Acta Ortopédica Mexicana 2024; 38(5): Sep.-Oct. 298-306

Original article

doi: 10.35366/117378

Comparative outcomes of PFN vs PFNA2 nailing for osteoporotic unstable intertrochanteric fractures in the elderly

Resultados comparativos del empleo de clavos PFN frente a PFNA2 para fracturas osteoporóticas inestables intertrocantéricas en ancianos

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ABSTRACT. Introduction: fixation of unstable intertrochanteric fractures presents a significant challenge, especially in the context of osteoporosis. Intramedullary implants have been established as superior to plate constructs. Our aim is to compare the complications and clinical outcomes of the Proximal Femur Nail (PFN) and Proximal Femur Nail Antirotation-2 (PFNA2) in managing unstable intertrochanteric fractures. **Material and methods:** a total of 212 patients meeting inclusion and exclusion criteria underwent fixation of trochanteric fractures using either a standard PFN (n = 110) or PFNA2 (n = 102). Their intraoperative and postoperative clinical and radiographic data were evaluated along with the quality of fixation. Data analysis was performed using the student's t-test, χ^2 test, and Mann-Whitney U test. **Results:** PFNA2 demonstrated more favorable outcomes compared to PFN in terms of a better intraoperative profile, functional outcomes (PFNA2: PFN = 82:75), and fewer implant-related complications. Significant issues in the PFN group included screw back-out, guidewire breakage, and proximal protrusion of the nail tip. In contrast, locking mechanism failure and lateral screw prominence were significant problems in the PFNA2 group. **Conclusion:** PFNA2 is the preferred implant for managing osteoporotic unstable intertrochanteric fractures, given the bone's weak inherent tendency to secure the implant.

Keywords: complications, intertrochanteric fractures, proximal femur nail.

RESUMEN. Introducción: la fijación de fracturas intertrocantéreas inestables presenta un desafío importante, especialmente en el contexto de la osteoporosis. Se ha demostrado que los implantes intramedulares son superiores a las construcciones con placas. Nuestro objetivo es comparar las complicaciones y los resultados clínicos del clavo de fémur proximal (PFN) y el clavo de fémur proximal antirotación-2 (PFNA2) en el tratamiento de fracturas intertrocantéreas inestables. **Material y métodos:** un total de 212 pacientes que cumplían con los criterios de inclusión y exclusión se sometieron a fijación de fracturas trocantéricas utilizando un PFN estándar (n = 110) o PFNA2 (n = 102). Se evaluaron sus datos clínicos y radiográficos intraoperatorios y postoperatorios junto con la calidad de la fijación. El análisis de los datos se realizó mediante la prueba t de Student, la prueba de χ^2 y la prueba U de Mann-Whitney. **Resultados:** PFNA2 demostró resultados más favorables en comparación con PFN en términos de un mejor perfil intraoperatorio, resultados funcionales (PFNA2: PFN = 82:75) y menos complicaciones relacionadas con los implantes. Los problemas importantes en el grupo PFN incluyeron el retroceso del tornillo, la rotura de la guía y la protrusión proximal de la punta del clavo. Por el contrario, la falla del mecanismo de bloqueo y la prominencia lateral del tornillo fueron problemas importantes en el grupo PFNA2. **Conclusión:** PFNA2 es el implante preferido para el tratamiento de fracturas intertrocantéreas inestables osteoporóticas, dada la débil tendencia inherente del hueso a asegurar el implante.

Palabras clave: complicaciones, fracturas intertrocantéreas, clavo de fémur proximal.

Level of evidence: III

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Received: 01-23-2024. Accepted: 02-21-2024.

How to cite: Dahuja A, Khatri K, Kaur R, Bansal K, Singh S. Comparative outcomes of PFN vs PFNA2 nailing for osteoporotic unstable intertrochanteric fractures in the elderly. Acta Ortop Mex. 2024; 38(5): 298-306. https://dx.doi.org/10.35366/117378

Introduction

Reverse oblique intertrochanteric fractures represent 2-23% of all trochanteric fractures[1,2,3,4,5] and are classified by the AO classification as AO31A3. Increasing clinical evidence supports the use of intramedullary devices for these fractures, with large national registry data from Norway recently advocating for intramedullary devices over sliding hip screws.[5]

Complications with peritrochanteric fractures primarily arise from fixation issues rather than from union or delayed union, as the peritrochanteric area consists of cancellous bone.[3,6] The strength of the fracture fragment-implant assembly depends on various factors, including bone quality, fragment geometry, reduction quality, implant design, and implant placement.[3,6] Among these factors, surgeons can directly control the quality of the reduction, the choice of implant, and its placement. The preferred type of fixation device for intertrochanteric fractures remains a subject of debate.[5]

While the Proximal Femoral Nail (PFN) has shown superiority over extramedullary devices for unstable intertrochanteric fractures, complications such as screw cut-out, back out, varus collapse, and rotational instability remain significant postoperative issues, with complication rates up to 31% reported in the literature.[7] Introduced in 2003, the Proximal Femoral Nail Antirotation (PFNA) utilizes a helical blade instead of the conventionally used two screws, believed to provide stability, compression, and rotational control of the fracture. Theoretically, it compacts the bone during insertion into the femoral neck, thereby offering higher cut-out strength compared to other devices. This characteristic potentially reduces the chance of implant failure, especially in elderly, osteoporotic bones. This study was undertaken to compare these two types of intramedullary devices in managing unstable intertrochanteric fractures.

Table 1: Demographic data of the patients.

	PFN group	PFNA2 group
Number of patients (n)	110	102
Mean age (years)	66 (61-82)	69 (62-84)
Sex (M:F)	2:3	4:5
AO classification 31A. 2.2: 2.3: 3.1	78: 23: 9	69: 27: 6
Patients with significant osteoporosis	42/110	37/102

PFN = Proximal femur nail. PFNA2 = Proximal femur nail antirotation-2.

Materials and methods

Between January 2012 and June 2021, 240 adults with trochanteric fractures were operated on at our tertiary care hospital, and their data were evaluated. Patients over the age of 55 years with acute unilateral trochanteric fractures classified as AO/ASIF 31-A2 and AO 31-A3, who were independent ambulators prior to injury, were included and prospectively studied. Institutional ethical clearance was obtained (GGS/IEC/18/30). Patients with pathological fractures, open fractures, polytrauma, neuromuscular disorders, or severe cardiopulmonary insufficiency were excluded. A total of 212 patients meeting the inclusion and exclusion criteria underwent Closed Reduction and Internal Fixation (CRIF) of trochanteric fractures with either a standard Proximal Femoral Nail (PFN) (n = 110) or Proximal Femoral Nail Antirotation (PFNA2) (n = 102) as shown in demographics *(Table 1)*. All patients provided written informed consent before the surgery.

Surgical exposures for both implants were similar, except for the techniques and instrumentation used in each system. Background and demographic variables, including age, gender, associated comorbidities, and pre-injury ambulatory status, were obtained. Fracture types were assessed and recorded as per the AO/ASIF classification system using orthogonal radiographs of the affected hip. All patients were administered spinal or epidural anesthesia and positioned supine on a fracture table prior to closed reduction of the fracture. Perioperatively, the duration of surgery, amount

Table 2: Intraoperative/Perioperative details of the patients.

	PFN group (n =110)	PFNA2 group (n = 102)	p
Operative time (min)	54 (39-97)	44 (32-77)	< 0.05
Blood loss (ml)	121 (96-214)	91 (58-146)	< 0.05
Blood transfusion (units)	9	6	0.64
Fluoroscopy time (sec)	51 (33-86)	37 (28-71)	< 0.05
Reduction criteria			
TAD > 25 mm	9	11	0.8
Screw placement (suboptimal)	8	6	0.7
Neck shaft angle (± > 100)	18	6	< 0.05
Length of hospital stay (days)	6 (4-14)	6 (3-15)	-
Reoperation	3	2	-

TAD = tip apex distance. PFN = Proximal femur nail. PFNA2 = Proximal femur nail antirotation-2.

Figure 1: Anteroposterior pelvic radiograph showing backout of PFN screws and proximal protrusion of PFN nail.

Figure 2: Anteroposterior right hip radiograph showing broken guide wire with single screw.

of blood loss, and the number of images shot on the image intensifier were recorded.

All patients received three doses of prophylactic antibiotics, including the pre-operative dose given within 30 minutes prior to the skin incision. Postoperatively, all patients received thromboprophylaxis with low molecular weight heparin for the duration of the hospital stay or the first 10 postoperative days, whichever was shorter, followed by aspirin for four weeks. All patients were allowed touch-down weight- bearing ambulation using a walking frame starting from the first postoperative day until six weeks, after which progressive weight bearing was allowed depending on the status of fracture union.

Fractures were classified using the AO alphanumeric classification[8] after obtaining radiographs - an anteroposterior view of the pelvis with both hips and a lateral view of the affected hip. Singh's index[9] was used to grade the radiographs for the degree of osteoporosis. Preoperative and postoperative hemoglobin levels and units of blood transfused were recorded. The operative time was documented as per the anesthesia record sheet.

The quality of reduction was assessed by comparing the neck-shaft angle of the operated hip to that of the normal hip on the anteroposterior view. A variation of less than 5 degrees from the normal side was considered a «good» reduction. Between 5 and 10 degrees of variation was considered 'acceptable', and more than 10 degrees of variation was considered «poor».[10] The quality of fixation was assessed using the tip-apex distance described by Baumgaertner MR[11] and the Cleveland index.[12]

Clinical and radiological assessments of fracture union/ complications for all patients were done pre- operatively and post-operatively at six weeks, three months, six months, and one year. Functional evaluation was conducted at 1-year post-op using the Harris Hip Score.

Statistical Analysis

Statistical analysis was performed using SPSS software (IBM Version 20). The statistical difference between

Figure 3: Fluoroscopy imaging of the hip showing guide wire in the coxofemoral joint.

Figure 4: Anteroposterior hip radiograph showing «Z effect» of PFN as a complication: proximal screw into the joint with varus collapse. Smaller proximal PFN screw doesn't hold well in osteoporotic bone whereas a larger screw can lead to «Z effect».

continuous variables was assessed using the student's t-test. Categorical variables were compared using the χ^2 test. Statistical significance was set at a P-value of 0.05 or less. χ^2 and student T test used to check significance.

Results

Our study consisted total of 212 patients with the demographics as shown in *Table 1*. There was female preponderance with 37% of osteoporotic patients. Average operative time, fluoroscopy time and blood loss were significantly lower in PFNA2 group as shown in *Table 2*.

The average operative time in PFNA2 group was 44 min as compared to 54 min in PFN group. Average blood loss was also lower in PFNA2 group (PFN: PFNA2; 121 ml: 91 ml). The fluoroscopy time was significantly lower in PFNA2 group.

There was no difference in the average length of hospital stay and reoperation rate in both the groups.

Implant related complications like screw back out *(Figure 1)*, guide wire breakage *(Figures 2 and 3)*, Z effect *(Figure 4)*, TAD outliers *(Figure 5)* were more in PFN group whereas lateral screw protrusion, locking mechanism failure and barrel disengagement was more in PFNA2 group as shown in *Figures 6-9*. Neck shaft valgus outliers are more common in PFN group *(Figure 10)*.

There was no difference between the two groups in terms of surgery related complications, except for early postoperative limb length discrepancy, which was significantly higher in PFN group *(Table 3)*.

There was significant hip pain and varus malalignment in PFN group as shown in *Table 4* and *Figure 11*. Walking aid requirement was relatively on higher side in PFN group (PFN: PFNA2; 13:9) at six months as shown in *Figure 12*. Persistent pain (PFN: PFN2; 23:14), limb length discrepancy (PFN: PFNA2; 11:4) and varus malalignment (PFN: PFNA2; 19:11) was significantly higher in PFN group.

Favorable results of PFNA2 over PFN in terms of better intraoperative profile, functional outcome (PFNA2: PFN = 82:75) and minimum implant related complications are shown in *Figure 13*.

Discussion

The literature suggests that the Proximal Femoral Nail (PFN) is a reliable method for treating peritrochanteric femur fractures. However, technical complications, such as intraoperative placement issues, cut-out, and the Z-effect in screws of proximal fixation, have been reported.[10,13] The Proximal Femoral Nail Antirotation-2 (PFNA) was designed to simplify the technique and reduce implant-related complications. Replacing column screws with a helical blade increases the contact surface area between the holding device and the cancellous bone of the femoral head, enhancing stability in fracture fixation and significantly higher rotational torques, as demonstrated in biomechanical studies.[10,14,15,16,17]

Intraoperative data favored the PFNA group compared to the PFN group, with surgical duration, blood loss, and fluoroscopy time being significantly lower, supporting

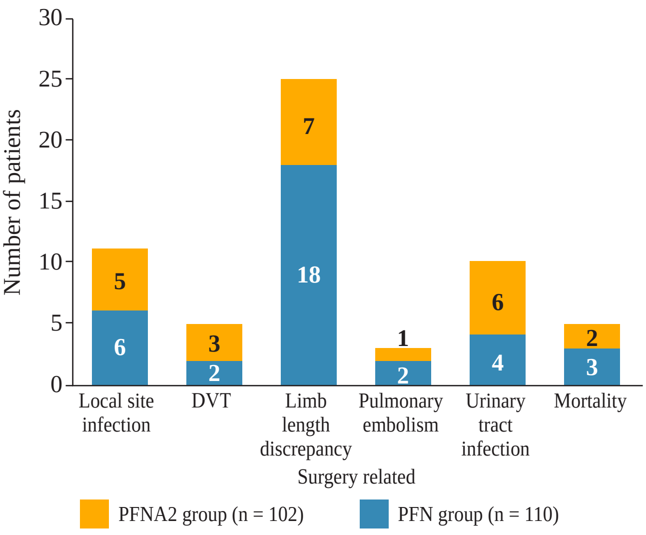

Figure 6: Comparing surgery related complications in both the groups.

Figure 5: Radiographic series of right hip showing TAD outliers in PFNA2 but long-term good results.

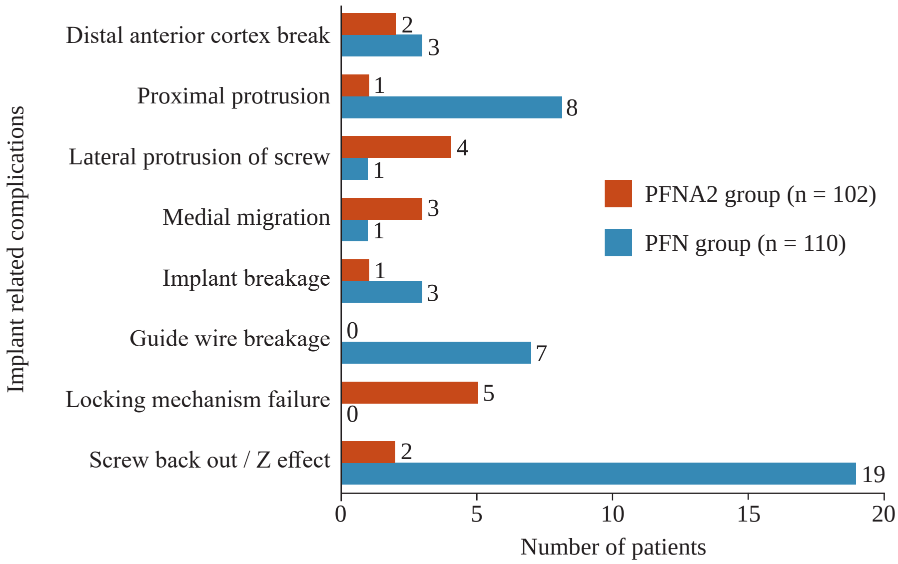

Figure 7:

Comparison of implant related complications in both the groups.

Figure 8: Radiographic series of left hip showing locking mechanism failure of a long helical screw.

Figure 9: Anteroposterior hip radiographs showing barrel disengagement of helical blade of PFNA2.

findings from previous studies.[18,19] Kashid MR et al. and Xie et al. found similar functional results between PFNA and PFN, but PFNA significantly reduced surgery time, blood loss, and fluoroscopy time.[9,18,19]

We observed nearly double the number of complications in the PFN group compared to the PFNA2 group, with implant-related complications constituting a significant portion, reinforcing findings from previous studies.[20,21,22,23] Gardenbroek et al. found that the risk of secondary late complications and reoperation is much higher with PFN than with the helical blade device.[20] Overall, implant-related complications were 34% in the PFN group.[7,20,21,22,23]

Implant-related complications, such as screw back-out, guidewire breakage, and proximal protrusion, were more pronounced in the PFN group, whereas lateral screw protrusion and medial migration were notable in the PFNA2 group.[24] Lateral screw protrusion was observed in four patients in the PFNA2 group and one patient in the PFN group at the final follow-up in our study. Hu et al suggested a morphological mismatch in the Asian population between the proximal fragment of PFNA2 and the greater trochanter, leading to post-operative lateral trochanter pain.[24]

Nikoloski et al recommended a tip apex distance (TAD) of 20-30mm for PFNA2,[25] observing a higher incidence of cut-through when TAD was more than 30 mm or less than

20 mm. In our study, TAD outliers (< 20 or > 30) were 9 and 11 in the PFN and PFNA2 groups, respectively, with a higher implant failure rate, which is consistent with the study by Sharma et al, who had more outliers in the PFNA2 group but fewer implant failures.[26] Our results, supporting the study by Sharma et al., indicate that achieving an

Figure 10: Postoperative X-rays of left and right hip showing excessive valgus angulation of PFN and PFNA2.

Table 3: Comparison of surgical and implant related complications.

	PFN group	PFNA2 group	p
Surgery related complications			
Local site infection (n)	6	5	–
Deep vein thrombosis (DVT)	2	3	–
Limb length discrepancy on the 2nd postoperative day (± 1 cm)	19	6	< 0.05
Pulmonary embolism	2	1	–
Urinary tract infection	4	6	–
Mortality	3	2	–
Total complications	35	24	–
Implant related complications			
Screw back out / Z effect	19	2	< 0.05
Locking mechanism failure	–	5	–
Guide wire breakage	7	0	< 0.05
Implant breakage	3	1	–
Medial migration	1	3	–
Lateral protrusion of screw	1	4	< 0.05
Proximal protrusion	8	1	< 0.05
Distal anterior cortex break	3	2	–
Total complications	42	18	< 0.05

PFN = Proximal femur nail. PFNA2 = Proximal femur nail antirotation-2.

Table 4: Comparison of clinicoradiological outcomes in both the groups.

	PFN group	PFNA2 group	p
Harris Hip Score at 1 year follow up	75 (59-89)	82 (64-91)	0.15
Requirement of walking aids	13	9	0.32
Return to preinjury status	21	31	0.18
Persistent pain	23	14	< 0.05
Varus malalignment	19	11	< 0.05
Time to fracture union (average in months)	5.3	4.7	< 0.22
Limb length discrepancy (one year follow up)	11	4	< 0.05

PFN = Proximal femur nail. PFNA2 = Proximal femur nail antirotation-2.

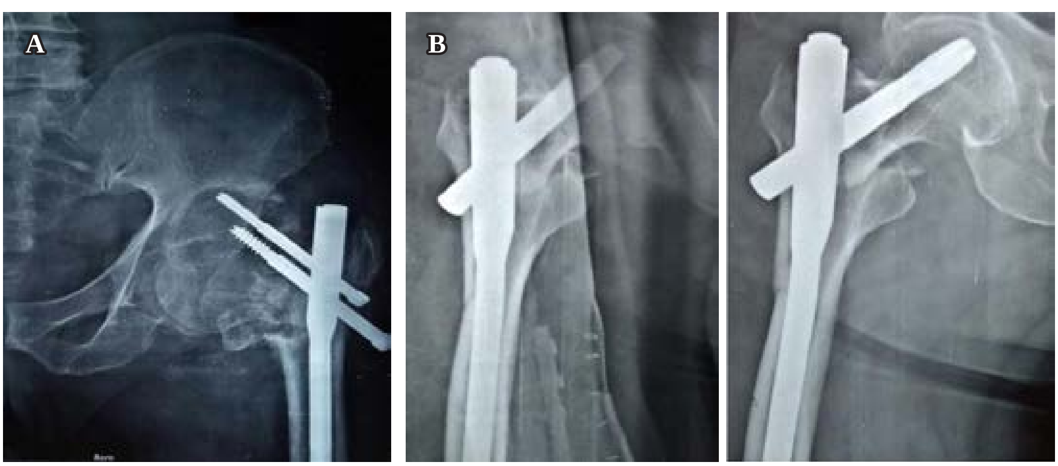

Figure 11:

A) Anteroposterior hip radiograph showing varus collapse with PFN screws into the superior acetabular region. **B)** Radiographic series of the hip showing varus collapse of PFNA2 with medial migration of helical blade in second image.

optimal TAD is crucial, but some outliers are acceptable in the PFNA2 group (as shown in *Figure 5)*, likely due to its inherent stability.

According to the Cleveland index, maintaining an optimal position (centre-centre, inferior-centre) of the screw is crucial for a good outcome.[12] Complications were more frequent when the screw position was suboptimal in the PFN group. When the index was centre-centre in both groups, no complications were observed, and outcomes were better, whereas five out of eight screws that were in a suboptimal position backed out. Only one case in the PFN group with an inferior-centre index showed a complication of screw back-out. Our results are consistent with other studies comparing these implant designs. Mora A et al compared PFNA with PFN and found a lower incidence of cut-out with PFNA.[27] Choo SK et al found less postoperative sliding with PFNA compared to PFN, like our study, which found no difference in walking capacity between patients with either implant.[28]

Maintaining the neck-shaft angle difference between the operated and normal side to less than 5º is necessary for better outcomes.[29] In our study, varus malalignment and Limb Length Discrepancy (LLD) were associated with a neck shaft angle difference of 10º and 5º in the PFNA and PFN groups, respectively. Neck shaft angle outliers were more common in the PFN group *(Figure 10)*, likely to achieve better proximal screw purchase and to avoid postoperative varus collapse, whereas outliers in TAD were more common in the PFNA group, possibly due to difficulty in differentiating between the screwdriver tip and screw head while engaged.

Limb lengthening was notably more common in the PFN group compared to the PFNA group postoperatively (19:6) and even at 1-year follow-up (11:4). No study in the literature highlights LLD between the two groups. Limb lengthening in the PFN group, which was managed with a shoe raise, was likely due to the need to accommodate two screws with better purchase in the middle and inferior part of the neck and excessive intraoperative valgus to achieve the same.

Functional and Radiological Outcomes

Harris Hip Score (HHS) scores and union rates were better in the PFNA2 group (82:75) but statistically non-significant, favoring the study by Mallya et al.[30] Varus malalignment, persistent pain, and limb length discrepancy were significantly more common in the PFN group. Park et al and Li et al concluded that PFNA2 outperforms PFNA in terms of functional outcome and mobility scores, whereas Loo et al, from their review article of 62 patients, concluded that PFNA is a better implant for stabilizing proximal hip fractures than PFNA2.[31,32,33]

A recent study by Baek SH et al demonstrated better clinical outcomes with similar surgical time in both the groups whereas in contrast our study the surgical time was significantly less in PFNA2 group though better clinical outcomes.[34] Our study favoured Yadav et al results which highlighted PFNA2 superiority over PFN in terms of shorter duration of surgery and lesser fluoroscopic exposure.[35]

Limitations: This is a short-term follow-up study. Although the results suggest that PFNA2 is more cost-effective than PFN due to fewer complications, cost-

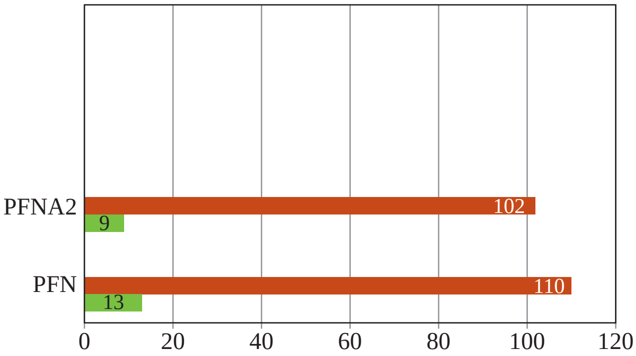

Figure 12: Number of patients requiring walking aids at 6 months in both the groups depicted in green colour.

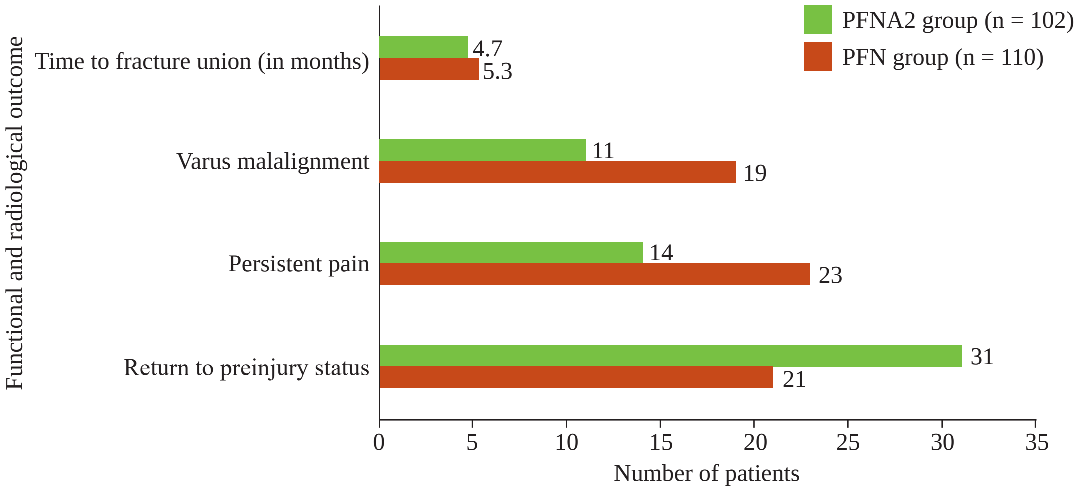

Figure 13: Functional and radiological outcome in both the groups.

effectiveness was not evaluated. Further studies should be focused on to limit the complications and if so, then how to manage them.

Conclusion

Our study strongly favors PFNA2 over the PFN implant in terms of fewer implant-related intraoperative, postoperative, and short-term complications, while functional outcomes are comparable in both groups. PFNA2 is the implant of choice for osteoporotic unstable intertrochanteric fractures, where the bone's inherent ability to hold the implant is weak.

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