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# PFNA *vs.* DHS helical blade for elderly patients with osteoporotic femoral intertrochanteric fractures

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**Abstract. – OBJECTIVE: This study sought to compare the effects of proximal femoral nail anti-rotation (PFNA) and dynamic hip screw (DHS) helical blade treatments in patients with osteoporotic femoral intertrochanteric fractures.**

**PATIENTS AND METHODS: Eighty elderly osteoporosis patients with femoral intertrochanteric fracture complications admitted to the hospital between January 2013 and December 2014 were selected and divided into control (n=40) and observation (n=40) groups. The control group received DHS internal fixation while the observation group received PFNA treatment. Patients were followed up for 18 months, during which pre- and post-operative duration, Harris hip joint function scale, pain, bone mineral density and calcitonin level, 10 meter walking speed, five-fold-sit-to-stand test time, fracture healing and weight bearing time, and related complications were compared between groups.**

**RESULTS: Operational duration, hemorrhaging and drainage volume were all decreased in the observational group relative to the control group ($p<0.05$). Pre-operative Harris hip joint function scale scores were not significantly different between the two groups, but were superior in the observation group post-operation ($p<0.05$). A similar trend was observed for pain degree, bone mineral density and calcitonin levels, 10-meter walking speed, five-fold-sit-to-stand test time, and fracture and weight healing time ($p<0.05$). Complication incidence, such as coxa vara, loose nail, bone nonunion, delayed union of fracture, femoral head necrosis and deep venous thrombosis, etc., in the observation group was significantly lower than in the control group ($p<0.05$).**

**CONCLUSIONS: PFNA is characterized by minimal invasiveness, shorter time of operation, and accelerated post-operative recovery during the treatment of osteoporotic intertrochanteric fractures, and effectively improved patient bone density post-operatively, thus further promoting joint function recovery and reducing complication incidence.**

Key Words

Femoral intertrochanteric fracture, PFNA, DHS, Elderly, Osteoporosis.

## Introduction

With the increasingly aging population in China, the proportion of elderly patients experiencing osteoporosis-related complications has significantly increased, and the incidence of femoral intertrochanteric fractures has also increased year-by-year[1]. In cases of elderly osteoporosis patients complicated with a variety of internal medicine pathologies in combination with poor immunity and malnutrition, early operation is recommended so as to avoid the increased complications caused by long-term bed rest[2]. At present, there are various operation methods available. The dynamic hip screw (DHS) technique, a commonly-used method in the past, affects postoperative early ambulation for patients due to the unsatisfactory stability of the internal fixation and shear stress change, so its treatment effect for elderly patients with osteoporosis is limited[3]. The proximal femoral nail anti-rotation (PFNA) technique has biomechanical advantages, and is currently the most commonly used and satisfactory treatment method for elderly patients with osteoporotic intertrochanteric[4]. Its internal fixation arm is short, and the closed reduction and internal fixation can be performed commonly through a minimally-invasive incision, reducing operative tissue injury without influencing the blood supply to the fracture site[5]. This study compared the clinical treatment value of PFNA and DHS to clarify their treatment effects on elderly patients with osteoporotic intertrochanteric fractures.

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## Patients and Methods

### Patients

Eighty elderly (aged ≥ 60 years of age) osteoporosis patients complicated with femoral intertrochanteric fractures admitted in Renmin Hospital of Wuhan University between January 2013 and December 2014 were selected, with all of them receiving an imaging examination (X-ray, CT, or MRI) before enrollment. The protocol was declared to and approved by the Ethics Committee of Renmin Hospital of Wuhan University, and patients signed the informed consent before enrollment. Exclusion criteria were as follows: 1) patients with bone or joint motor system diseases, diabetes mellitus, severe cardiorespiratory, hepatic, or renal dysfunctions, mental disorders, coagulation disorders, systemic malignant tumors, malignant tumor cachexia, or contraindications after intraspinal anesthesia puncture; 2) patients who used analgesia devices or drugs after the operation; 3) patients declined to consent to enrollment. These eighty patients were divided into two groups of 40 each according to the random number method. The observation group consisted of 20 males and 20 females aged 60-89 years with an average age of 75.6±2.5 years. Regarding the site of injury, there were 15 cases of left-side and 25 cases of right-side injury. On the Evans scale, there were 4 Type I, 10 Type II, 16 Type III, and 10 Type IV cases. The control group consisted of 21 males and 19 females aged 60-90 years with an average age of 75.5±2.6 years. Regarding site of injury, there were 15 cases of left-side and 25 cases of right-side injury. On the Evans scale, there were 3 Type I, 12 Type II, 15 Type III, and 10 Type IV cases. There were no statistically significant differences in gender, age, injured site, and Evans fracture type between the two groups ($p>0.05$).

### Operation Methods

All patients included received the operation under combined spinal-epidural anesthesia. Prior to the operation, all patients signed informed consent for surgery and anesthesia. After the anesthetic had taken effect, patients were placed on a traction table in the supine position with the affected limb receiving closed traction reduction first. C-arm fluoroscopy was used to determine the traction effect, and a 5 cm-long skin incision was made 2 cm away from the greater trochanter of the femur (which the operator identified through palpation with the index finger). The model of intramedullary nail was determined after another fluoroscopy. After the main nail was placed, the control group received DHS internal fixation, with the guide steel needle placed using a sighting device towards the femoral neck. Under C-arm fluoroscopy, the direction and depth of the guide steel needle were adjusted to ensure that it was located in the femoral neck, and the lag screw was then drilled. For patients with fracture gaps longer than 3 mm, the fracture gap could be reduced by increasing pressure, and then the anti-rotation nail was tightened. The observation group received PFNA treatment, where the guide sleeve was placed, the depth and position of the steel needle were determined through C-arm fluoroscopy, and then the intramedullary nail was placed and locked using a locking device in combination with a sighting device. Finally, the tail cap of mail nail was placed. After determining the treatment effect *via* fluoroscopy, the drainage tube was retained and the incision was sutured.

### Observation Indicators

All patients were followed up for 18 months through outpatient follow-up, door-to-door follow-up, and telephone follow-up. The following perioperative parameters were examined: operation duration, operation blood loss, postoperative drainage volume, the Harris hip joint function scale score, pain degree, bone mineral density and calcitonin level, 10-meter walking speed, five-fold-sit-to-stand test time, fracture healing and weight bearing time, and related complications (i.e., coxa vara, loose nail, bone nonunion, delayed union of fracture, femoral head necrosis and deep venous thrombosis).

### Evaluation Criteria

The total Harris function scale score was 100, comprising 10 times scored out of 10 points each: pain, deformity, activity, walking assistance, ability to tie shoes and wear socks, ability to sit on a chair, ability to take public transport, claudication, walking distance, and stair climbing. A score greater than 90 was ranked as excellent, 70 to 89 was ranked as fair, and a score below 70 was ranked as poor. Regarding bone mineral density measurements, a Discovery-W double-light energy X-ray bone densitometer (Hologic, San Diego, CA, USA) was used to measure the proximal femoral (femoral neck) bone mineral density, and all investigations were performed by physicians with more than 5 years of experience in a clinical laboratory. The visual analogue scale score (VAS score) was adopted for evaluating pain scores. A score of 10

**Table I.** Comparison of perioperative conditions between the two groups (x̄±s).

| | Operation duration (min) | Hemorrhage during operation (ml) | Postoperative drainage volume (ml) |
|---|---|---|---|
| Observation group | 38.5±5.7 | 143.5±16.5 | 95.3±10.2 |
| Control group | 43.6±9.0 | 289.6±25.3 | 156.8±21.7 |
| *t* | 3.028 | 30.592 | 16.222 |
| *p* | 0.003 | 0.000 | 0.000 |

indicated severe pain, while a score of 0 indicated no pain. Regarding bone calcitonin level measurements, 5 ml fasting elbow venous blood was drawn from patients in the morning as part of follow-up procedures and examined *via* radioimmunoassay using an FJ-2008PS bone calcitonin γ radioimmunoassay detector (Xi'an Nuclear Instrument Factory, Xi'an, China). The normal reference values for bone calcitonin levels in adults were 4.8-10.2 μg/L. The following criteria was employed to evaluate fracture healing: no local tenderness and longitudinal percussion pain and no local abnormal activity or bony crepitus; X-ray of the fracture site showed a fuzzy fracture line with continuous porosis through the fracture line, and continuous porosis existing in at least 3 sites. The following was used to evaluate femur function: whether the patient was able to walk freely for more than 500 meters without the support of external fixations.

During the 14-day follow-up, after the external fixation was removed and if no deformation was found in the fracture site, 10 m walking speed were measured by the primary nurse or by a nurse with professional training. Three trials were conducted in succession and the average time was taken. The five-fold-sit-to-stand test was conducted as follows: subjects were asked to sit on a 43 cm-tall armless chair with both feet on the ground and hands across their chest, and then stand up and sit down 5 times as quickly as possible. The time taken for this was recorded, and the test was repeated three times in succession, with the average time used. Weight-bearing duration was determined as the patient being able to walk continuously for 3 minutes or more, with a walking distance no fewer than 30 steps, after external fixation removal.

Finally, during the 18-month follow-up period, relevant complications were summarized, including the coxa vara, loose nail, bone nonunion, delayed union of fracture, femoral head necrosis and deep venous thrombosis.

### Statistical Analysis

Statistical Product and Service Solutions (SPSS) 19.0 (SPSS Inc., Chicago, IL, USA) were used, with measurement data presented as mean ± standard deviation (x̄±s). *t*-test was used for the comparison of means between two groups, and $\chi^2$-test was used for the comparison of rates between two groups. Single factor analysis was conducted for relevant patients information, with subsequent non-conditional multi-factor logistic regression analysis performed for items with statistical significance. $p<0.05$ indicated statistical significance.

## Results

### Comparison of Perioperative Conditions Between the Two Groups

The operation duration, hemorrhage during operation, and post-operative drainage volume were all decreased in the observation group compared to the control group ($p<0.05$, Table I).

### Perioperative Harris Hip Joint Function Scale Scores

The pre-operative Harris hip joint function scale scores between the two groups were not statistically significant ($p>0.05$), but the scores in the observation group post-operation were superior to those of the control group ($p<0.05$, Table II).

**Table II.** Pre- and post-operative Harris hip joint function scale scores (x̄±s).

| | Before operation | After operation |
|---|---|---|
| Observation group | 45.5±1.5 | 85.3±2.4 |
| Control group | 45.6±1.5 | 72.3±1.6 |
| *t* | 0.298 | 28.504 |
| *p* | 0.766 | 0.000 |

**Table III.** Comparison of pre- and post-operative pain scores ($\overline{x}$±s).

| | Before operation | After operation |
|---|---|---|
| Observation group | 6.1±0.4 | 4.2±0.2 |
| Control group | 6.0±0.4 | 5.4±0.3 |
| *t* | 1.118 | 21.049 |
| *p* | 0.267 | 0.000 |

### *Comparison of Pre- and Post-Operative Pain Degree*

Pain degree did not differ between the two groups prior to the operation ($p>0.05$), but the observation group reported significantly decreased pain relative to the control group after the operation ($p<0.05$, Table III).

### *Comparison of Bone Mineral Density and Calcitonin Levels Pre- and Post-Operation*

No pre-operative differences in bone mineral density and calcitonin level were observed between the two groups ($p>0.05$), but both bone mineral density and calcitonin levels were elevated in the observation group relative to the control group post-operation ($p<0.05$, Table IV).

### *Comparison of 10-Meter Walking Speed and Five-Fold-Sit-to-Stand Test Times Between the Observation and Control Groups*

After the operation, 10-meter walking speed in the observation group was faster than in the control group ($p<0.05$), and five-fold-sit-to-stand test times were shorter in the observation group compared to the control group ($p<0.05$, Table V).

### *Comparison of Time to Fracture Healing and Weight Bearing Between the two Groups*

Both the times to fracture healing and weight bearing were shorter in the observation group than the control group ($p<0.05$, Table VI).

### *Comparison of Complication Incidence between the two Groups*

The incidence of complications, including coxa vara, loose nail, bone nonunion, delayed union of fracture, femoral head necrosis, and deep venous thrombosis, in the observation group was significantly lower than in the control group ($p<0.05$, Table VII).

## Discussion

Osteoporosis is a common orthopedic disease for middle-aged and elderly people, and mainly manifests clinically in the form of chronic pain, pathological fractures, loss of height, and spinal deformities. These are mainly caused by decreases in bone tissue cell content per unit volume that accompanies bone tissue metabolic disorders. Os-

**Table IV.** Comparison of pre- and post-operative pain scores ($\overline{x}$±s).

| | | Bone mineral density (g/cm$^2$) | Bone calcitonin (ng/L) |
|---|---|---|---|
| Observation group | Pre-operative | 0.68±0.03 | 8.13±0.12 |
| | Post-operative | 0.79±0.04 | 17.36±0.25 |
| Control group | Pre-operative | 0.68±0.04 | 8.12±0.12 |
| | Post-operative | 0.67±0.03 | 12.05±0.18 |

**Table V.** Comparison of 10-meter walking speed and five-fold-sit-to-stand test times between the observation and control groups ($\overline{x}$±s).

| | 10-meter walking speed (m/s) | Five-fold-sit-to-stand test time (s) |
|---|---|---|
| Observation group | 1.6±0.2 | 51.3±11.0 |
| Control group | 0.9±0.1 | 73.6±13.0 |
| *t* | 19.799 | 8.282 |
| *p* | 0.000 | 0.000 |

**Table VI.** Comparison of 10-meter walking speed and five-fold-sit-to-stand test times between the observation and control groups ($\overline{x}$±s).

| | Time to fracture healing (weeks) | Time to weight bearing (d) |
|---|---|---|
| Observation group | 14.6±1.1 | 49.6±2.8 |
| Control group | 16.4±1.0 | 66.9±5.3 |
| *t* | 6.993 | 18.254 |
| *p* | 0.000 | 0.000 |

**Table VII.** Comparison of complication incidence between the two groups [cases (%)].

| | Coxa vara | Loose nail | Bone non-union | Delayed union of fracture | Femoral head necrosis | Deep venous thrombosis | Total incidence |
|---|---|---|---|---|---|---|---|
| Observation group | 1 | 1 | 1 | 1 | 1 | 1 | 6 (15.0%) |
| Control group | 3 | 3 | 3 | 4 | 3 | 3 | 19 (47.5%) |
| $\chi^2$ | | | | - | | | 9.833 |
| *p* | | | | - | | | 0.002 |

teoporosis often occurs in elderly females[6]. With an increasingly aged society, the incidence of osteoporosis has significantly increased in China, with fractures being the most common and serious complication for osteoporosis patients[7]. Femoral intertrochanteric fracture is a common disease involving femoral damage for elderly patients with osteoporosis, and can be divided into stable and unstable intertrochanteric fractures according to cause of injury and integrity of the femoral calcar[8]. Given that elderly patients are more prone to a variety of internal medicine diseases, malnutrition, and decreased immunity, early surgical intervention is recommended to better promote the patient recovery. Many surgical methods exist at present, including PFNA[9], PFN[10], Gamma nail[11], and DHS[12]. PFNA is characterized by a minimally-invasive incision, shorter operation time, less trauma, faster postoperative recovery, and higher biomechanical stability after treatment, and is considered to be the most effective method for the treatment of elderly patients with osteoporotic intertrochanteric fractures[13].

In this study, the observation group received PFNA internal fixation treatment, whereas the control group received DHS treatment. PFNA demonstrated higher stability and more ideal clinical effects (Figure 1). In terms of relevant perioperative parameters, operation duration, hemorrhaging during operation, and postoperative drainage were all decreased in the observation group compared to the control group. In addition, the post-operative Harris hip function scale score was superior in the observation group compared to the control group, despite both groups showing similar pre-operative scores. A similar trend was observed for pain scores. Bone mineral density and calcitonin levels were also improved in the observation group, as well as 10-meter walking speed and five-fold-sit-to-stand test results. Finally, times to fracture healing and weight-carrying were shorter in the observation group, and the observation group experienced fewer complications. Combined, these results indicated that PFNA treatment shortened operation duration, improved postoperative recovery, improved hip joint function recovery, reduced post-operative pain, promoted bone strength, reduced complications, and improved patient quality of life.

In this study, elderly patients with osteoporotic intertrochanteric fractures received the PFNA internal fixation, which was more compatible with tissues. A lateral angle of 6° for the main nail after placement is better aligned with the femur anatomy[14]. Moreover, when the screw blade was screwed to further shorten the exposure time and decrease the amount of bone removed during the operation, only the lateral cortex was opened for the placement of the internal fixation device[15]. Indeed, PFNA treatment is characterized by the shorter arm and minimally-invasive fluoroscopy, which effectively reduced or even avoided damage to key blood vessels in fracture sites[16]. Furthermore, the sleeve technique significantly reduced femoral shaft stress[17], thus reducing iatrogenic secondary injury to the femoral shaft and effectively avoiding the local excessive compression stress present in DHS treatment. The observed increases in bone mineral density and calcitonin levels in the observation group may be related to the lateral angle

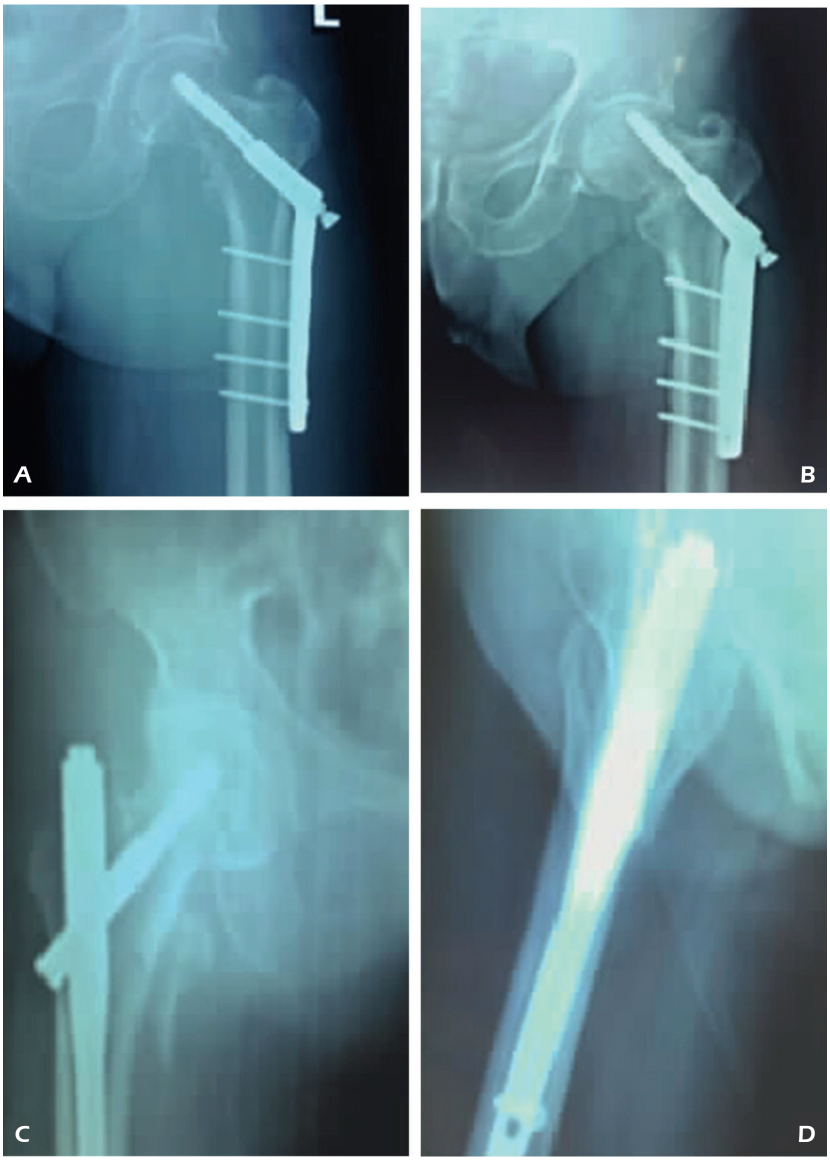


**Figure 1**. X-ray images for some typical cases. **A**, An immediate review after internal fixation of the left-side DHS for a 75-year-old male patient. **B**, Internal fixation migration shown in an X-ray film taken 3 months after internal fixation of the left-side DHS for a 75-year-old male patient. **C**, X-ray film of an immediate review after internal fixation of the right-side closed reduction PFNA for a 76-year-old male patient. **D**, X-ray film taken 3 months after internal fixation of the right-side closed reduction PFNA for a 76-year-old male patient.

of 6° of the main nail after placement of internal fixation[18], which may continuously stimulate cancellous bone osteoblast activity – thereby increasing bone formation and calcitonin secretion rates[19]. This easing of osteoporosis would then translate to improved walking and sitting ability. The improvements in time to fracture healing and weight bearing observed in the observation group may be explained by how during the PFNA operation, the fixture was knocked by external forces and placed into the femoral medullary cavity, allowing for the narrowing of the separation distance and promoting anatomical reduction for patients with separate fracture sites, especially within 3 mm, during the knocking process[20]. The PFNA internal fixation device also had superior anti-rotation ability and supporting stability, which could protect the periosteum to a greater extent and promote postoperative recovery. Finally, the incidence of complications in the observation group was lower, further confirming the safety of the PFNA operation.

## Conclusions

PFNA is characterized by minimal invasiveness, decreased operation durations, and accelerated postoperative recovery in the treatment of osteoporotic intertrochanteric fractures, and can also effectively improve post-operative bone density. All this combines to promote joint function recovery and reduce complication incidence in patients after the procedure.

## Conflict of Interests

The authors declared no conflict of interest.

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