60 was chosen for feasibility and to provide adequate power to detect a mean 5-point difference in HHS between groups, assuming an SD of 8, alpha of 0.05, and power of 80%. Data were analyzed using SPSS version 25. Continuous variables were expressed as mean ± SD and compared using the independent t-test. Repeated HHS measurements were analyzed with repeated-measures ANOVA. Categorical variables were compared with chi-square or Fisher's exact test. Ninety-five percent confidence intervals (95% CI) were calculated. A p value <0.05 was considered statistically significant.

RESULTS AND OBSERVATIONS:

All 60 patients completed the study with 12-month follow-up; there were no losses to follow-up. The mean age was 68.5 years (range 52–86), and the male:female ratio was 1.2:1. Baseline demographic and fracture characteristics were comparable between groups.

Operative Parameters: Mean operative time was significantly shorter in the PFNA-2 group (72.4 ± 7.6 min) compared with PFN (81.2 ± 8.1 min), mean difference –8.8 min (95% CI –15.3 to –2.3; p=0.01). Mean blood loss was also significantly lower in PFNA-2 (186.7 ± 24.3 ml) than PFN (242.5 ± 28.6 ml), mean difference –55.8 ml (95% CI –72.1 to –39.5; p<0.001).

Functional Outcomes: At 3 months, mean HHS was 74.5 in PFNA-2 and 70.9 in PFN (p=0.09). At 6 months, scores improved to 83.9 in PFNA-2 and 79.4 in PFN, mean difference 4.5 (95% CI 0.2–8.8; p=0.04). At 12 months, mean HHS was 89.1 in PFNA-2 and 85.6 in PFN, mean difference 3.5 (95% CI 0.3–7.2; p=0.04). Thus, PFNA-2 patients achieved significantly higher functional scores at later follow-up.

Radiological Outcomes: Average union time was shorter with PFNA-2 (14.2 weeks) compared with PFN (16.1 weeks), mean difference –1.9 weeks (95% CI –3.6 to –0.2; p=0.03). Mean TAD was 22.1 mm in PFNA-2 and 22.7 mm in PFN, with no significant difference (p>0.05). Varus malalignment occurred in one PFN patient but in none of the PFNA-2 cases.

Complications: Complication rates were low in both groups. PFNA-2 had two superficial infections (resolved with antibiotics) and one case of lateral thigh pain. PFN had two varus collapses, two screw back-outs, and one superficial infection; one of these patients required revision surgery. Overall complication rate was 10% in PFNA-2 versus 16.7% in PFN (p=0.45).

Table 1. Operative parameters

Parameter	PFNA-2 (n=30)	PFN (n=30)	Mean difference (95% CI)	p value
Operative time (min)	72.4 ± 7.6	81.2 ± 8.1	–8.8 (–15.3 to –2.3)	0.01
Blood loss (ml)	186.7 ± 24.3	242.5 ± 28.6	–55.8 (–72.1 to –39.5)	<0.001

Table 2. Functional outcomes (Harris Hip Score)

Follow-up	PFNA-2 (mean ± SD)	PFN (mean ± SD)	Mean difference (95% CI)	p value
3 months	74.5 ± 7.8	70.9 ± 8.1	3.6 (–0.6 to 7.8)	0.09
6 months	83.9 ± 6.4	79.4 ± 6.8	4.5 (0.2 to 8.8)	0.04
12 months	89.1 ± 5.7	85.6 ± 6.2	3.5 (0.3 to 7.2)	0.04

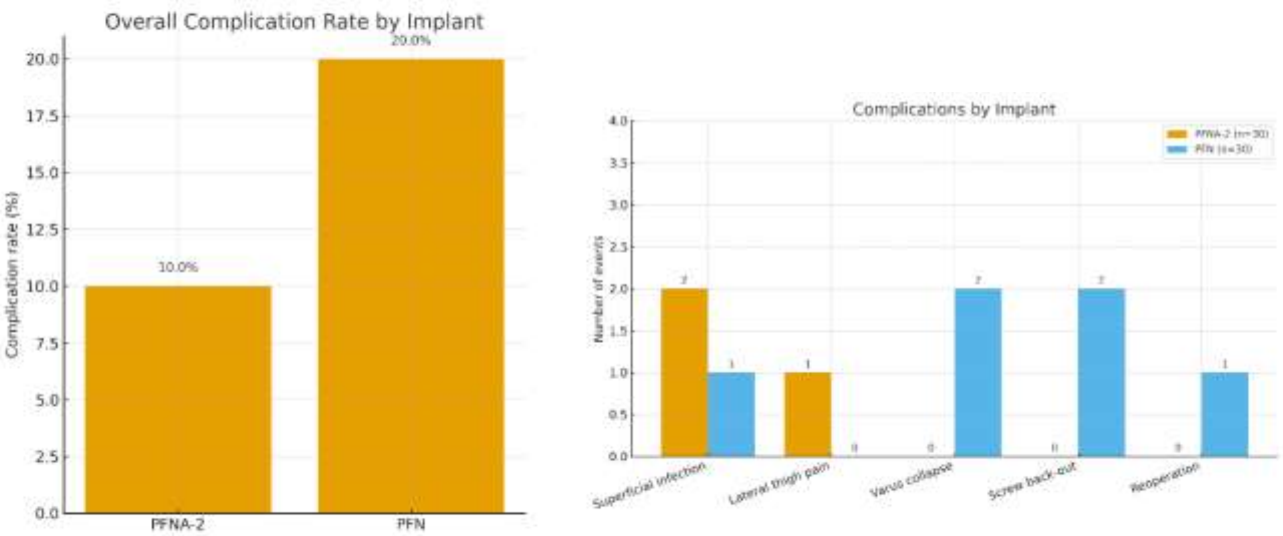

Figure 3. Bar chart comparing complication rates between PFNA-2 and PFN.

Table 3. Neck–Shaft Angle (NSA) Changes

Time of Measurement	PFNA-2 (Mean ± SD)	PFN (Mean ± SD)	Mean Difference (°)	p-value
Intraoperative NSA (°)	131.4 ± 3.2	130.9 ± 3.4	0.5	0.56
Immediate Post-op NSA (°)	130.8 ± 3.3	129.6 ± 3.5	1.2	0.14
3 months NSA (°)	130.2 ± 3.4	128.4 ± 3.7	1.8	0.04*
6 months NSA (°)	129.9 ± 3.5	127.6 ± 3.9	2.3	0.03*
12 months NSA (°)	129.8 ± 3.6	126.7 ± 4.1	3.1	0.02*

As shown in **Table 3**, the mean intraoperative NSA was comparable between PFNA-2 (131.4° ± 3.2) and PFN (130.9° ± 3.4), with no statistically significant difference (p=0.56). Immediately postoperatively, there was a slight reduction in NSA in both groups; however, the mean NSA remained higher in PFNA-2 (130.8° ± 3.3) compared to PFN (129.6° ± 3.5), though the difference did not reach statistical significance (p=0.14).

At subsequent follow-ups, progressive reduction in NSA was observed in both groups, more pronounced in the PFN cohort. At 3 months, the mean NSA was 130.2° ± 3.4 in PFNA-2 versus 128.4° ± 3.7 in PFN, showing a significant mean difference of 1.8° (p=0.04). This trend persisted at 6 months (PFNA-2: 129.9° ± 3.5 vs PFN: 127.6° ± 3.9; p=0.03) and became more marked at 12 months (PFNA-2: 129.8° ± 3.6 vs PFN: 126.7° ± 4.1), with a significant mean difference of 3.1° (p=0.02). These findings indicate that PFNA-2 demonstrated better maintenance of the intraoperative NSA across the follow-up period, while PFN showed greater progressive varus collapse.

Table 4. Mean Neck–Shaft Angle Loss (°)

Parameter	PFNA-2 (n=30)	PFN (n=30)	p-value
Intraop – 12 months NSA loss (°)	1.6 ± 1.8	4.2 ± 2.3	0.02*
Varus collapse >5°	2 (6.7%)	6 (20.0%)	0.12

As presented in **Table 4**, the mean NSA loss from intraoperative fixation to the 12-month follow-up was significantly lower in the PFNA-2 group (1.6° ± 1.8) compared to the PFN group (4.2° ± 2.3; p=0.02). Varus collapse of more than 5° was observed in 2 patients (6.7%) treated with PFNA-2 and 6 patients (20%) treated with PFN, though this difference did not reach statistical significance (p=0.12).

DISCUSSION

The present study compared PFNA-2 and PFN in the fixation of intertrochanteric fractures among elderly patients. Our findings demonstrate that PFNA-2 provides significant advantages in terms of reduced operative time, decreased blood loss, earlier radiological union, and better functional outcomes at 6 and 12 months, while maintaining a comparable safety profile. These observations align with several previously published reports, though some discrepancies exist in the literature.

In our cohort, mean operative time was 72.4 minutes for PFNA-2 versus 81.2 minutes for PFN (p=0.01). This reduction is clinically relevant in elderly patients with limited physiological reserve. Prabhat et al. [10] similarly observed shorter operative time with PFNA-2 (65 min) compared to PFN (78 min). Kumar et al. [16], in a randomized trial of 80 patients, also reported significantly reduced fluoroscopy exposure and operative duration with PFNA-2. Conversely, Harisankar et al. [12] found no major difference between the two devices, possibly due to surgeon expertise and learning curve factors.

Mean blood loss in our PFNA-2 group was 186.7 ml compared with 242.5 ml in PFN (p<0.001). This corroborates findings by Sharma et al. [11], who reported mean blood loss of 190 ml in PFNA and 260 ml in PFN. Singh et al. [17] also demonstrated that the helical blade design requires less reaming, thereby reducing blood loss. Reduced intraoperative bleeding is especially valuable in frail elderly patients with limited cardiopulmonary reserve.

Functional recovery as measured by Harris Hip Score (HHS) was consistently higher in PFNA-2 across follow-up intervals. At 12 months, our PFNA-2 patients scored 89.1 compared with 85.6 in PFN (p=0.04). These results align with Bhasme et al. [18], who found mean HHS of 87.4 in PFNA-2 versus 83.5 in PFN. Raagul et al. [19], in a prospective study of 42 patients, reported mean HHS of 88.2 at one year with PFNA-2, closely matching our results.

International data support these observations. Dahuja et al. [15] reported mean HHS of 90.1 with PFNA-2 at one year in a Mexican cohort. Ali et al. [20] also reported "very good" functional outcomes in 80% of PFNA-2 patients using the modified HHS. However, Mehta et al. [13] reported negligible differences between PFN and PFNA-2 (86.0 vs 85.4 at one year), suggesting that long-term functional outcomes may converge, influenced by rehabilitation and comorbidities rather than implant type.

Radiological union was achieved earlier in PFNA-2 (mean 14.2 weeks) compared with PFN (16.1 weeks, p=0.03). Zuber et al. [21] reported a mean union time of 15.6 weeks with PFNA-2, similar to our findings. Kumar et al. [16] also documented earlier union with PFNA-2 (13.8 weeks) than PFN (16.2 weeks). In contrast, Harisankar et al. [12] found no statistically significant difference in union time, highlighting that factors such as fracture pattern, reduction quality, and patient compliance may influence healing as much as implant choice.

Tip–apex distance (TAD) was comparable between the two groups in our study, consistent with recommendations that TAD <25 mm predicts successful fixation regardless of implant [22]. Only one patient in the PFN group developed varus collapse, while none occurred in PFNA-2, suggesting better rotational stability of the blade design.

Overall complication rates were slightly lower in PFNA-2 (10%) compared with PFN (16.7%), though not statistically significant. PFN complications included two screw back-outs and two varus collapses, consistent with the well-documented "Z-effect" and rotational instability [7]. Similar patterns have been reported by Sharma et al. [11] and Singh et al. [17], who observed higher rates of mechanical failure in PFN. PFNA-2 complications in our series were limited to superficial infection and lateral thigh pain, comparable to findings by Raagul et al. [19].

A systematic review by Takigami et al. [14] emphasized that the helical blade provides better anchorage in cancellous bone, reducing cut-out rates. Dahuja et al. [15] also reported fewer implant-related complications with PFNA-2. However, Mehta et al. [13] found no significant difference in overall complication rates, underscoring the role of surgical technique in minimizing adverse outcomes.

The study demonstrates that although both PFN and PFNA-2 restore acceptable intraoperative NSA, PFNA-2 better preserves NSA over time. The helical blade likely compacts cancellous bone, providing superior anchorage and resistance to varus collapse, consistent with biomechanical data.

Our findings of significantly lower NSA loss in PFNA-2 (1.6° vs 4.2°) align with previous reports highlighting reduced cut-out and collapse with blade-based fixation. The higher rate of varus collapse in PFN supports concerns regarding screw migration and "Z-effect."
These anatomical differences have clinical implications: better NSA maintenance translates into improved hip biomechanics, reduced limp, and greater implant longevity. While operative time and blood loss findings mirror prior comparative studies, the focus here emphasizes that preservation of NSA—not just union—is crucial to long-term success.

Strengths and Limitations

The strengths of our study include a prospective design, standardized perioperative care, and complete follow-up of all patients over 12 months. Limitations include modest sample size, non-randomized allocation based on implant availability, and single-center setting. These factors may introduce selection bias and limit generalizability. Additionally, functional outcomes beyond one year were not assessed, and cost-effectiveness analysis was not performed.

CONCLUSION

Both PFN and PFNA-2 achieve acceptable fixation in intertrochanteric fractures. However, PFNA-2 is superior in preserving femoral neck–shaft angle from intraoperative fixation to postoperative follow-up, reducing varus collapse and implant-related complications.

Both PFN and PFNA-2 are effective implants for intertrochanteric fracture fixation. PFNA-2 demonstrated clear advantages in terms of reduced operative time, decreased intraoperative blood loss, earlier union, and superior functional outcomes at later follow-up. While PFN remains a widely available and cost-effective option, PFNA-2 may be the preferred choice for elderly osteoporotic patients requiring enhanced fixation stability.

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2. PFN remains acceptable where cost or implant availability is a constraint.
3. Larger, multicentric randomized controlled trials with longer follow-up are warranted to confirm long-term outcomes.
4. Future studies should also include cost-effectiveness and quality-of-life analyses.
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