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Retrospective Study

Does proximal femoral nail antirotation achieve better outcome than previous-generation proximal femoral nail?

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Abstract

BACKGROUND

There are few studies in the literature comparing the clinical outcomes and radiographic results of proximal femoral nail (PFN) and proximal femoral nail antirotation (PFNA) for pertrochanteric femoral fracture (PFF) in elderly patients.

AIM

To evaluate both clinical and radiographic outcomes after fixation with PFN and PFNA in an elderly patient population.

METHODS

One hundred fifty-eight patients older than 65 years with PFF who underwent fixation with either PFN or PFNA were included. Seventy-three patients underwent fixation with PFN, whereas 85 were fixed with PFNA. The mean follow-up was 2.4 years (range, 1-7 years). Clinical outcome was measured in terms of operation time, postoperative function at each follow-up visit, and mortality within one year. Radiographic evaluation included reduction quality after surgery, Cleveland Index, tip-apex distance (TAD), union rate, time to union, and sliding distance of the screw or blade. Complications including nonunion, screw cutout, infection, osteonecrosis of the femoral head, and implant breakage were also investigated.

RESULTS

Postoperative function was more satisfactory in patients who underwent PFNA than in those who underwent PFN ($P = 0.033$). Radiologically, the sliding

additional data are available.

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difference was greater in PFN than in PFNA patients (6.1 and 3.2 mm, respectively, $P = 0.036$). The rate of screw cutout was higher in the PFN group; eight for PFN (11.0%) and two for PFNA patients (2.4%, $P = 0.027$). There were no differences between the two groups in terms of operation time, mortality rate at one year after the operation, adequacy of reduction, Cleveland Index, TAD, union rate, time to union, nonunion, infection, osteonecrosis, or implant breakage.

CONCLUSION

Elderly patients with PFF who underwent PFNA using a helical blade demonstrated better clinical and radiographic outcomes as measured by clinical score and sliding distance compared with patients who underwent PFN.

Key Words: Pterochanteric fracture; Proximal femoral nail; Proximal femoral nail antirotation; Sliding distance; Cutout; Outcome

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Core Tip: There are few studies comparing the clinical outcomes and radiographic results in elderly patients with pterochanteric femoral fracture (PFF) receiving proximal femoral nail antirotation (PFNA) and those receiving the previous-generation proximal femoral nail. PFNA using a helical blade demonstrated better clinical and radiographic outcomes in terms of clinical score, sliding distance and cutout rate in elderly patients with PFF.

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INTRODUCTION

As the population continues to age, the incidence of pterochanteric femoral fracture (PFF) has also increased^[1] and surgery has been reported as a standard treatment for achieving better clinical outcomes, including shorter hospitalization, earlier return to preinjury status, and fewer complications such as bed sores, pulmonary thromboembolism, and pneumonia^[2-4]. Among the numerous implants currently available for the internal fixation of PFF^[5-7], proximal femoral nail (PFN; Synthes®, Solothurn, Switzerland) has been reported in the last decade to be a suitable implant for the treatment of unstable PFF in elderly patients^[8-10]. However, some studies have reported several complications associated with the use of PFN, including cutout and the Z-effect^[8,11,12]. To overcome these complications, a newly-designed implant, proximal femoral nail antirotation (PFNA; Synthes®, Solothurn, Switzerland), has been developed. According to a biomechanical study conducted in the laboratory setting, the PFNA blade compacts the cancellous bone, leading to increased stability and higher resistance to cutout in the osteoporotic bone^[13]. However, there are few studies comparing clinical outcomes and radiographic results (including cutout after fixation) between elderly patients with PFF receiving PFNA and those receiving the previous-generation PFN. Therefore, we evaluated the clinical and radiographic outcomes after fixation with PFN and PFNA for PFF in elderly patients.

MATERIALS AND METHODS

This retrospective study was approved by the institutional review board in our institution which waived informed consents. From January 2003 to December 2009, 204 patients over 65 years of age with PFF underwent fixation with either PFN or PFNA at a single institution. Among them, 46 patients were excluded because of bilateral PFF (2 patients) and loss to follow-up before radiographic follow-up at one

year (44 patients). Thus, the remaining 158 patients were included. The mean duration of radiographic follow-up was 2.4 years (range, 1-7 years). Seventy-three patients underwent fixation with PFN (PFN group), whereas 85 patients were fixed with PFNA (PFNA group). The PFN group was composed of 31 men and 42 women with an average age of 76.6 ± 7.3 years. Based on the AO classification^[14], fractures were categorized as 31-A1 in 14 patients, A2 in 42 patients, and A3 in 17 patients. The PFNA group consisted of 37 men and 48 women with an average age of 74.9 ± 7.2 years. Fractures were classified as 31-A1 in 19 patients, A2 in 50 patients, and A3 in 16 patients. We identified each patient's medical history and converted it to a Charlson Comorbidity Index^[15] score by deploying questionnaires at each patient's visit to the clinic and conducting a careful review of medical records. In addition, femoral bone mineral density was also investigated. Demographic details and fracture characteristics are described in [Table 1](#). There were no differences between the two groups ($P > 0.05$).

All operations were performed using a fracture table under the guidance of fluoroscopy. We encouraged the Q-setting exercise with an active range of motion, with wheelchair ambulation at one day after index operation. Clinical outcome was measured in terms of operation time, postoperative function according to Salvati and Wilson's hip function rating system^[16] at each patient's visit to the clinic, and mortality rate within one year. The operation time was calculated from skin incision to closure. We searched the National Statistical Office for death certificates for patients who failed follow-up^[17]. Radiographic evaluation included the reduction state after the operation, which was categorized into three groups using modified Baumgartner's criteria^[18], the Cleveland Index^[19], tip-apex distance (TAD)^[7], union rate, time to union and sliding distance of the screw or blade. Complications, including nonunion, screw cutout, infection, osteonecrosis of the femoral head, and implant breakage were also investigated.

The Pearson chi-square test and Student *t*-test were performed for statistical analysis using SPSS software version 22.0 (SPSS, Chicago, IL, United States), and differences were considered significant when the *P* value was < 0.05 . The statistical methods used in this study were reviewed by Won Kee Lee, Professor of Biostatistics of Kyungpook National University.

RESULTS

Clinical outcomes

In the PFN group, postoperative hip function was graded as excellent in 26 (35.6%), good in 35 (47.9%), fair in 8, and poor in 4 patients, respectively ([Table 2](#)). In the PFNA group, hip function was classified as excellent in 36 (42.4%), good in 44 (51.8%), fair in 4, and poor in 1 patient, respectively. The proportion of patients with excellent or good postoperative function was significantly higher in the PFNA group compared to the PFN group (94.1% and 83.6%, $P = 0.033$). Differences in operation time and mortality within one year were not significantly different between the two groups ($P > 0.05$).

Radiographic outcomes

The union rate was 87.7% for the PFN group (64/73) and 94.1% for the PFNA group (80/85) ($P = 0.155$), and the union time was 14.9 wk (range, 12-17) and 13.7 wk (range, 11-18), respectively ($P = 0.156$).

In the PFN group, reduction was graded as good in 34 (46.6%), normal in 31 (42.5%), and poor in 8 patients, whereas it was rated as good in 42 (49.4%), normal in 36 (42.4%), and poor in 7 patients in the PFNA group ($P = 0.830$; [Table 3](#)). According to Cleveland *et al*^[19], zones 5, 6, 8, and 9 were shown in 67 (91.8%) patients with PFN, whereas those zones were demonstrated in 79 patients (92.9%) with PFNA ($P = 0.218$). TAD was 7.2 mm (range, 2.1-12.3) in the PFN group, whereas it was 7.9 mm (range, 3.6-14.9) on immediate postoperative radiographs in the PFNA group.

Sliding distance was 6.1 mm (range, 0-23.6 mm) in the PFN group, whereas it was 3.2 mm (range, 0-18.4 mm) in the PFNA group at final follow-up compared to radiographs taken immediately after the index operation. The sliding difference was significantly higher in the PFN group ($P = 0.036$). There was no difference between the two groups in terms of reduction state, Cleveland Index, TAD, union rate and time to union ([Figures 1 and 2](#)).

Table 1 Demographic details and fracture characteristics in the proximal femoral nail and proximal femoral nail antirotation groups

	PFN group	PFNA group	P value
Number of patients	73	85	NA
Male:female	31:42	37:48	0.893
Age, yr	76.6 (65-90)	74.9 (65-92)	0.213
BMI, kg/m ²	21.4 (18.5-31.6)	22.8 (20.4-28.3)	0.576
Femoral BMD, T-score	-2.83 (-1.3 to -5.3)	-3.14(-1.1 to -6.1)	0.518
Charlson Comorbidity Index ^[15]	13.4 (3-18)	11.9 (4-19)	0.536
Cause of injury			0.890
Slip down	56	65	
Traffic accident	8	11	
Fall down	9	9	
AO/OTA classification			0.750
31-A1	14	19	
31-A2	42	50	
31-A3	17	16	
Stay before operation, d	4.02 (1-13)	2.84 (1-17)	0.253

PFN: Proximal femoral nail; PFNA: Proximal femoral nail antirotation; NA: Not available; BMI: Body mass index; BMD: Bone mineral density.

Table 2 Clinical outcomes in the proximal femoral nail and proximal femoral nail antirotation groups

	PFN group	PFNA group	P value
Operation time, min	67.3	63.2	0.395
Salvati and Wilson score score ^[16]			0.328
Excellent (32 or more)	26	36	
Good (24-31)	35	44	
Fair (16-23)	8	4	
Poor (15 or less)	4	1	
Excellent + good	61 (83.6%)	80 (94.1%)	0.033
Mortality within one year	16 (21.9%)	20 (23.5%)	0.629

PFN: Proximal femoral nail; PFNA: Proximal femoral nail antirotation.

Complications

Screw cutout was demonstrated in eight (11.0%) patients in the PFN group and in two (2.4%) patients in the PFNA group ($P = 0.027$; Table 4). However, there was no statistical difference between groups in terms of nonunion, infection, osteonecrosis of the femoral head, or implant breakage.

DISCUSSION

Among the various implants used for treating proximal femur fracture, PFNA has been developed to overcome several problems of PFN, which has a similar design but uses a helical blade^[8,11,12]. According to one biomechanical study, better clinical outcomes might be expected in patients undergoing PFNA than in those receiving the previous-generation PFN^[13]. However, few studies have compared the clinical and radiographic outcomes, including cutout after fixation, between PFNA and PFN in

Table 3 Radiographic results in the proximal femoral nail and proximal femoral nail antirotation groups

	PFN group	PFNA group	P value
Reduction			0.830
Good, <i>n</i> (%)	34 (46.6%)	42 (49.4%),	
Normal, <i>n</i> (%)	31 (42.5%)	36 (42.4%)	
Poor	8	7	
Cleveland Index			0.577
Zone 1	0	0	
Zone 2	1	0	
Zone 3	0	0	
Zone 4	2	2	
Zone 5	34	42	
Zone 6	11	15	
Zone 7	3	4	
Zone 8	14	19	
Zone 9	8	3	
Zone 5 + 6 + 8 + 9, <i>n</i> (%)	67 (91.8%)	79 (92.9%)	0.218
TAD, mm	7.2 (2.1-12.3)	7.9 (3.6-14.9)	0.222
Union rate, % (<i>n</i>)	87.7 (64/73)	94.1 (80/85)	0.155
Union time, wk	14.9 (12-17)	13.7 (11-18)	0.156
Sliding distance, mm	6.1 (0-23.6)	3.2 (0-18.4)	0.036

PFN: Proximal femoral nail; PFNA: Proximal femoral nail antirotation; TAD: Tip-apex distance.

Table 4 Complications in both groups

	PFN group	PFNA group	P value
Screw cutout, <i>n</i> (%)	8 (11.0%)	2 (2.4%)	0.027
Nonunion, <i>n</i> (%)	9 (12.3%)	5 (5.9%)	0.155
Infection	2	1	0.473
ONFH	1	0	0.279
Implant breakage	1	0	0.279

PFN: Proximal femoral nail; PFNA: Proximal femoral nail antirotation; ONFH: Osteonecrosis of the femoral head.

elderly patients with PFF. Thus, we performed the current study. Our results indicate that PFNA is associated with better clinical outcomes and fewer complications (in terms of sliding distance and screw cutout) compared to PFN.

In our study, the group that underwent PFNA with a helical blade demonstrated less sliding distance compared to the group undergoing PFN with a conventional screw. This result is comparable with previous studies conducted in the laboratory setting, which demonstrated increased resistance of the blade to implant migration, and an increase in interlocking stability^[13,20,21]. In a clinical study comparing the sliding distance between PFN and PFNA groups, Choo *et al*^[22] reported that the sliding distance was shorter in the PFNA group than in the PFN group, which was consistent with our results.

Similar to our study, several studies comparing PFN and PFNA indicated that the PFN group had more implant-related complications^[23-25]. We speculate that this result is due to the biomechanical properties of the helical blade of PFNA^[13]. As reaming is

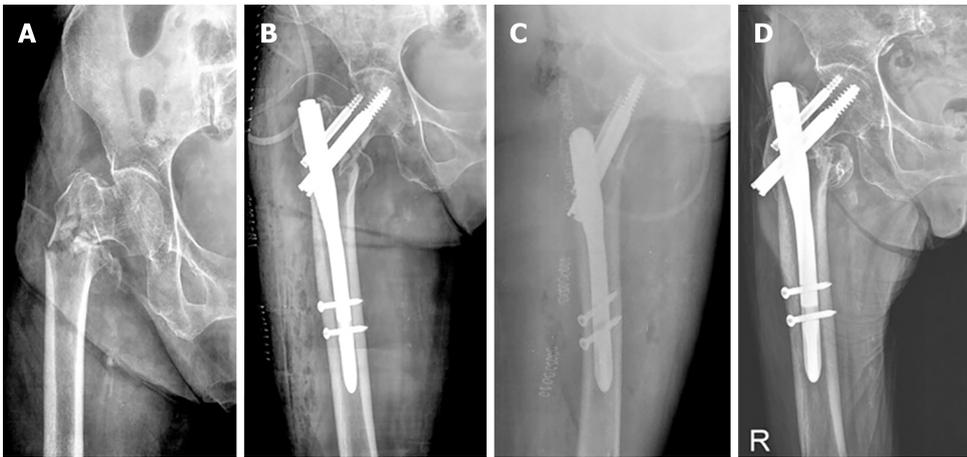


Figure 1 Radiographic results. A: A preoperative radiograph shows an intertrochanteric fracture with AO classification type A3.2. in a 79-year-old female patient. She underwent closed reduction and fixation with proximal femoral nail. Immediate postoperative radiographs demonstrate good reduction, tip-apex distance of 12.1 mm and Cleveland Index of 5 on anteroposterior (B) and axial view (C). D: A radiograph taken at follow-up duration of 3 years shows bone union with the sliding distance of 14.5 mm.

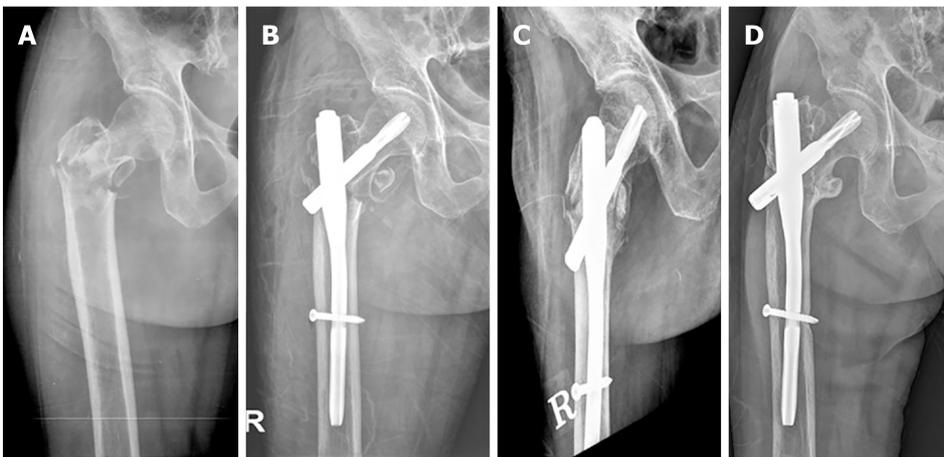


Figure 2 Radiographic results. A: A preoperative radiograph shows an intertrochanteric fracture with AO classification type A3.3 in a 59-year-old female patient. She underwent closed reduction and fixation with proximal femoral nail antirotation. B and C: Immediate postoperative radiographs demonstrate distal fragment is distracted, leaving a fracture gap, tip-apex distance of 21.2 mm and Cleveland Index of 5 on anteroposterior (B) and axial view (C). D: A radiograph taken at follow-up duration of 7 years shows bone union with the sliding distance of 8.6 mm.

not performed before blade insertion, the bone stock of the femoral head can be preserved, thereby increasing the contact area between the implant and cancellous bone of the femoral head. In addition, when the blade is inserted, the cancellous bone is compressed, which increases resistance to rotational stress and varus collapse^[26]. However, Mallya *et al*^[27] described that there was no difference in implant-related complications between the two groups. We presume that their study was conducted with a short follow-up period of 6 mo; thus, there was no difference between the two groups.

In the present study, the clinical score after surgery was significantly higher in the PFNA group than in the PFN group ($P = 0.033$). This result is different to previous studies that reported no difference in clinical outcomes between the two groups^[22,25,27,28]. We speculate that the decrease in blade sliding had a smaller effect on native hip biomechanics, including offset and limb length, leading to less reduction in walking ability. In addition, decreased sliding might have resulted in less irritation of the iliotibial band and gluteal sling by the blade itself, leading to less pain.

Our study showed no difference in surgical time between the two groups. In contrast to our findings, several studies^[22,24,27,28] reported a shortened time of operation with PFNA when compared with PFN due to the simplified surgical steps. We estimated that this discrepancy among studies might originate from the learning curve associated with the initial introduction of PFNA, which could affect operation time.

The current study is limited by its nonrandomized, retrospective nature, as well as the fact that there were no selection criteria applied for each implant. However, the analysis of demographic characteristics and data related to the operation in the two groups did not reveal any confounding factors such as selection bias. Second, our findings cannot reflect long-term clinical outcomes because of the relatively short-term follow-up. However, a high mortality rate within 5 years has been reported in the literature^[29]. Lastly, the current study included a relatively small number of patients, which can weaken statistical power. Nevertheless, we believe that our findings are important as when a theoretically improved implant is introduced, comparison with previous implants of a similar design is paramount to determine the value of the new implant.

CONCLUSION

In conclusion, PFNA using a helical blade demonstrated better clinical and radiographic outcomes in terms of clinical score, cutout, and sliding distance following treatment of PFF in elderly patients. However, a randomized study with longer-term follow-up may be necessary to draw a definitive conclusion.

ARTICLE HIGHLIGHTS

Research background

There are few studies comparing clinical and radiologic outcomes between proximal femoral nail antirotation (PFNA) and previous-generation proximal femoral nail (PFN) in elderly patients with pertrochanteric femoral fracture (PFF).

Research motivation

We evaluated the clinical and radiographic outcomes after fixation with PFN and PFNA for PFF in elderly patients.

Research objectives

From January 2003 to December 2009, seventy-three patients underwent fixation with PFN (PFN group), whereas 85 patients were fixed with PFNA (PFNA group). The mean duration of radiographic follow-up was 2.4 years (range, 1-7 years). The PFN group was composed of 31 men and 42 women with an average age of 76.6 ± 7.3 years. The PFNA group consisted of 37 men and 48 women with an average age of 74.9 ± 7.2 years.

Research methods

We evaluated each patient's medical history and converted it to a Charlson Comorbidity Index score and femoral bone mineral density. There was no difference in demographics between the two groups ($P > 0.05$). Clinical outcome was measured in terms of operation time, postoperative function according to Salvati and Wilson's hip function rating system and mortality rate within one year. Radiographic evaluation included the reduction state after the operation, the Cleveland Index^[19], tip-apex distance (TAD), union rate, time to union and sliding distance of the screw or blade. Complications, including nonunion, screw cutout, infection, osteonecrosis of the femoral head, and implant breakage were also investigated.

Research results

The proportion of patients with excellent or good postoperative function was significantly higher in the PFNA group compared to the PFN group (94.1% and 83.6%, respectively, $P = 0.033$). Differences in operation time and mortality within one year were not significantly different between the two groups ($P > 0.05$). Sliding distance was 6.1 mm (range, 0-23.6 mm) in the PFN group, and was 3.2 mm (range, 0-18.4 mm) in the PFNA group at final follow-up ($P = 0.036$). There was no difference between the two groups in terms of reduction state, Cleveland Index, TAD, union rate and time to union. Screw cutout was demonstrated in eight (11.0%) patients in the PFN group and in two (2.4%) patients in the PFNA group ($P = 0.027$).

Research conclusions

PFNA using a helical blade demonstrated better outcomes in terms of clinical score, sliding distance and cutout rate following treatment of PFF in elderly patients than PFN.

Research perspectives

A randomized control study with longer-term follow-up may be necessary to draw a definitive conclusion.

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