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Original Article

A Comparative Study of Long Proximal Femoral Nail Antirotation (Long PFNA2) Versus Short Proximal Femoral Nail Antirotation (Short PFNA2) in Unstable Intertrochanteric Fractures – A Randomized Clinical Trial

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ABSTRACT

Introduction - An analysis of the results of a randomized control trial comparing the effects of short versus long proximal femoral nail antirotation on patients with unstable intertrochanteric fractures in northeastern India.

Materials and methods - Patients receiving treatment at Gauhati Medical College and Hospital for intertrochanteric fractures participated in a randomised control trial. Of the 32 patients who were enrolled in the study, 16 received short PFNA2 treatment, while the remaining patients received long PFNA2. Demographic information, peri-operative results, and complications were compared.

Results - In terms of hospital stay, time from injury to surgery, blood transfusion after surgery, and AO fracture classification, there was no discernible difference between the two groups. When compared to a long PFNA2 procedure (74-105 minutes), the surgical time for a short PFNA2 procedure was substantially shorter (62-88 minutes). In a similar vein, the long PFNA2 group experienced a significantly greater intraoperative blood loss than the short PFNA2 group. But the long PFNA2 implant had fewer complications like screw backout, varus collapse, anterior thigh pain, peri implant fractures and non union.

Conclusion - For the treatment of unstable pertrochanteric fractures, short PFNA2 can be choosen option due to its shorter surgical time, reduced blood loss, and improved learning curve with trainee surgeons. Although better stability, lesser incidence of perimplant fracture proves long PFNA2 to be a better choice in certain scenarios.

***Keywords**:* Orthopedic Surgery, Proximal Femoral Nail Antirotation, Intertrochanteric Fracture, Randomized Controlled Trial, Short versus Long PFNA2.

INTRODUCTION

Intertrochanteric fractures occur from the extracapsular basilar neck region to the area along the lesser trochanter, which is proximal to the medullary canal's development. These fractures result from damage to the fragile cortical bone, intersecting cancellous compression and tensile lamellar networks, and the proximal metaphyseal region. This damage leads to fracture fragment displacement and associated muscle group involvement.

Fractures in adults over 50 are primarily caused by low-energy falls, accounting for 90% of cases, with a higher frequency in women. In contrast, high-energy trauma is the usual cause of intertrochanteric fractures in children and adolescents. The primary goal in treating these fractures is to achieve a painless, stable, and functional hip joint. Treatment options include conservative measures, extramedullary, and intramedullary internal fixation techniques, each with its own advantages and disadvantages.

Unstable fracture patterns are particularly challenging, as they require more recovery time and involve greater surgical complexity. Unstable features include displaced greater trochanteric (lateral wall) fractures, basicervical patterns, reverse obliquity patterns, posterior-medial fragmentation, and an inability to reduce the fracture before fixation. Post-surgical stability indicates the probability of a successful union without deformity or implant failure. However, significant deformities may arise from sliding implant devices. A critical aspect of current implant selection is determining the acceptable degree of deformity and fracture site motion for full functional recovery. [1]

Since the initial reports of surgical treatment for pertrochanteric fractures, certain patterns—such as subtrochanteric fractures, reverse obliquity fractures, and fractures with lateral wall extension—have been shown to be unsuitable for simple screw/nail side-plate devices. Worldwide, cephalomedullary nails (CMNs) are widely used to treat intertrochanteric fractures, with intramedullary repair rates increxasing significantly from 3% to 67% in the US and Europe. [2] Research in the late 20th century focused on reducing implant failure and cutout of the femoral head and neck components, even if it meant accepting some loss of fracture reduction. Initially, CMNs were all short, but full-length nails were developed due to concerns about stress risers and breakage at the nail tip. [3] Older nail designs had postoperative femoral shaft fracture rates ranging from 6% to 17%. [4]

Improved nail designs have reduced the incidence of peri-prosthetic fractures, though the risk persists. Both short and long CMNs are used to treat intertrochanteric fractures, with each type offering unique advantages and disadvantages. [5] Short PFNA2 nails, for instance, reduce perioperative blood loss, operating time, and blood transfusion rates. However, they may cause anterior thigh pain, peri-prosthetic fractures, and inadequate diaphyseal fixation in cases with subtrochanteric extension. Long PFNA2 nails, on the other hand, have lower incidences of postoperative thigh pain and peri-prosthetic fractures and can address fractures with subtrochanteric extension. Their disadvantages include longer operative times, greater perioperative blood loss, and increased transfusion rates. Additionally, curve mismatches between the nail and femoral bow may perforate the anterior cortex.

The optimal choice between short and long PFNA2 nails remains unclear, as the literature provides no definitive consensus. This study aims to determine a reliable conclusion regarding the use of short versus long PFNA2 nails for managing unstable intertrochanteric fractures effectively.

METHODS

Study Design

This is a randomized prospective analytical study. After obtaining approval from the hospital's ethical committee, patients meeting the inclusion criteria were evaluated. These patients were informed about the operative procedure, and 32 patients were selected for the study. After completing the required clinical and laboratory evaluations, informed consent was obtained. Patients were then randomized into two groups using a randomization chart:

- **Group A**: Patients treated with short proximal femoral nail anti-rotation (SHORT PFNA2).
- **Group B**: Patients treated with long proximal femoral nail (LONG PFNA2).

The clinical and radiological outcomes were evaluated using the Harris Hip Score and serial X-rays at 2 weeks, 6 weeks, and 6 months post-operatively. Any complications occurring during the study period were also recorded.

Exclusion Criteria

Patients meeting any of the following criteria were excluded from the study:

- Compound fractures.
- Pathological fractures.
- Bone metabolism disorders other than osteoporosis.
- Co-morbidities that rendered them unsuitable for surgery.
- Patients under the age of 18.

Pre-Operative and Post-Operative Care

As soon as patients were medically stable and suitable for anesthesia, surgery was performed.

- **Pre-operative care**: Preventive antibiotics were administered to all patients.
- **Post-operative care**: Analgesics, including NSAIDs and opioid analgesics, were provided to manage pain for the first few days and subsequently as needed. Patients were encouraged to sit up in bed the day after surgery, and quadriceps-strengthening exercises were introduced. Measures to prevent pressure sores and deep vein thrombosis (DVT) were implemented. Most patients were discharged on the third post-operative day.
- **Follow-up**: Stitches were removed after one week, with subsequent follow-ups scheduled at 2 weeks, 1 month, and monthly thereafter up to 6 months.

Surgical Intervention and Implant Used

- Thirty minutes prior to the surgical incision, injectable third-generation cephalosporin antibiotics were administered to all patients.
- Patients were given either spinal or epidural anesthesia, depending on the anesthetist's preference, and positioned supine on a radiolucent fracture table.
- Traction was applied to the operating limb. Internal fixation was performed using either a short or long PFNA2 implant, depending on the group assignment. Reduction was achieved either by closed or open methods.

Outcome Measures

The primary outcomes were clinical and radiological results, assessed using the Harris Hip Score and serial X-rays. Secondary outcomes included recording any complications during the study period.

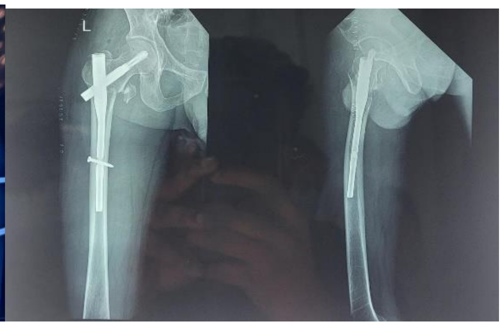

Figure 1 **Figure 2**

Figure 1 and 2 showing pre operative and immediate post operative xray of an unstable pertrochanteric fracture treated with short PFNA2 nail

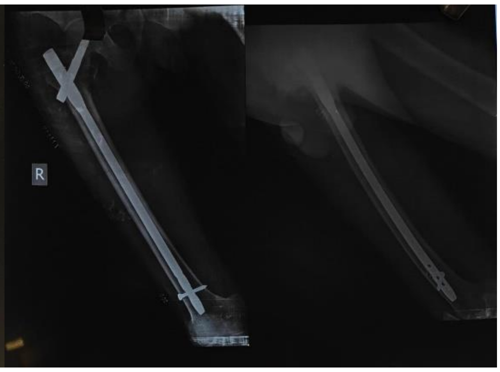

Figure 3 **Figure 4**

Figure 3 and 4 showing pre operative and post operative xray of an unstable pertrochanteric fracture treated with long PFNA2

Post operative protocol and outcome evaluation

Post-Operative Care

1. **Antibiotics:**
   Intravenous antibiotics (ceftriaxone 1 gram and amikacin 500 mg) were administered every 12 hours for at least 72 hours post-operatively. Patients were then transitioned to oral antibiotics.
2. **Mobilization and Physical Therapy:**
   - On the second post-operative day, patients were permitted to sit upright in bed, and static quadriceps exercises were initiated along with knee and ankle physical therapy.
   - For patients with osteoporotic bones, weight-bearing was delayed and started only after evaluating the fracture's stability and fixation suitability.
3. **Wound Care and Discharge:**
   - On the third post-operative day, the wound was examined for the first time. Following satisfactory wound inspections, patients were discharged.
   - Sutures were removed on the fourteenth day after surgery.
4. **Follow-Up:**
   - Patients were monitored every six weeks until the fracture healed, with X-rays taken at each visit to evaluate fracture union and identify any complications. After healing, follow-up was conducted every three months.

Study Parameters and Outcome Measures

1. **Patient Data:**
   - **Preoperative Parameters:** Age distribution, sex distribution, limb side distribution, mode of injury, fracture pattern, and time elapsed between injury and procedure.
   - **Intraoperative Parameters:** Duration of surgery and estimated blood loss.
   - **Postoperative Outcomes:** Duration of hospital stay, anterior thigh pain, time to union, and Harris Hip Score.
2. **Harris Hip Score:**
   - Functional outcomes were assessed using the Harris Hip Score, which involves a questionnaire with ten fundamental components, each scored out of a possible 100 points.
3. **Radiological Assessment:**
   - At each follow-up, AP and lateral view radiographs were examined to check for the following:
     - Screw cut-out.
     - Symptomatic back-out of the screw.
     - Implant breakage.
     - Peri-prosthetic fractures.
     - Varus collapse (change in neck shaft angle > 5 degrees).
     - Union, non-union, or mal-union.
     - Z effect and reverse Z effect.

RESULTS

Study Populations and Demographic Characteristics

1. **Age Distribution:**
   - The mean age of patients in Group A was 64.1 ± 11.56 years, while in Group B, it was 61.1 ± 10.4 years.
   - Most patients in Group A were aged 51 to 78, whereas those in Group B were between 45 and 76 years.
2. **Gender Distribution:**
   - A total of 12 females underwent surgery: 7 in Group A and 5 in Group B.
   - Of the 20 male patients, 11 were assigned to Group B and 9 to Group A.
   - The male-to-female ratio in the study was 5:3.
3. **Side of Fracture:**
   - Left-sided trochanteric fractures were observed in 9 patients from Group A and 7 from Group B.
   - Right-sided fractures occurred in 8 patients in Group B and 6 in Group A.
4. **Mode of Injury:**
   - A trivial fall was the most common cause of injury, accounting for 68.75% of all cases.
     - Group A: 12 patients (75%) sustained injuries due to a trivial fall.
     - Group B: 10 patients (62.5%) had injuries caused by a trivial fall.
   - Traffic accidents accounted for 3 cases (18.75%) in Group A and 6 cases (37.5%) in Group B.
   - One patient in Group A was injured from a fall from height.
5. **Time from Injury to Operation:**
   - The average time from injury to surgery was 8.6 ± 3.15 days for Group A and 5.8 ± 3.62 days for Group B.

Operative Data

1. **Duration of Surgery:**
   - The average procedure time for Group A was 75.4 ± 8.62 minutes, while for Group B, it was 88.6 ± 9.38 minutes.
   - Almost all surgeries in Group A were completed in less than 90 minutes.
2. **Fracture Patterns:**
   - The AO31A2 type was the most prevalent fracture pattern:
     - 10 cases in Group A.
     - 9 cases in Group B.
   - Each group had 4 patients with the A1 type.
   - The more complex A3 pattern was observed in 5 patients (3 in Group B and 2 in Group A).
3. **Blood Loss:**
   - Blood loss was calculated by adding 50 milliliters per mop to the blood volume collected in the suction device:
     - Group A: 102 ± 48.5 ml.
     - Group B: 133.8 ± 39.4 ml.
   - Open reduction, which causes greater blood loss, was required for 3 patients in Group A and 2 in Group B.

Post-Operative Data

1. **Hospital Stay:**
   1. The average length of hospital stay was 5.3 ± 1.75 days for Group A and 6.5 ± 2.45 days for Group B.
2. **Fracture Union:**
   1. Union was achieved in 93.7% of patients in both the long and short PFNA2 groups, representing 15 patients in each group.
   2. The mean union time for Group A was 17.84 ± 3.76 weeks, while for Group B, it was 16.77 ± 2.05 weeks.

Table 1 - Table showing Preoperative patient characteristics in short and long PFNA2 groups

Patient variable	Short PFNA2 group	Long PFNA2 group
Age		
Average (years)	64.1 ± 11.56	61.1 ± 10.4
Range (years)	51 to 78	45 to 76
Sex		
Male	9	11
Female	7	5
Mode of injury		
Fall from height	12	10
RTA	3	6
Trivial fall	1	0
AO/OTA Classification		
AO31A1	4	4
AO31A2	10	9
AO31A3	2	3

Table 2 - Table showing intraoperative assessment in short and long PFNA2 groups

Patient variable	Short PFNA2 group	Long PFNA2 group	P value
Duration of Procedure (in minutes)			
Average			
Range	75.4 ± 8.62 62-88	88.6 ± 9.38 74-105	0.0003
Estimated blood loss (ml)			
Average			
Range	102 ± 48.5 45-158	133.8 ± 39.4 87-179	0.054

Table 3 - Table showing complications and post operative assessment in short and long PFNA2 group

Parameters	Short PFNA2	Long PFNA2	P value
Duration of hospital stay (in days)			
Average			
Range	5.3 ± 1.75 3-8	6.5 ± 2.45 3-10	0.120
Time to full weight bearing (in weeks)			
Average	8.3 ± 2.25	5.6 ± 1.2	
Range	5-11	4-8	
Time to union (in weeks)			
Average	17.84 ± 3.76	16.77 ± 2.05	0.324
Range	12 – 24	13 – 21	
Complications			
Screw cut out	0	0	
Superficial wound infection	2	2	
Anterior thigh pain	2	0	
Screw back out	1	0	
Varus collapse	1	0	
Non Union	1	1	

Functional Outcomes

1. **Assessment Tool:**
   - Functional outcomes were evaluated using the Harris Hip Scoring System at the most recent follow-up.
2. **Overall Results:**

- The mean Harris Hip Score was:
  - Group A: 84.1 ± 12.62.
  - Group B: 82.3 ± 13.44.
- The difference between the two groups was statistically insignificant.

3. **Score Distribution:**
   - Twenty-one patients achieved a good to excellent score (>80).
   - Two patients in each group had lower score

Table 4 - Table showing Harris Hip score as an indicator for outcome for functional outcome in short and long PFNA2 goups

Harris Hip score	Short PFNA2 group	Long PFNA2 group	P value
Average	82.3 ± 13.44	84.1 ± 12.62	0.7
90-100 (Excellent)	2	3	
80-90 (Good)	8	8	
70-80 (Fair)	4	3	
<70 (Poor)	2	2	

Complications

1. **Revision Procedures:**
   - Two revision surgery was required for short PFNA2 group while one case of Long PFNA2 needed revision surgery
   - In the short PFNA2 group, revision was due to a varus collapse caused by screw back-out and non union.
   - In the long PFNA2 group, revision was needed due to non union.
2. **Non-Union Cases:**
   - One case of non-union was reported in each group.
3. **Infections:**
   - Both groups experienced two cases of superficial wound infection, which resolved with systemic antibiotics and did not require additional debridement.
4. **Patient Complaints:**
   - Two patients in the short PFNA2 group reported anterior thigh pain.
5. **Other Observations:**
   - No cases of deep infection, screw cut-through, reverse Z effect, or mortality were reported in either group.

DISCUSSION

In the elderly population with osteoporosis, hip fractures are a major concern, with a considerable mortality and morbidity rate [6]. This issue is compounded by a growing aging population, and as the number of fragility hip fractures rises over time, the associated expenses are also expected to increase. Nearly 90% of hip fractures occur following a fall [7]. The best measure for predicting pertrochanteric fractures has been shown to be bone mineral density (BMD) of the trochanteric region of the femur, as determined by dual-energy X-ray absorptiometry (DXA) [8]. The purpose of this study was to determine the ideal nail length by comparing the outcomes of treating intertrochanteric fractures with short and long PFNA2. In our study, 32 patients with intertrochanteric fractures were prospectively evaluated after being treated with either a short or long PFNA2. They were randomly assigned to one of the groups using computer-based random number tables, and various parameters and results were compared with those of other comparable studies. According to a femur finite element (FE) model study, pertrochanteric fractures generate 621 MPa of stress, with the intramedullary implant's lag screw hole experiencing the highest stress concentration [9]. The FE model also revealed the highest interfragmentary movements between the proximal and distal fracture fragments in both axial and transverse directions, causing fracture fragments to slide and open. The angle of nail insertion during surgery, which influences the pre-stress of the nail, is a critical factor [9]. Lag screw cutout in the treatment of pertrochanteric fractures is a well-documented complication. Ideal lag screw placement, with a tip-apex distance of less than 25 mm, minimizes the risk of screw cutout [10]. Multiplanar cyclic loading can cause femoral head rotation, as shown in cadaveric studies, leading to rotational cutout and varus collapse, particularly with eccentrically positioned lag screws. This rotational effect occurs in about 12% of collapsing pertrochanteric fractures with lag screw cutout [11]. The PFNA2 helical blade is designed to counteract these rotational effects. In our study, the average patient age was 62.6 years. Patients in the Long PFNA2 group ranged from 45 to 76 years, with a mean age of 61.1 ± 10.4 years, while those in the Short PFNA2 group ranged from 51 to 78 years, with a mean age of 64.1 ± 11.56 years. A study by Guo reported an average age of 82.7 years in the short nail group and 78.9 years in the long nail group, indicating differences likely due to variations in population life expectancy [12]. The sex distribution in most studies demonstrates a female preponderance, attributed to the higher prevalence of osteoporosis in women at older ages. Zhi Li's study reported 20 men and 39 women in the long nail group and 46 men and 51 women in the short nail group, showing a clear female preponderance [13]. However, in our study, the male-to-female ratio was 5:3, with 20 men and 12 women. The Long PFNA2 group had five female and eleven male patients, while the Short PFNA2 group had seven female and nine male patients. This male preponderance in our study may reflect demographic differences, given our younger and more active study population.

Duration of surgery

The operational time was reduced because the short PFNA2 did not necessitate full reaming of the medullary canal before nail insertion. Moreover, distal locking could be accomplished with zig. However, because of discrepancies between the curvature of the nail and the anterior bowing of the femur, inserting a long nail required full length serial reaming of the intramedullary canal, being careful not to puncture the anterior cortex. Moreover, image assistance was necessary for distal locking in the long PFNA2 in order to guarantee that the drill was aimed accurately. The average operating time for short intramedullary nail fixation (56.8 ± 19.4 minutes) was significantly longer (P value 0.001) than for short nail fixation (44.0 ± 10.7 minutes), according to a study by Boone [14]. The short nail group's operating time was significantly shorter (43.5 min ± 12.3 min) than the long nail group's (58.5 min ± 20.3 min) (P value 0.002), according to a similar study by Guo [15]. The mean surgical time for the short PFNA2 group in our study was substantially less than that of the long PFNA2 group. The average operating time for the Long PFNA2 group was 88.6 ± 9.38 minutes (range 74-105 minutes), compared to 75.4 ± 8.62 minutes (range 62-88 minutes) for the Short PFNA2 group (0.003 P-value).

Functional outcomes

At each follow-up after radiological union, the Harris Hip Score (HHS) was used to evaluate functional outcomes, with the score at the last follow-up also assessed. Both groups demonstrated similar and good Harris hip scores, indicating no clear functional benefit to using one implant over the other. In the long PFNA2 group, the HHS was 82.3 ± 13.44, ranging from 51 to 93 (P value 0.8657), while in the short PFNA2 group, it was 81 ± 11.62, ranging from 46 to 91. These findings suggest that both long and short PFNA2 implants are effective in treating intertrochanteric fractures and can be used interchangeably. Similar results were observed in other studies. Ocku reported an average HHS of 79 in the long nail group and 74 in the short nail group at the last follow-up [16]. Zhi Li's study also found comparable outcomes, with an average HHS of 76.16 in the long nail group and 79.98 in the short nail group [13]. The average time for full weight bearing was 8.3 ± 2.25 weeks for short PFNA2 and 5.6 ± 1.2 weeks for long PFNA2. The findings are comparable to study conducted by Gagandeep Singh. The findings from both studies indicate that neither implant offers a significantly superior functional outcome compared to the other.


Figure 5


Figure 6


Figure 7

Figure 5, 6, 7 showing functional outcome of a patient treated with short PFNA2



Figure 8, 9, 10 showing functional outcome of a patient treated with long PFNA2

Radiological outcomes

Simpler fractures generally heal more quickly when managed with accurate anatomical reduction. Younger, active individuals tend to experience earlier fracture union compared to elderly women with osteoporosis and reduced pre-injury mobility. In this study, fracture union was observed in 31 patients, including all 16 in the short PFNA2 group and 15 patients in the long PFNA2 group. The average union times were nearly identical between the groups: 17.84 ± 3.76 weeks in the short PFNA2 group (range: 12-24 weeks) and 16.77 ± 2.05 weeks in the long PFNA2 group (range: 13-21 weeks), with no statistically significant difference (P = 0.324). Previous studies have reported mixed results: Zhi Li observed no significant difference in union times between the groups [13], Mahesh noted faster union in the short nail group [17], and Shyam Kumar found quicker union with the long nail group [18].

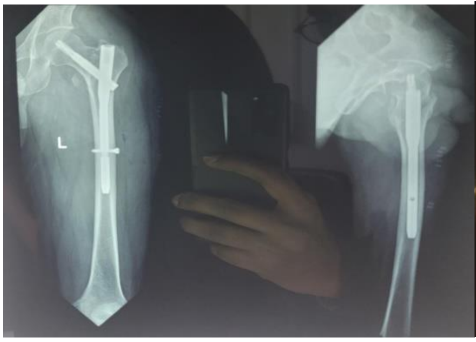

Figure 11 **Figure 12**

Figure 11 – Follow up xray showing union in a patient treated with Short PFNA2
Figure 12 – Follow up xray showing union in a patient treated with Long PFNA2

Complications

This study defined implant failure as either a periprosthetic fracture or hardware breakage requiring revision treatment. Two cases in the short PFNA2 group required revision procedures, while one patient in the long PFNA2 group required a similar intervention. In the short PFNA2 group, one case involved screw back-out leading to varus collapse and necessitating reoperation, along with one case of non-union. In the long PFNA2 group, a single case of non-union was observed.

Superficial wound infections occurred in four patients, with two in each group, and were successfully treated with systemic antibiotics without the need for further debridement. Anterior thigh pain was reported by two patients in the short PFNA2 group and no patient in the long PFNA2 group. Femoral shaft fractures near the distal nail tip were noted exclusively in the short PFNA2 group, while none were observed in the long PFNA2 group. Parmar reported a higher incidence of Z-effect and reverse Z-effect complications in the short nail group (2 and 3 cases, respectively) compared to the long nail group (0 and 1 case) [19]. The study concluded that using long nails minimizes complications such as anterior thigh pain and femoral shaft fractures.

Several comparative studies support these findings. Josh Vaughn reported a higher secondary fracture rate with short nails (3.33%) compared to none in the long nail group (P = 0.054), indicating an increased risk of femoral re-fracture with short cephalomedullary nails (CMNs) [20]. Similarly, Zhi Li's retrospective study showed a lower failure rate in the long nail group (0/59) compared to the short nail group (3/97), with long nails also associated with reduced postoperative hip pain [13]. Nicholas B. Frisch noted fewer periprosthetic fractures with long nails (short nail: 8.3%, long nail: 0%, P = 0.013), although the long nails exhibited a higher trend of screw cutouts (long nail: 5.2%, short nail: 0%, P = 0.134) [21].

Other studies further highlight the comparative outcomes. Kleweno reported an overall periprosthetic fracture rate of 2% (11/559), with short nails showing a slightly higher rate (2.7%) compared to long nails (1.5%) [22]. Meanwhile, Okcu observed no significant differences in reoperation or mortality rates between short and long nails in a pilot trial on reverse obliquity fractures [16]. Guo's retrospective study also identified one case of periprosthetic fracture in each group [12]. Collectively, these findings suggest that while short and long nails have similar overall complication rates, long nails are associated with fewer femoral fractures and postoperative pain, making them a more reliable option in specific cases.

Figure 13 **Figure14**

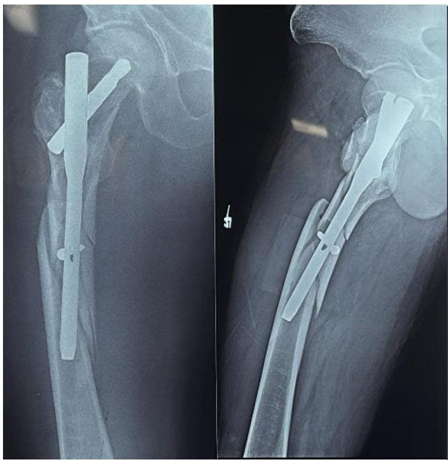

Figure 15

Figure 16

Figure 17

Figure 13 showing pre op xray of an intertrochanteric fracture, Figure 14 showing fracture union treated with short PFNA2, Figure 15 showing peri implant fracture in short PFNA2 follow up, Figure 16 showing the post op xray of peri implant fracture treated with long PFNA2, Figure 17 showing 3 month follow up Xray of the patient after being treated with long PFNA2

CONCLUSION

The PFNA2 is an effective implant for managing unstable pertrochanteric fractures, with both short and long nails delivering excellent outcomes. Neither implant shows a significant advantage over the other regarding estimated blood loss, fracture union, complications, reoperation rates, hospital stay, or Harris hip score. However, the choice of implant should be individualized based on the patient's specific characteristics to achieve optimal results.

For younger male patients, the short PFNA2 may be preferred due to advantages such as a shorter mean operative time. Conversely, in frail and elderly patients, a full-length PFNA2 is recommended to minimize the risk of stress risers. However for unstable pertrochanteric fractures, due to better stability and lesser chance of implant failure, long PFNA2 is preferred. Further studies are warranted to assess long-term outcomes, including the potential for avascular necrosis of the femoral head, which could impact clinical scores and influence treatment preferences.

Conflict of interest

There are no conflict of interest.

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