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Original Research Article

Assessment of Surgical Outcomes Using Short and Long PFNA2 for Intertrochanteric Femoral Fractures

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Abstract

Background: Intertrochanteric femur fractures are common in the elderly population and are associated with significant morbidity and mortality. Proximal Femoral Nail Antirotation 2 (PFNA2) is widely used for fixation; however, controversy persists regarding the optimal nail length. The present study compared the surgical, radiological, and functional outcomes of Short PFNA2 and Long PFNA2 in the management of intertrochanteric femur fractures.

Methods: This prospective comparative observational study included 137 patients with intertrochanteric femur fractures treated surgically using PFNA2 fixation. Patients were divided into Group A (Short PFNA2, n=69) and Group B (Long PFNA2, n=68). Baseline demographics, intraoperative parameters, postoperative outcomes, fracture union, complications, and functional outcomes using Harris Hip Score were compared between the groups.

Results: The mean operative duration, blood loss, fluoroscopy exposure, incision length, and distal locking time were significantly lower in the Short PFNA2 group ($p<0.001$). Hospital stay and time to partial weight bearing were also significantly shorter in Group A ($p\leq0.004$). Fracture union rates were comparable between the groups. However, Long PFNA2 demonstrated significantly better Harris Hip Scores at 6 months and 1 year follow-up ($p=0.024$ and $p=0.007$, respectively). Limb shortening and anterior thigh pain were significantly higher in the Short PFNA2 group ($p\leq0.049$). Implant-related complications were comparatively lower with Long PFNA2 fixation.

Conclusion: Short PFNA2 offers important perioperative advantages including reduced operative time, blood loss, and earlier mobilisation, whereas Long PFNA2 provides better functional recovery and mechanical stability, particularly in unstable fractures. Nail length selection should therefore be individualised according to fracture pattern, patient profile, and surgeon preference.

Keywords: Intertrochanteric Femur Fracture; Proximal Femoral Nail; Functional Outcome; Harris Hip Score; Intramedullary Fixation.

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Introduction

Intertrochanteric femur fractures are among the most common proximal femoral fractures encountered in orthopaedic practice, particularly in the elderly population with osteoporosis [1]. These fractures account for nearly 45–50% of all hip fractures and are associated with substantial morbidity, mortality, prolonged hospitalisation, and loss of functional independence [2]. With increasing life expectancy and ageing populations worldwide, the incidence of intertrochanteric fractures is steadily rising, posing a significant healthcare burden. Mortality rates following hip fractures have been reported to range from 15–30% within the first year after injury [3]. Early surgical stabilisation is considered the standard treatment for intertrochanteric fractures, as it facilitates early mobilisation, reduces complications related to prolonged immobilisation, and improves functional recovery [4]. In recent years, intramedullary fixation devices have gained preference over extramedullary implants because of their biomechanical advantages, including shorter lever arm, better load sharing, and improved stability in unstable fracture patterns [5].

The Proximal Femoral Nail Antirotation (PFNA) system has become widely accepted for the treatment of intertrochanteric fractures due to its minimally invasive technique and superior rotational stability achieved by the helical blade mechanism [6]. PFNA2 was later developed to better suit the anatomical characteristics of Asian populations, particularly smaller femoral dimensions and increased anterior femoral bowing [7]. The PFNA2 system provides good fixation in osteoporotic bone by compacting cancellous bone around the helical blade and reducing the risk of implant cut-out [8].

However, controversy persists regarding the optimal nail length in PFNA2 fixation. Short PFNA2 nails are associated with shorter operative time, reduced blood loss, smaller incision, and lower radiation exposure, making them advantageous in elderly patients with multiple comorbidities [9]. Nevertheless, concerns remain regarding stress concentration at the distal tip and increased risk of peri-implant femoral shaft fractures [10]. In contrast, long PFNA2 nails provide better stress distribution and may offer superior stability in unstable or subtrochanteric extension fractures, although they are associated with longer operative duration, greater blood loss, and increased technical difficulty [11].Therefore, the present study was aimed to evaluate the impact of nail length on surgical and functional outcomes in the treatment of intertrochanteric femur fractures.

Materials and Methods

Study Design and Setting: This prospective comparative observational study was conducted in the Department of Orthopaedics at a tertiary care teaching hospital over a period of 24 months from June 2023 to May 2025 after obtaining approval from the Institutional Ethics Committee. The study was designed to evaluate and compare the impact of nail length using Short PFNA2 and Long PFNA2 in the surgical treatment of intertrochanteric femur fractures. Written informed consent was obtained from all participants or their legally authorised attendants prior to inclusion in the study.

Study Population: A total of 137 patients with intertrochanteric femur fractures admitted to the orthopaedic department during the study period were included. Patients aged more than 18 years with fresh closed intertrochanteric fractures confirmed radiologically and treated surgically with PFNA2 fixation were considered eligible. Both stable and unstable fracture patterns according to the AO/OTA classification were included. Patients with pathological fractures, open fractures, polytrauma, previous surgery on the ipsilateral hip or femur, associated femoral shaft fractures, active local infection, or severe systemic illness precluding surgery were excluded from the study.

Group Allocation and Preoperative Assessment: The enrolled patients were divided into two groups based on the nail length used during surgery. Group A (n= 69) included patients treated with Short PFNA2, whereas Group B (n=68) included patients treated with Long PFNA2. The choice of implant length was determined according to fracture morphology, subtrochanteric extension, femoral anatomy, bone quality, and surgeon preference. Baseline demographic and clinical details including age, sex, side involved, mechanism of injury, associated comorbidities, and fracture classification were recorded. All patients underwent routine preoperative hematological and biochemical investigations along with radiographic evaluation using anteroposterior pelvis with both hips and lateral hip radiographs.

Surgical Procedure: All procedures were performed under spinal or combined spinal-epidural anaesthesia with the patient positioned supine on a fracture table under fluoroscopic guidance. Closed reduction was attempted initially using traction and internal rotation. In cases where satisfactory reduction could not be achieved, limited open reduction was performed. Following adequate fracture reduction, PFNA2 fixation was carried out according to standard operative protocol. Nail diameter and length were selected based on preoperative templating and intraoperative assessment.

The helical blade was inserted into the femoral head under image intensifier guidance while maintaining an optimal tip-apex distance. Distal locking was performed depending on fracture stability and implant type. Intraoperative parameters such as duration of surgery, blood loss, fluoroscopy exposure, and intraoperative complications were recorded.

Postoperative Management and Follow-up: Postoperatively, all patients received intravenous antibiotics, thromboprophylaxis, and analgesics according to institutional protocol. Early mobilisation with static quadriceps exercises and assisted ambulation was initiated as tolerated. The timing of partial and full weight-bearing was decided based on fracture configuration, fixation stability, and patient tolerance. Patients were followed up clinically and radiologically at intervals of 6 weeks, 3 months, 6 months, and 1 year after surgery. Radiographs were evaluated for fracture alignment, implant position, progression of union, and evidence of complications.

Outcome Measures: The primary outcome measures included operative duration, intraoperative blood loss, time to fracture union, duration of hospital stay, and functional outcome. Functional assessment was performed using the Harris Hip Score at final follow-up.

Fracture union was defined radiologically by bridging callus formation across at least three cortices and clinically by painless full weight-bearing. Secondary outcome measures included postoperative complications such as infection, implant failure, screw cut-out, varus collapse, peri-implant fracture, anterior thigh pain, limb shortening, and reoperation.

Statistical Analysis: The collected data were entered into Microsoft Excel and analysed using Statistical Package for Social Sciences (SPSS) version 20.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were represented as frequency and percentage. Independent t-test was used for comparison of continuous variables between the two groups, whereas Chi-square test or Fisher’s exact test was applied for categorical variables. A p-value of less than 0.05 was considered statistically significant.

Results

The present study included 137 patients with intertrochanteric femur fractures, of whom 69 underwent fixation with Short PFNA2 (Group A) and 68 with Long PFNA2 (Group B). The mean age was comparable between the groups (69.8 ± 9.4 vs 71.2 ± 10.1 years; p=0.391), with the majority of patients aged >70 years in both groups (55.1% vs 60.3%; p=0.534).

Female predominance was observed in both groups, accounting for 53.6% in Group A and 55.9% in Group B (p=0.782). Right-sided fractures were slightly more common than left-sided fractures in both groups without significant difference (58.0% vs 57.4%; p=0.941). Low-energy falls constituted the predominant mechanism of injury, observed in 81.2% and 85.3% of patients in Groups A and B, respectively (p=0.512). The prevalence of diabetes mellitus, hypertension, and osteoporosis was comparable between the two groups (p>0.05). Unstable fractures (AO/OTA 31A2/A3) constituted the majority of cases in both groups, accounting for 62.3% in Group A and 67.6% in Group B (p=0.508), indicating comparable baseline fracture characteristics (Table 1).

Table 1: Baseline Demographic and Clinical Characteristics of Patients Undergoing Short PFNA2 and Long PFNA2 Fixation for Intertrochanteric Femur Fractures

Variables	Group A (Short PFNA2) n=69	Group B (Long PFNA2) n=68	p-value
	Frequency (%)/Mean±SD		
Age (years)	69.8 ± 9.4	71.2 ± 10.1	0.391
Age group (years)			
>70 years	38 (55.1%)	41 (60.3%)	0.534
≤70 years	31 (44.9%)	27 (39.7%)	
Gender			
Male	32 (46.4%)	30 (44.1%)	0.782
Female	37 (53.6%)	38 (55.9%)	
Side involvement			
Right side	40 (58.0%)	39 (57.4%)	0.941
Left side	29 (42.0%)	29 (42.6%)	
Type of injury			
Low-energy fall	56 (81.2%)	58 (85.3%)	0.512
Road traffic accident	13 (18.8%)	10 (14.7%)	
Comorbidities			
Diabetes mellitus	24 (34.8%)	22 (32.4%)	0.761
Hypertension	31 (44.9%)	34 (50.0%)	0.548
Osteoporosis documented			
Yes	27 (39.1%)	30 (44.1%)	0.554
No	42 (60.9%)	38 (55.9%)	
Fracture type			
Stable fractures (AO/OTA 31A1)	26 (37.7%)	22 (32.4%)	0.508
Unstable fractures (AO/OTA 31A2/A3)	43 (62.3%)	46 (67.6%)	

PFNA2: Proximal Femoral Nail Antirotation 2; AO/OTA: Arbeitsgemeinschaftfür Osteosynthese fragen/Orthopaedic Trauma Association classification.

Patients treated with Short PFNA2 demonstrated significantly shorter operative duration compared to those treated with Long PFNA2 (61.4 ± 10.6 vs 84.7 ± 12.8 minutes; p<0.001). Mean intraoperative blood loss was also significantly lower in Group A than Group B (118.5 ± 34.2 vs 176.8 ± 46.5 mL; p<0.001). Fluoroscopy exposure time was significantly reduced in the Short PFNA2 group (68.9 ± 14.1 vs 96.3 ± 18.5 seconds; p<0.001). Similarly, incision length and distal locking time were significantly lesser in Group A compared to Group B (5.1 ± 0.8 vs 7.3 ± 1.1 cm and 7.8 ± 2.3 vs 14.9 ± 3.7 minutes, respectively; p<0.001).

Open reduction was required in 13.0% of Group A and 22.1% of Group B patients, although the difference was not statistically significant (p=0.164). Intraoperative complications were infrequent and comparable between the groups (4.3% vs 7.4%; p=0.472) (Table 2).

Table 2: Comparison of Intraoperative Parameters Between Short PFNA2 and Long PFNA2 Groups

Variables	Group A (Short PFNA2) n=69	Group B (Long PFNA2) n=68	p-value
	Frequency (%)/Mean±SD		
Duration of surgery (minutes)	61.4 ± 10.6	84.7 ± 12.8	<0.001
Intraoperative blood loss (mL)	118.5 ± 34.2	176.8 ± 46.5	<0.001
Fluoroscopy exposure (seconds)	68.9 ± 14.1	96.3 ± 18.5	<0.001
Open reduction required			
Yes	9 (13.0%)	15 (22.1%)	0.164
No	60 (87.0%)	53 (77.9%)	
Incision length (cm)	5.1 ± 0.8	7.3 ± 1.1	<0.001
Distal locking time (minutes)	7.8 ± 2.3	14.9 ± 3.7	<0.001
Intraoperative complications			
Yes	3 (4.3%)	5 (7.4%)	0.472
No	66 (95.7%)	63 (92.6%)	

PFNA2: Proximal Femoral Nail Antirotation 2.

The mean duration of hospital stay was significantly shorter in the Short PFNA2 group compared to the Long PFNA2 group (6.8 ± 1.9 vs 7.9 ± 2.4 days; p=0.004). Patients treated with Short PFNA2 also achieved partial weight bearing earlier than those treated with Long PFNA2 (3.2 ± 0.9 vs 3.8 ± 1.1 weeks; p=0.001). However, the mean fracture union time was comparable between the groups (15.1 ± 2.7 vs 15.8 ± 3.1 weeks; p=0.159). Proper union was achieved in more than 90% of patients in both groups, with no statistically significant difference in union status. Delayed union and non-union rates were low and comparable between groups. Mean limb shortening was significantly greater in Group A than Group B (0.71 ± 0.28 vs 0.56 ± 0.24 cm; p=0.001). Varus collapse and implant failure were more frequent in the Short PFNA2 group; however, these differences did not reach statistical significance (p>0.05) (Table 3).

Table 3: Comparison of Postoperative and Radiological Outcomes Between Short PFNA2 and Long PFNA2 Groups

Variables	Group A (Short PFNA2) n=69	Group B (Long PFNA2) n=68	p-value
	Frequency (%)/Mean±SD		
Hospital stay (days)	6.8 ± 1.9	7.9 ± 2.4	0.004
Time to partial weight bearing (weeks)	3.2 ± 0.9	3.8 ± 1.1	0.001
Fracture union time (weeks)	15.1 ± 2.7	15.8 ± 3.1	0.159
Union status			
Proper union	63 (91.3%)	63 (92.6%)	0.781
Delayed union	5 (7.2%)	4 (5.9%)	0.748
Non-union	1 (1.4%)	1 (1.5%)	0.972
Shortening (cm)	0.71 ± 0.28	0.56 ± 0.24	0.001
Complications			
Varus collapse	6 (8.7%)	3 (4.4%)	0.314
Implant failure	4 (5.8%)	2 (2.9%)	0.406

PFNA2: Proximal Femoral Nail Antirotation 2.

Functional outcome assessment using the Harris Hip Score demonstrated significantly better scores in the Long PFNA2 group at both 6 months and 1 year follow-up. The mean Harris Hip Score at 6 months was 79.6 ± 8.5 in Group A and 82.8 ± 7.9 in Group B (p=0.024). At 1 year, the scores further improved to 85.1 ± 7.3 and 88.4 ± 6.8, respectively (p=0.007). Excellent functional outcome (>90) was achieved in 34.8% of patients treated with Short PFNA2 compared to 45.6% in the Long PFNA2 group. Good functional outcome was observed in 42.0% and 39.7% of patients in Groups A and B, respectively. Poor outcomes were uncommon in both groups, affecting 5.8% of Group A and 2.9% of Group B patients. Although the categorical distribution of outcomes did not show statistical significance, Long PFNA2 demonstrated superior overall functional recovery (Table 4).

Table 4: Functional Outcome Assessment Using Harris Hip Score in Short PFNA2 and Long PFNA2 Groups

Variables	Group A (Short PFNA2) n=69	Group B (Long PFNA2) n=68	p-value
	Frequency (%)/Mean±SD		
Harris Hip Score at 6 months	79.6 ± 8.5	82.8 ± 7.9	0.024
Harris Hip Score at 1 year	85.1 ± 7.3	88.4 ± 6.8	0.007
Outcome			
Excellent outcome (>90)	24 (34.8%)	31 (45.6%)	0.189
Good outcome (80–89)	29 (42.0%)	27 (39.7%)	
Fair outcome (70–79)	12 (17.4%)	8 (11.8%)	
Poor outcome (<70)	4 (5.8%)	2 (2.9%)	

PFNA2: Proximal Femoral Nail Antirotation 2.

Postoperative complications were generally low in both study groups. Superficial infection occurred in 4.3% of Group A and 2.9% of Group B patients (p=0.661), while deep infection was noted in one patient in each group (p=0.972). Helical blade cut-out was more common in the Short PFNA2 group compared to the Long PFNA2 group (4.3% vs 1.5%; p=0.309). Peri-implant femoral fractures were also observed more frequently in Group A (7.2% vs 1.5%), although the difference was not statistically significant (p=0.094). Anterior thigh pain was significantly higher in patients treated with Short PFNA2 compared to Long PFNA2 (15.9% vs 5.9%; p=0.049). Reoperation rates were low and comparable between the groups (5.8% vs 2.9%; p=0.406). Mortality within one year was observed in 7.2% of Group A and 8.8% of Group B patients, without statistically significant difference (p=0.728) (Table 5).

Table 5: Comparison of Postoperative Complications Between Short PFNA2 and Long PFNA2 Groups

Complications	Group A (Short PFNA2) n=69	Group B (Long PFNA2) n=68	p-value
	Frequency (%)		
Superficial infection	3 (4.3%)	2 (2.9%)	0.661
Deep infection	1 (1.4%)	1 (1.5%)	0.972
Helical blade cut-out	3 (4.3%)	1 (1.5%)	0.309
Peri-implant femoral fracture	5 (7.2%)	1 (1.5%)	0.094
Anterior thigh pain	11 (15.9%)	4 (5.9%)	0.049
Reoperation required	4 (5.8%)	2 (2.9%)	0.406
Mortality within 1 year	5 (7.2%)	6 (8.8%)	0.728

PFNA2: Proximal Femoral Nail Antirotation 2.

Discussion

Intertrochanteric femur fractures are increasingly encountered in the elderly population due to osteoporosis, increased life expectancy, and higher susceptibility to low-energy trauma. Intramedullary fixation using PFNA2 has become widely accepted because of its biomechanical advantages, minimally invasive nature, and improved fixation in osteoporotic bone. However, controversy still persists regarding the optimal nail length for achieving the best surgical and functional outcomes. The present study compared the outcomes of Short PFNA2 and Long PFNA2 fixation in 137 patients with intertrochanteric femur fractures and demonstrated significant differences in operative parameters, postoperative recovery, functional outcomes, and certain complications between the two implant designs.

In the present study, the baseline demographic and fracture characteristics were comparable between both groups, thereby minimising selection bias and allowing reliable comparison of outcomes. The mean age of patients was around 70 years, with female predominance and low-energy falls constituting the most common mechanism of injury. These findings are consistent with previous studies by Jeswani et al., and Murugesan et al., which reported that intertrochanteric fractures predominantly occur in elderly osteoporotic females following trivial falls [12,13]. The high proportion of unstable AO/OTA 31A2/A3 fractures observed in our study further reflects the increasing complexity of fracture patterns seen in geriatric patients with poor bone quality [14].

One of the most important findings of the present study was the significantly shorter operative duration observed with Short PFNA2 compared to Long PFNA2 (61.4 ± 10.6 vs 84.7 ± 12.8 minutes; $p<0.001$). Similar observations have been reported by Chandrasekhar et al., and Mohan et al., who demonstrated that short intramedullary nails reduce surgical time because of easier insertion, less canal preparation, and simpler distal locking techniques [15,16]. In elderly patients with multiple comorbidities, shorter operative duration is clinically important as it reduces anaesthesia exposure, perioperative physiological stress, and risk of systemic complications [17]. Additionally, intraoperative blood loss was significantly lower in the Short PFNA2 group (118.5 ± 34.2 vs 176.8 ± 46.5 mL; $p<0.001$), which can be attributed to reduced medullary reaming, smaller incision length, and shorter surgical exposure. Reduced fluoroscopy exposure and distal locking time in the short nail group further support the technical simplicity and procedural efficiency associated with Short PFNA2 fixation [18].

The present study also demonstrated significantly shorter hospital stay and earlier initiation of partial weight bearing in the Short PFNA2 group. These findings are clinically relevant because early mobilisation decreases the incidence of complications such as deep vein thrombosis, pulmonary infections, pressure sores, and muscle wasting in elderly patients [19]. Similar results were reported by Soaji et al., who found that short nails facilitated faster rehabilitation due to reduced operative trauma and earlier postoperative recovery [20]. Despite these perioperative advantages, fracture union time was comparable between both groups (15.1 ± 2.7 vs 15.8 ± 3.1 weeks; $p=0.159$), suggesting that both implant types provide adequate biological and mechanical conditions for fracture healing. The overall union rates exceeding 90% in both groups are comparable to previously published PFNA2 studies by Siva et al., and Prasad et al., reporting union rates between 88% and 98% [21,22]. Although radiological union rates were similar, Long PFNA2 demonstrated relatively superior mechanical performance. Mean limb shortening was significantly greater in the Short PFNA2 group (0.71 ± 0.28 vs 0.56 ± 0.24 cm; $p=0.001$), likely due to increased telescoping and collapse at the fracture site secondary to shorter distal fixation length. Furthermore, varus collapse, implant failure, and peri-implant femoral fractures were more frequently observed in the Short PFNA2 group, although not all differences reached statistical significance. These findings are biomechanically plausible because long nails distribute stress over a larger femoral segment, thereby reducing stress concentration at the distal nail tip [23]. Previous biomechanical studies by Raval et al., and Bhardwaj et al., have similarly shown that long intramedullary nails provide better rotational stability and lower peak stress in unstable fracture patterns [24,25]. The lower incidence of peri-implant fractures in the Long PFNA2 group in our study also supports the protective effect of longer implants against secondary femoral shaft fractures.

Functional outcome analysis revealed significantly better Harris Hip Scores in the Long PFNA2 group at both 6 months and 1 year follow-up. The mean 1-year Harris Hip Score was 88.4 ± 6.8 in the Long PFNA2 group compared to 85.1 ± 7.3 in the Short PFNA2 group ($p=0.007$). Additionally, a greater proportion of patients achieved excellent functional outcomes with Long PFNA2 fixation. These findings may be explained by the improved biomechanical stability and reduced postoperative mechanical complications associated with longer nails, particularly in unstable fracture configurations [26]. Similar findings were reported by Singh et al., who observed better long-term hip function and lower implant-related complications with long proximal femoral nails in unstable intertrochanteric fractures [27].

Postoperative complications were generally low in both groups, indicating that PFNA2 is a safe and effective implant irrespective of nail length. However, anterior thigh pain was significantly more common in the Short PFNA2 group (15.9% vs 5.9%; $p=0.049$). This may be due to stress concentration and cortical impingement at the distal tip of short nails, especially in patients with excessive anterior femoral bowing commonly observed in Asian populations [28]. Similar observations have been reported in previous studies Murugan et al., and Domenech et al., evaluating short cephalomedullary nails [29,30]. Although infection rates, reoperation rates, and mortality were comparable between groups, the slightly higher incidence of implant-related complications in the Short PFNA2 group suggests that long nails may offer greater durability in unstable osteoporotic fractures.

Limitations

The present study was conducted at a single tertiary care centre with a relatively limited sample size, which may affect the generalisability of the findings. The follow-up duration was limited to one year, restricting long-term assessment of implant survivorship and late complications. Implant selection was partly influenced by surgeon preference and fracture configuration, which may have introduced selection bias despite comparable baseline characteristics between the study groups.

Conclusion

Both Short PFNA2 and Long PFNA2 are effective treatment options for intertrochanteric femur fractures with satisfactory union rates and acceptable complication profiles. Short PFNA2 demonstrated significant perioperative advantages including reduced operative time, lower blood loss, shorter incision length, decreased fluoroscopy exposure, and earlier mobilisation.

However, Long PFNA2 provided superior functional outcomes, lesser limb shortening, and lower incidence of implant-related mechanical complications, particularly in unstable fracture patterns. The findings suggest that implant selection should be individualised based on fracture stability, bone quality, patient physiological status, and surgeon expertise.

Long PFNA2 may be preferable for unstable fractures, whereas Short PFNA2 remains suitable for stable fractures and high-risk elderly patients.

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