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Original Research Article

A Study of Surgical Management of Displaced Intertrochanteric Fractures with the Proximal Femoral Nail Antirotation II

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Abstract

Background: Proximal femoral nail antirotation-2 (PFNA-2) has been extensively utilized for treating intertrochanteric fractures, with previous studies reporting varied outcomes. The entry point of the nail is crucial for achieving acceptable reduction, stable fixation, and minimizing implant-related complications. This study aims to determine the optimal greater trochanteric entry point for PFNA-2 in managing unstable intertrochanteric femur fractures.

Methods: A retrospective analysis was conducted to assess the outcomes of PFNA II nail fixation in unstable intertrochanteric fractures. The study cohort comprised 20 patients (15 males and 5 females) with a mean age of 58.66 years (range: 35-70 years). Right hip involvement was observed in 12 patients, while the remaining 8 patients sustained fractures in the left hip. The majority of fractures (10) were attributed to low-energy falls. The remaining cases were caused by high-energy mechanisms such as motor vehicle accidents or falls from a significant height. Preoperative radiographs were used to classify the fractures according to the AO classification system, with distribution as follows: 10 (31.A1), 7 (31.A2), and 3 (31.A3).

Results: PFNA II nails showed promise for intertrochanteric fractures (n=20). Small (200mm) nails were the most common (50%). Most patients achieved good fracture healing (75%) and alignment (75%). Intraoperative complications were limited (fracture of the greater trochanter in 15%). Postoperative complications were mostly minor (nail mismatch 10%, pain 5%). Functional outcomes were positive, with 80% of patients achieving good or excellent scores on the Harris Hip Score.

Conclusion: In conclusion, our study suggests that the PFNA II nail presents a promising option for the surgical management of unstable intertrochanteric fractures. This fixation method offers potential advantages of reduced operative time and a demonstrably low complication rate.

Keywords: Proximal Femoral Nail Antirotation II, Unstable Intertrochanteric Fractures, Harris Hip Score.

Introduction

Intertrochanteric fractures frequently occur in elderly patients with osteoporosis, and their incidence is expected to rise with increasing life expectancy [1]. The optimal treatment for active and mentally alert elderly patients with displaced intra-capsular femoral neck fractures remains a subject of debate, aptly termed the "Unsolved Fracture" [2]. The primary goal of surgery is early mobilization of the patient, necessitating the use of an implant that is minimally invasive, permits early weight-bearing, and has a low complication rate [3, 4]. Implants for these fractures are categorized into extramedullary implants and intramedullary nails, with the choice depending on the fracture pattern (stable or unstable). Unstable intertrochanteric fractures involve significant disruption of the posteromedial cortex due to comminution or present with reverse oblique patterns or subtrochanteric extension. Conversely, fractures without posteromedial cortex disruption or subtrochanteric extension are considered stable [5, 6]. The optimal treatment for active and mentally alert elderly patients with displaced intra-capsular femoral neck fractures remains controversial and has been aptly termed the "Unsolved Fracture" [7]. Despite advancements in understanding the epidemiology, biomechanics, and vascular supply of the hip and proximal femur, no universally accepted treatment exists. In 1902, Whitman R attempted to treat femoral neck fractures by immobilizing the fracture in a spica cast, with approximately one-third of the patients who survived the complications showing union [8]. The

focus later shifted to operative treatment, specifically internal fixation in various forms. The triflanged nail introduced by Smith PMN in 1923 made internal fixation more acceptable because it allowed fracture reduction under direct vision, although the results were not very promising [9]. Even for undisplaced fractures in octogenarians, the re-operation rate was 31% [10]. Internal fixation outcomes are often marked by a high incidence of nonunion and avascular necrosis. Literature suggests that intramedullary nailing is one of the best choices for surgical fixation, offering better clinical outcomes compared to arthroplasty [11, 12].

The Proximal Femoral Nail Antirotation-2 (PFNA-2) is a newer design widely used to treat proximal femoral fractures [13]. Previous studies have shown varied outcomes with this implant [14, 15], which may be attributed to factors such as patient age, fracture type, implant design, and the quality of reduction and fixation. The entry point is crucial for achieving acceptable reduction, stable fixation, and avoiding implant-related complications [16]. Studies suggest that a lateral entry point can damage the gluteus muscle tendon during reaming for intramedullary nail insertion. Research on the anatomy of the greater trochanter indicates that the entry point should be at the rear tip to fit the implant into the proximal femoral medullary canal curvature [17]. This study aims to determine the optimal greater trochanteric entry point for PFNA-2 in unstable intertrochanteric femur fractures.

Material and Methods

This prospective study was done in the Department of Orthopedics, Medical College and Hospital. Institutional Ethical approval was obtained for the study. Written consent was obtained from all the participants after explaining the nature of the study in the vernacular language. Those voluntarily willing to participate were included in the study.

Patients with unstable intertrochanteric fractures treated with the PFNA II were followed retrospectively. This study involved 15 men and 5 women with a mean age of 58.66 ± 5.5 years (range 35-70). The right hip was involved in 12 patients and the left in 8. In 10 patients, fractures were caused by a trivial fall, while the rest resulted from road traffic accidents or falls from height. The fractures were classified using the AO classification system, with 10 classified as 31A-A1, 7 classified as 31A-A2, and 3 as 31A-A3 based on pre-operative radiographs. All surgeries were performed at our tertiary care center within a mean of six days (range 3 -12 days) from the date of injury. Surgeries were conducted on a fracture table with patients in the supine position. Closed reduction under fluoroscopic guidance was achieved in 16 cases, while the remaining cases required minimal opening of the fracture site using various reduction maneuvers, such as strategically placed Hohmann retractors and reduction clamps. The mean operative time (skin to skin) was 35 minutes (range 20-90 minutes). All patients received prophylactic antibiotics (cefazolin) within one hour of the skin incision.

The most commonly used nail diameter was 10 mm, used in 13 patients, while a 9 mm nail was used in the remaining patients. The most common nail length was 200 mm, and the commonly used blade lengths were between 90-105 mm. The placement of the helical blade in the femoral head was evaluated using Cleveland zones and tip apex distance (TAD). Fracture reduction was assessed on the first post-operative radiograph using the Garden Alignment Index (GAI) and fracture gap measurements. Results were classified using the GAI as very good (anteroposterior 160°), good (anteroposterior 180°-160°), acceptable (anteroposterior 160°-150°), or poor (anteroposterior<150°/lateral, not 180°). The fracture gap was classified as good (0-3 mm), acceptable (3-5 mm), or poor (>5 mm). Active range of motion exercises and partial weight-bearing mobilization were started on the first postoperative day as tolerated. The proximal end of the nail protruded from the tip of the greater trochanter in 3 patients. The helical blade was centrally placed in both AP and lateral views in 12 patients. Intraoperative fractures of the greater trochanter occurred in 4 patients, with no femoral shaft fractures. The mean hospital stay was 6.5 days (range 5 -15). Sutures were removed on the 14th postoperative day. The mean follow-up period was 12.5 months (range 9 - 18). All patients were evaluated clinically using the Harris hip score and radiologically at 6 weeks, 12 weeks, 6 months, 9 months, and then every 6 months thereafter. The mean time to full weight-bearing was 6 weeks. Anteroposterior and lateral plain radiographs were obtained at each visit to assess fracture union, tip apex distance, cut-out, or lateral migration of the helical blade.

Results

Table 1 depicts the sizes of PFNA II nails used in a study of 20 patients with intertrochanteric hip fractures treated with this surgical technique. Predominance of Small and Long Nails: The majority of nails used were either "Small" (200mm, 50%) or "Long" (length not specified, 35%). This suggests that fracture patterns in this group of patients might have favored these particular nail lengths for optimal fixation. Limited Use of Standard and Very Small Nails: Standard (240mm) and very small (170mm) nails were used in only a small number of cases (10% and 5% respectively). This indicates that these lengths were less suitable for the majority of fractures in this study.

Table 1: Nail sizes used in 20 cases of intertrochanteric fractures

Nail Size	Frequency (n)	Percentage (%)
Small (200 mm)	10	50.0
Standard (240 mm)	2	10.0
Very small (170 mm)	1	5.0
Long	7	35.0
Total	20	100.0

Table 2 evaluates two key measures following hip fracture surgery. Fracture Gap: Good (0-3 mm): 15 patients (75%) had minimal fracture gaps, indicating good healing. Acceptable (3-5 mm): 3 patients (15%) had an acceptable gap, suggesting some healing but not perfect alignment. Poor (>5 mm): 2 patients (10%) had a significant gap, which could indicate incomplete healing or improper positioning of the bone fragments. GAI: Very good: 5 patients (25%) achieved the best possible alignment. Good: 10 patients (50%) had good alignment. Acceptable: 3 patients (15%) had acceptable alignment, but not ideal. Poor: 2 patients (10%) had poor alignment. The majority of patients (75% for fracture gap and 75% for GAI combined) achieved good or very good outcomes in terms of healing and alignment. This suggests that the surgical procedure was successful for most patients in our study.

Table 2: Assessment of fracture gap and GAI in the cases of the study

		Frequency	Percentage
Fracture gap	Good (0 – 3 mm	15	75.0
	Acceptable 3 – 5 mm	3	15.0
	Poor > 5 mm	2	10.0
GAI	Very good	5	25.0
	Good	10	50.0
	Acceptable	3	15.0
	Poor	2	10.0

Table 3 summarizes the complications encountered during and after surgery for hip fractures using PFNA II nails. Fracture of greater trochanter (15%): This occurred in 3 patients and is a relatively common complication during this type of surgery. Femoral shaft fracture (0%): no patients experienced this more serious complication, which involves a break in the main shaft of the femur. Postoperative Complications: Nail mismatch at the proximal end (10%): In 2 patients, the nail did not fit perfectly at the upper end of the femur. This could potentially affect the stability or alignment of the fracture. Anterior thigh pain (5%): One patient experienced anterior thigh pain, which could have various causes like muscle strain, nerve irritation, or hardware irritation. One patient had pain in the fascia lata due to laterally protruding helical blades. No patients developed a varus deformity, where the leg angles inwards at the hip joint. The mean Caput-collum-diaphyseal angle was 136.5° (range, 126° - 145°). This is a positive outcome as it indicates good alignment after surgery. One patient continued to limp after surgery, which could be due to various factors like incomplete healing, pain, or stiffness. No patients developed abnormal bone formation (heterotopic ossification) around the surgical site, which is a potential complication.

Table 3: Assessment of intraoperative and postoperative complications

		Frequency	Percentage
Intra-operative	Fracture of greater trochanter	3	15.0
	Femoral shaft fracture	0	0.0
Post-operative	Nail mismatch at the proximal end	2	10.0
	Anterior thigh pain	1	5.0
	Fascia lata pain	1	5.0
	Secondary varus development	0	0.0
	Persistent limp	1	5.0
	Heterotopic ossification	0	0.0

Table 4 depicts the functional outcomes of patients following hip surgery using the Harris Hip Score (HHS). The HHS is a scoring system used to assess pain, function, deformity, and range of motion in patients with hip problems. The scoring ranges estimated are Excellent (90-100): Minimal or no pain, good function in daily activities, and walking ability. Good (80-89): Mild pain, some limitations in strenuous activities. Fair (70-79): Moderate pain, significant limitations in daily activities. Poor

(Below 70): Severe pain, and difficulty with daily activities. The majority of patients (80%) achieved good to excellent functional outcomes following hip surgery, as measured by the Harris Hip Score. This indicates a positive impact of the surgery on their hip function. At the latest follow-up, 15 patients (75%) were able to walk independently, 4(20%) needed walkers or crutches and 1 patient (5%) were unable to walk. Walking ability to preoperative levels was restored in 17 (85.0%) patients.

Table 4: Functional assessment of the cases using Harris Hip score

Harris Hip Score	Frequency	Percentage
Excellent	7	35.0
Good	9	45.0
Fair	3	15.0
Poor	1	5.0

Discussion

The cases involving unstable intertrochanteric fractures are increasing and it is for this reason that this type of fracture is expected to increase in the future. These fractures pose many difficulties to the average Orthopedic Surgeon. Management includes Osteosynthesis with Dynamic hip screw and Cephalomedullary nails and at times, Arthroplasty. However, the most suitable implant to use in cases of unstable intertrochanteric fractures is yet to be determined. However, PFNA II is now preferred in Western countries with many trials endorsing its application [18, 19]. Despite this, research is scarce on this area in the context of the Indian population. Finally, considering our series of unstable intertrochanteric fractures treated with PFNA II, we saw good results, low complication profile, high union, short surgical procedures, and early mobilization our results are comparable with that of the other similar studies [20].

Changing to a helical blade was intended to decrease the likelihood of cut-out but cut-out of the helical blade continues to be one of the primary reasons for blade failures. It is important to note that there were no cut-outs encountered in the study. In one study, the cut-out rate was found to be between 2-25% [21, 22]. Cut-out and medial perforation of subchondral bone have been attributed to the design of helical blades [18]. Baumgaertner et al. [23] reported that the position of lag screw is ideally placed in the center-center position. The anteroposterior and axial view should have the lag screw and the helical blade placed centrally within the femoral head and neck. The tip-apex distance (TAD) was identified earlier as one of the major predictors of cut-out occurrence [24]. A 44% cut-out rate was noted for intertrochanteric fracture fixations with TAD of greater than 25 mm by Geller et al. [25] however; no cut-outs were seen when TAD was less than 25 mm. We did not observe any blade cut-outs despite 14 patients having a TAD greater than 25 mm in our series. Our findings are in agreement with Jin et al. [26] hence using an acetabular APPS blade of shorter length than usually advised due to the likelihood of fracturing the femoral head due to the collapse of the fracture site. Nikoloski et al observed the rotation in the femoral head different from that of a screw and suggested a TAD of between 20-30 mm as used in the present study of 21mm. Jin et al. [26] proposed the use of longer PFNA nails rather than shorter ones in instances of excessive anterior curvatures of the femur. In the present investigation, the direct impact of the nail tip with the anterior cortex (240 mm nail length) was observed in four cases due to increased bowing and overall femoral length in the Indian population. Similar to what the Chinese authors also observed [27], this gap between, nail design and femoral canal anatomy could be addressed by using longer nails to span the curve or short nails to avoid issues in patients with excessive anterior femoral bowing. Intraoperative femoral shaft fractures were not present in this study. In another study, Yaozeng et al. [28] they found six (5.6%) intraoperative femoral shaft fractures in their 107 intertrochanteric fractures cases. Longer nails also contribute to this complication and proper reaming of the femoral canal will prevent this complication. Boopalan et al. [29] reported a 21 % incidence of intraoperative lateral wall fractures in the management of 31 A1 and A2 per trochanteric fractures. They also discovered that the occurrence of lateral wall fractures does not impede the formation of fracture unions. Gotfried et al. [30] reported 24 cases of lateral wall fractures in their study wherein they noticed varus malalignment with medialization of the femoral shaft in all the cases. This was because the implant used was a 16 mm diameter lateral cortex drill for the sliding screw. Our study revealed six lateral wall fractures during the operation with 2 cases later developing a secondary varus collapse of 5 degrees. Not many of these fractures necessitated reoperation.

In our earlier days, we once experienced intraoperative fracture distraction. This is normally realized in cases where the wide end of the nail goes through the intertrochanteric region. The proximal fracture fragment moves up and down along the intertrochanteric line and the distal part of the nail tends to pull the femur toward the side. This may result in varusmalalignment. However, varus deformity and distraction may also be seen if the

guide wire is placed straight through the fracture line [31]. They suggest using an entry reamer after over-distracting the fracture it will ream the lateral edge of the medial fragment which was responsible for varus and distraction. To overcome such issues, we find the method described by Aithala P et al. [32] to be helpful. They recommend that the proximal fragment should be well-reamed to allow the passage of the nail and recommend the use of an assistant to apply pressure on the trochanter while they pass the proximal part of the nail. One of the most effective methods of minimizing distraction is to engage the lesser trochanteric area beneath the femoral head with long artery forceps or a Hohmann retractor and push up on the femoral head during the passage of the nail.

Conclusion

In conclusion, our study suggests that the PFNA II nail presents a promising option for the surgical management of unstable intertrochanteric fractures. This fixation method offers potential advantages of reduced operative time and a demonstrably low complication rate. However, it is essential to acknowledge that achieving these benefits hinges on the meticulous application of proper surgical technique. Optimizing fracture stability and minimizing complications relies heavily on the surgeon's skill and adherence to established best practices. Future research endeavors could focus on refining surgical techniques for PFNA II nail placement and exploring optimal patient selection criteria for maximizing the effectiveness of this approach.

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