

PFNA-II protrusion over the greater trochanter in the Asian population used in proximal femoral fractures

Sun-Jun Hu, Shi-Min Chang, Zhuo Ma, Shou-Chao Du, Liang-Ping Xiong¹, Xin Wang¹

ABSTRACT

Background: The treatment of proximal femoral fractures in geriatric osteoporotic patients continues to be a challenge in orthopaedic trauma. Various kinds of cephalomedullary nails, such as gamma nail, InterTan and PFNA were used clinically. The latest generation PFNA II, specially designed for Asian population, is commonly used for geriatric per-/intertrochanteric fractures. The aim of this study was to determine whether the current PFNA-II proximal segment length is suitable for the greater trochanter height, as assessed by postoperative radiograph measurements.

Materials and Methods: 51 consecutive patients with per-/intertrochanteric fractures treated with the PFNA-II between July 2012 and December 2012 were enrolled in this study. There were 19 males and 32 females, with an average age of 78.6 years (range 66–92 years). According to AO/OTA classification system, there were 4 cases of 31A1 fractures, 35 cases of 31A2 fractures, and 12 cases of 31A3 fractures. The nail protrusion height over the lateral greater trochanter and the Parker ratio of the helical blade tip in the femoral head were measured and compared using pelvic digital anteroposterior radiographs taken within 2 weeks postoperatively. Patients were followed up for a minimum period of 1 year to check whether they had lateral trochanter pain.

Results: Postoperative digital anteroposterior (AP) films were used for assessment and any prominence was recorded as positive. Overall, nail protrusion over the greater trochanter occurred in 87.8% of cases. In 60.8% of the cases, protrusion height was >5 mm. The average protrusion height was 6.25 ± 4.27 mm (male average 4.84 ± 4.38 mm, and female average 7.09 ± 4.70 mm). The average Parker ratio of all cases was 51.0 ± 6.9% (male average 49.8 ± 7.5% and female average 51.7 ± 6.5%). Protrusion height was positively correlated ($r = 0.394$, $P = 0.004$) with the helical blade position in the femoral head (Parker ratio). Clinically, a total of 42 patients were followed up at an average of 15.0 ± 2.6 months (range 12–24 months) they were able to walk independently or with a stick. There were 13 patients with lateral trochanter pain on the injured side. Protrusion height of these patients was 11.13 ± 3.75 mm, whereas the protrusion height of the remaining 29 patients was 3.87 ± 3.39 mm.

Conclusions: There was a morphologic mismatch between the proximal segment length of the PFNA-II and the greater trochanter in the Asian population, which may be the cause of postoperative lateral trochanter pain. A modification to shorten the proximal part of the nail is proposed to avoid protrusion over the greater trochanter.

Key words: Intertrochanteric fractures, intramedullary nail, nail protrusion, proximal femoral nail antirotation-II, soft tissue irritation

MeSH terms: Intertrochanteric fractures, intramedullary nailing, pain, ascitic race

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INTRODUCTION

The proximal femoral nail antirotation (PFNA) was introduced by the Arbeitsgemeinschaft für Osteosynthesefragen (AO)/Association for the Study of Internal Fixation group in 2004^{1,2} and the PFNA-II (Asian version) was introduced in 2008.³ Since the introduction of PFNA and PFNA-II, the cephalomedullary nail with a single head-neck helical blade has commonly been used to treat osteoporotic geriatric patients with unstable pertrochanteric and/or intertrochanteric fractures. Good results and functional outcomes have been reported globally by many authors.⁴⁻⁸ However, complications, such as lateral cortex impingement, medial head perforation or “cut-through” of the helical blade, abutment of the distal nail tip to the anterior femur cortex, and over prominence of the proximal nail end outside of the greater trochanter, have also been reported.⁹⁻¹¹

The treatment of unstable proximal femoral fractures,⁴ can be either by side-plate screw system represented by dynamic hip screw (DHS) or the intramedullary nail system. Cephalomedullary nails, including Gamma nail, InterTan, proximal femoral nail (PFN) and PFNA, are now favoured in the treatment of unstable proximal femur fractures for their unique characteristics in insertion mode and morphological design. The PFNA is also preferred for its distinctive features like one single helical blade perforated into the femoral head, wrench-in, large axial contact area and squeeze cancellous bone, while PFNA II was modified to avoid lateral cortex impingement during the insertion of nail.

The PFNA-II design has three modifications to the PFNA to accommodate Asian anatomic characteristics: (1) The proximal nail diameter was reduced from 17 mm to 16.5 mm, (2) the mediolateral angle was reduced from

6° to 5°, and (3) a flat proximal lateral surface was adapted to avoid impingement of the femoral lateral cortex. The PFNA-II is available in four lengths (170 mm, 200 mm, 240 mm, and long). There are four distal diameters available (9 mm, 10 mm, 11 mm, and 12 mm), all measuring 105 mm in proximal segment length. The long types of PFNA-II are designed with an anterior curvature (radius, 1500 mm) to meet the bow of the femur.

During our clinical use of PFNA II, we found that the proximal nail frequently protruded over the greater trochanter area [Figure 1]. The purpose of this study was to clarify whether the proximal segment length (105 mm) is suitable for the height of the greater trochanter in the Asian population.

MATERIALS AND METHODS

Sixty one consecutive patients with per-/intertrochanteric fractures were treated with the PFNA-II between July 2012 and December 2012, at our institution. We systematically chose nails that were as thick and long as possible, provided that the nail could be manually inserted into the femoral canal without additional distal segment reaming. The short-sized nail, measuring 200 mm in length and 10 mm in diameter, was most commonly used. In addition, we attempted to consistently place the helical blade in the center of the femoral head, both in anteroposterior (AP) and lateral views.

After a retrospective review of the clinical records and radiographs, 51 patients were included in this study based on the following inclusion criteria: (1) Patient age ≥ 60 years, (2) fracture was treated with closed reduction and PFNA-II fixation, (3) standard pelvic AP radiographs taken within 2 weeks postoperatively. The exclusion criteria includes



Figure 1: (a-d) Anteroposterior radiographs of hip joint with proximal thigh showing the typical cases with proximal nail end protrusion over the greater trochanter

patients without postoperative images, non-standard placement of implant, and failure of internal fixation.

There were 19 male patients (37.3%) and 32 female patients (62.7%), with an average age of 78.6 years (range 66–92 years). The left hip was involved in 27 cases, and the right hip was involved in 24 cases. The causes of injuries were low energy violence including falling while standing in 43 cases and pedestrian accidents in 8 cases. Preoperative radiographs and computed tomography scans showed 4 cases of 31A1 fractures, 35 cases of 31A2 fractures, and 12 cases of 31A3 fractures, according to the AO/American Orthopaedic Trauma Association classification. Patients were followed up at 4 weeks, 8 weeks, 3 months, 6 months, and 1 year after operation (range 12–24 months), and were checked whether they had lateral trochanter pain after the fracture healed.

The postoperative radiographs of pelvis anteroposterior view (AP) was taken within 2 weeks after surgery were used for this study. The parameters were measured by the image analysis software Digimizer 3.7 (Medcalc Software, USA). The parameters were calibrated using the known proximal nail diameter of 16.5 mm as the “pixel length ruler.” The nail protrusion height and Parker ratio were measured on the AP radiographs [Figure 2].

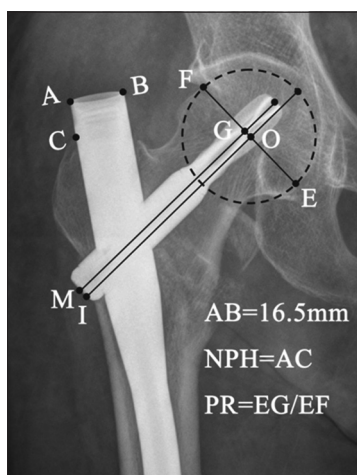


Figure 2: Measurements on the anteroposterior radiograph. A - lateral proximal tip of intramedullary nail. B - medial proximal tip of intramedullary nail. C - tip of greater trochanter connecting the lateral board of intramedullary nail. O - the center of femoral head. Line I - head-neck axial crossing the center of femoral head. Line M - the helical blade axial line. Line EF - perpendicular to line I crossing the point O. G - intersection point of lines EF and M. E, F - intersection points of line EF and the femoral head circle. NPH: Nail protrusion height. PR: Parker ratio

The design and protocol of this study were approved by the Ethics Committee of our Hospital, who waived the need for informed consent.

Statistical methods

Data were described as the mean \pm standard deviation, and paired *t*-test was used to compare the data between the male and female groups. Chi-square test was used to determine statistically significant differences between the two groups. The correlation between the protrusion height and the Parker ratio was calculated through the Pearson's correlation analysis. A $P < 0.05$ from the two-tailed tests was considered to be statistically significant. All statistical analyses were carried out using SAS 9.3 (SAS Institute Inc., North Carolina, USA).

RESULTS

Overall, nail protrusion over the greater trochanter occurred in 88.2% of cases (45/51), with male patients being 82.4% (15/19), and female patients being 90.6% (29/32), respectively. No significant difference was found in the protrusion percentages between the male and female patient groups. Of those patients showing nail protrusion, 60.8% (31/51) of the cases demonstrated protrusions >5 mm. The proportion of protrusions >5 mm in the male group was 42.1% (8/19), and 71.9% (23/32) in the female group and the difference between genders was statistically significant. The average height of the proximal nail end protrusion over the greater trochanter was shown in Table 1.

The average Parker ratio of all cases was $51.0\% \pm 6.9\%$ (range 35.8%–64.5%), the ratio for the male group was $49.8\% \pm 7.5\%$ (range 36.0%–64.5%) and the female group ratio was $51.7\% \pm 6.5\%$ (range 35.8%–64.2%). There was no significant difference between the male and female groups. Patients were divided into two groups according to the Parker ratio scores: One group of 23 cases with a Parker ratio of $<50\%$ (inferior blade position) and the other group of 28 cases with a Parker ratio of $\geq 50\%$ (superior blade position). The proximal nail protrusion heights were significantly different between the two groups [Table 1]. The nail protrusion height and the Parker ratio were positively correlated (coefficient of correlation of $r = 0.394$, $P = 0.004$).

Patients were followed up for at least 1 year to check whether they had lateral trochanter pain. Five patients died within 1 year of the surgery, and 4 patients were unable to walk or stand independently or with an orthopedic

Table 1: Nail-tail protrusion height postoperation ($\bar{x} \pm s$, min-max, mm)

	Overall (n=51)	Male (n=19)	Female (n=32)	PR<50% (n=23)	PR≥50% (n=28)
Protrusion height	6.25±4.67 (–4.56, 17.34)	4.84±4.38 (–4.56, 13.86)	7.09±4.70 (–4.55, 17.34)	3.26±3.37 (–4.56, 12.17)	8.71±4.16 (–3.86, 17.34)

walker. The remaining 42 patients were followed up for average of 15.0 ± 2.6 months (range 12–24 months). About 31.7% (13/41) patients had lateral trochanter pain including 3 mild pain, 8 moderate pain, and 2 severe pain. No sign of internal fixation failure (such as lateral protrusion of the blade) was found on the reviewed radiographs. The proximal nail protrusion heights were significantly different between patients with and without lateral trochanter pain [Table 2 and Figures 3-5].

DISCUSSION

Despite the wide use of PFNA and satisfactory outcomes with

low major complication rates, lateral cortex impingement in Asian patients has been reported.¹² A second version of PFNA (PFNA-II) was designed with a flattened lateral surface, decreased mediolateral nail angle, and decreased proximal nail diameter. Macheras *et al.*¹³ retrospectively reviewed 108 unstable pertrochanteric fractures treated with PFNA or PFNA-II and concluded that PFNA-II could avoid

Table 2: Subgroups of nail-tail protrusion height by symptom ($x \pm s$, min-max, mm)

	Without LTP (n=29)	With LTP (n=13)	P
Protrusion height	3.87 ± 3.38 (-3.79, 10.08)	11.13 ± 3.75 (5.67, 17.34)	<0.01

LTP=lateral trochanter pain



Figure 3: Radiograph and CT scan of hip joint and proximal femur (a) preoperative showing the intertrochanteric fracture (b and c) immediate postoperative X-rays showing tip of nail at level of greater trochanter (d-f) immediate postoperative computed tomography reconstructive images showing relation of tip of implant at greater trochanteric level (g and h) 1-year followup X-rays, anteroposterior view and lateral view showing relation of tip of implant to greater trochanter

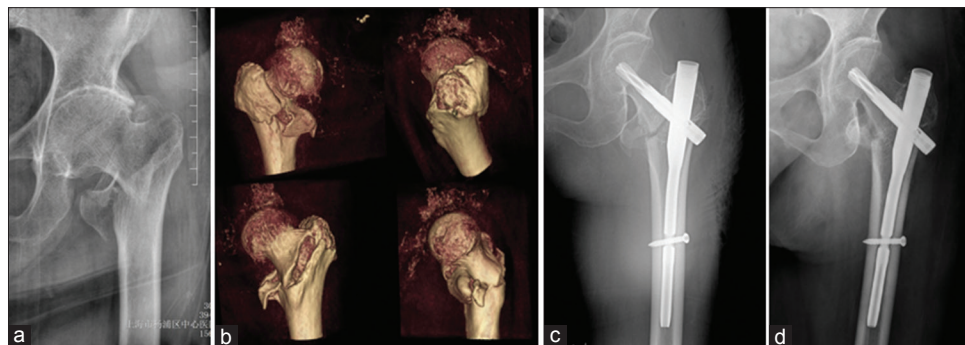


Figure 4: X-ray and CT scan of hip joint with proximal femur showing (a) intertrochanteric fracture (b) computed tomography reconstructive images showing fracture anatomy (c) immediate postoperative anteroposterior X-rays showing nail tip at level of greater trochanter (d) Totally healed fracture and nail tip at level of greater trochanter at 1 year followup

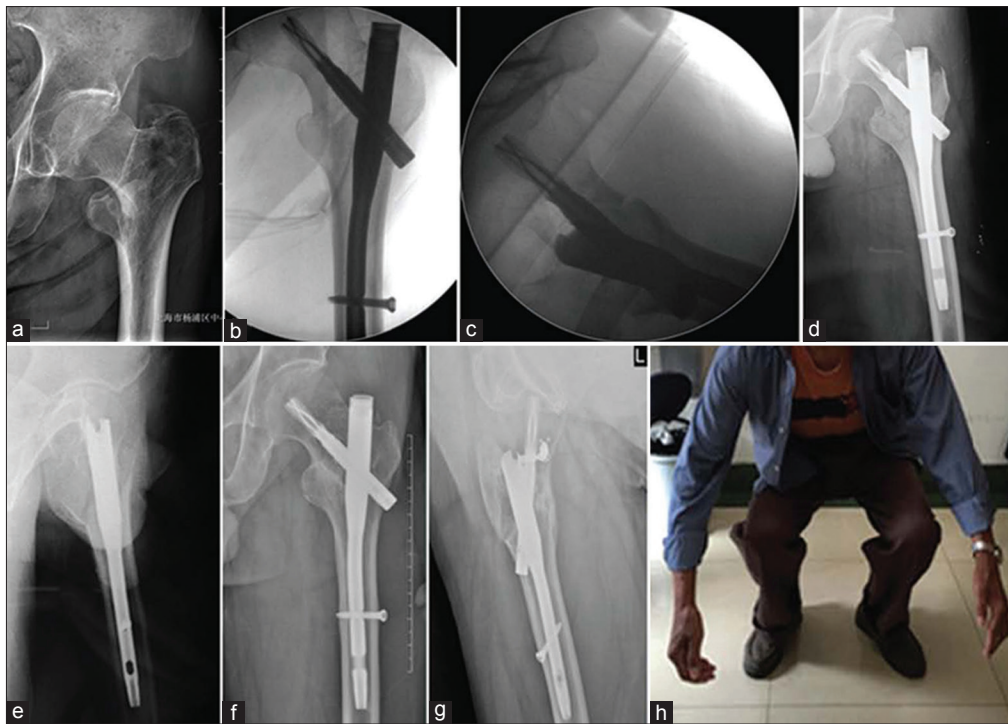


Figure 5: X-ray of hip joint with proximal femur (a) Preoperative X-ray showing the fracture (b and c) intraoperative fluoroscopy images showing nail tip positions (d and e) immediate postoperative X-rays, anteroposterior view and lateral view showing nail and trochanter relationship (f and g) 2 years followup X-rays, anteroposterior view and lateral view showing bony union and relation of tip of nail and greater trochanter (h) Clinical photograph of patient showing good functions, but complains lateral trochanter pain

lateral cortex impingement while providing fast and stable fixation of unstable pertrochanteric fractures.

In a previous study, we found that patients with PFNA-II fixation frequently reported hip–thigh pain (25.4%, 18/71 cases) at the 6-month followup, despite complete healing of the fracture.¹⁴ We speculated that the long standing lateral hip pain may be a result of soft tissue irritation caused by nail protrusion over the greater trochanter, which is a cause for the greater trochanter pain syndrome.¹⁵ In this study, protrusions >5 mm occurred in 60.8% of cases; the mean protrusion height was 6.25 ± 4.67 mm, and 31.7% patients had lateral trochanter pain after an average of 15 months followup. The nail protrusion height and Parker ratio¹⁶ were positively correlated (coefficient of correlation $r = 0.394$, $P < 0.01$), demonstrating that the superior positioning of the helical blade in the femoral head corresponds with a greater protrusion height over the trochanter.

As both the length of the proximal segment and the blade–nail angle (130° in our series) were fixed, several factors may have influenced the extent of the nail protrusion such as ethnicity, Parker ratio of helical blade position, and fracture reduction quality. In our practice, anatomic or slightly valgus reduction is preferred, and the blade is consistently placed centrally from both the AP and

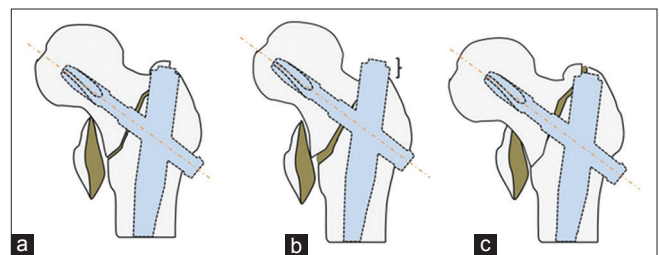


Figure 6: Schematic diagram of fracture reduction quality and nail protrusion. (a) Anatomical reduction. (b) Slight valgus reduction may cause nail end protrusion. (c) Slight varus reduction

the lateral view.¹⁷ As the helical blade is different from lag screw in mechanics and it tends to move medially rather than superiorly, central placement of the blade can prevent its failure from cut-through or head perforation.^{12,18} However, valgus reductions may increase the nail protrusion height [Figure 6].

CONCLUSION

We recommend a modification to the PFNA-II that would further shorten the proximal nail end 5–10 mm for the Asian population, so as to avoid soft tissue irritation on lateral trochanter. A suitable tail cap (0 mm, 5 mm, 10 mm, and 15 mm in height) could be used if the proximal tip of the nail is embedded in the greater trochanter.

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Conflicts of interest

There are no conflicts of interest.

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