European Review for Medical and Pharmacological Sciences 2022; 26: 3872-3877

Clinical effect of cement-enhanced APFN in the treatment of elderly osteoporotic intertrochanteric fractures

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Abstract. – OBJECTIVE: To explore the clinical effect of bone cement-enhanced Asian proximal femoral anti-rotation intramedullary nail (APFN) internal fixation in the treatment of elderly osteoporotic intertrochanteric fractures of the femur and provide it as a more robust treatment to elderly patients with osteoporotic intertrochanteric femoral fractures.

PATIENTS AND METHODS: Between January 2017 and January 2019, 42 patients with osteoporotic intertrochanteric fractures in our hospital were selected. All patients were randomly divided into the proximal femoral anti-rotation intramedullary nail (PFNA) group and APFN group. The PFNA group received conventional PFNA internal fixation, and the APFN group received bone cement-enhanced APFN internal fixation. The operation time, intraoperative blood loss, average fracture healing time, weight bearing time, and hip function recovery of the two groups of patients were evaluated.

RESULTS: All patients were followed up. There was no significant difference in intraoperative blood loss between the two groups. Compared with the PFNA group, the weight-bearing time and hospital stay of the APFN group were significantly shorter. According to the Harris score of hip joint function, the excellent and good rate of the APFN group was better than that of the PFNA group.

CONCLUSIONS: Compared with conventional PFNA internal fixation, cement-enhanced APFN internal fixation has the advantage of early functional reconstruction in the treatment of osteoporotic femoral intertrochanteric fractures. It can significantly shorten the time required for patients to get out of bed and bear weight. It is an effective method for the treatment of osteoporotic femoral intertrochanteric fracture.

Key Words:
Intertrochanteric fracture of the femur, Bone cement-reinforced APFN, Clinical efficacy.

Introduction

Femoral intertrochanteric fracture is a common clinical disease. Elderly individuals can experience fractures due to osteoporosis. If nonsurgical treatment is used, serious complications, such as pulmonary infections, urinary tract infections and pressure ulcers, can easily occur when lying in bed for a long time. The mortality rate associated with femoral intertrochanteric fracture in the elderly is 15-20%, which is mainly caused by complications or deterioration of coexisting diseases after fractures lying in bed[1,2]. Therefore, rapid control of the deterioration of coexisting diseases and effective prevention of bed rest complications play a key role in the successful treatment of femoral intertrochanteric fractures in the elderly.

The early stage of femoral intertrochanteric fracture fixation is mainly extramedullary fixation, including the dynamic hip screw system (DHS) and dynamic condylar screw system (DCS). DHS and DCS operations are widely exposed, with great trauma and blood loss. Due to stress shielding and periosteal ischemia under the steel plate, osteoporosis and comminuted fracture easily occur under the steel plate, and it is easy to cause ischemic necrosis of the fracture block due to excessive periosteal stripping, resulting in

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fracture nonunion. In the later stage, complications, such as hip varus screw cutting out, fracture under the steel plate and fracture of the steel plate and screw, can easily occur[3-5]. Therefore, for elderly patients with osteoporosis, the effect of selecting intramedullary fixation instruments is better than that of selecting the standard chute system. It has a small surgical incision, less bleeding, closed reduction and placement and little impact on the fracture site and can carry weight early after the operation, which is more in line with the principle of minimal invasiveness[6]. At present, intramedullary fixation has become the mainstream fixation method for femoral intertrochanteric fractures. With the development and replacement of several generations of internal fixation, such as gamma nail and PFN fixation, proximal femoral anti-rotation intramedullary nail (PFNA) fixation has become an ideal fixation method recognized by many experts. Compared with gamma nail, PFN and other internal fixations, PFNA's unique spiral blade design can greatly reduce the damage of cancellous bone in the femoral head. In contrast, it can pressurize cancellous bone and improve the anchoring force of the spiral blade during nail placement. Therefore, theoretically, it has considerable advantages in treating patients with unstable fractures and osteoporosis, although there are many reports[7] of complications, such as spiral blade cutting, fracture nonunion and hip varus. The cutting of the spiral blade is considered to be the most important factor for the failure of internal fixation. Therefore, the position of the spiral blade in the femoral head has always been a research focus. At the same time, some researchers[8,9] believe that a severe osteoporosis is a risk factor for internal fixation failure of femoral intertrochanteric fracture.

In view of the current shortage of internal fixation of femoral intertrochanteric fracture, the bone cement-enhanced APFN internal fixation system has recently emerged. It applies the innovative design of injectable bone cement hollow screw blade, injects a certain amount of bone cement through the bone cement outflow hole at the tip of the blade, diffuses along the reticular bone structure in the femoral neck to the adjacent bone and fracture site, fills the loose space and stabilizes the fracture end, The interface complex of "blade bone cement bone trabecula" is formed, which is the "tree root" to strengthen the anchoring effect[10]. Moreover, bone cement filling the loose space has a certain buffering and stabilizing effect on the fracture structure and adjacent parts, reduces the local stress around the fractured femur and prevents the further occurrence of the affected part of the fracture for patients with osteoporotic femoral intertrochanteric fracture. Bone cement-enhanced APFN internal fixation has achieved satisfactory clinical results.

Patients and methods

General Information

Between January 2017 and January 2019, 42 patients with osteoporotic intertrochanteric fractures were selected, including 26 females and 16 males, with an average age of 79.82 ± 11.67 years. According to the AO classification, there were eight cases of type A1, 16 cases of type A2 and 18 cases of type A3. The patients were divided into two groups. In the first group, 22 patients received conventional femoral intramedullary nail internal fixation (PFNA); in the second group, 20 patients received bone cement-enhanced APFN internal fixation. There was no significant difference in sex, age, height, weight or fracture classification between the two groups ($p > 0.05$).

Surgical Methods

The operations were performed by the same group of experienced orthopedic surgeons in our hospital, and the patients were all under epidural anesthesia. In the PFNA group, after the anesthesia was completed, the patient was placed on the orthopedic surgical traction bed. First, the fracture should be pulled to achieve anatomical reduction as much as possible. After the reduction was completed, the surgeon touched the apex of the ipsilateral femoral trochanter. A longitudinal surgical incision approximately 3-5 cm long was made at the proximal end of the apex of the greater trochanter of the affected side of the femur, the fascia layer was cut, and the muscle and other soft tissues were bluntly separated until the operator's fingers touched the apex of the greater trochanter of the femur. The guide needle was drilled through the needle insertion point. After the C-arm machine fluoroscopy confirmed that the guide needle was in the right position, the opening and reaming were carried out. Then, the PFNA main nail of moderate length was inserted, and the spiral blade was knocked into the femoral head through the sight. After the fluoroscopy confirmed that the spiral blade entered at the proper length, the blade was locked. Finally, the screw at the distal end of the main nail and the main nail tail were screwed in one by one. The surgical incision underwent hemostasis and was cleaned and sutured to the skin and soft tissue layer by layer.

In the APFN group, the operation process was basically the same as that in the first group. First, after anesthesia, the fracture was reduced on the surgical traction table. After satisfactory reduction, the best needle insertion point was selected to drill the guide needle and the main nail in turn, and the spiral blade was inserted. The position and length were confirmed under C-arm fluoroscopy. Then, a certain amount of bone cement was injected through the bone cement outflow hole of the tip of the blade through the hollow spiral blade of the bone cement. Finally, the screw was screwed at the distal end of the main nail and the main screw tail in turn. The surgical incision underwent hemostasis and was cleaned and sutured to the skin and soft tissue layer by layer.

Postoperative Treatment

The PFNA group and the APFN group were treated in the same way after the operation. Routine swelling, analgesia and antibiotics were used to prevent infection after the operation. On the second day after the operation, both groups were given anticoagulation therapy to prevent deep vein thrombosis in both lower extremities. On the second day, the surgical incision on the affected side was disinfected, the dressing was changed, and the affected side was filmed for inspection. Each patient was encouraged to perform quadricep contraction and ankle pump exercises while lying in bed. After the operation, patients were discharged from the hospital to report to the outpatient department of our hospital for film examination. According to the examination results, the next specific functional rehabilitation exercise plan was formulated.

Observation Indicators

The operation time, intraoperative blood loss, hospital stay, postoperative weight-bearing time, fracture healing and clinical effects of the two groups were analyzed. According to the Harris scoring standard, during follow-up hip joint function was evaluated.

Statistical Analysis

Data were processed by SPSS 20.0 statistical software (IBM Corp., Armonk, NY, USA). Measurement data conforming to the normal distribution were expressed as the mean ± standard deviation ($x \pm s$) and used two independent-samples t tests, count data used χ^2 tests and rank data comparisons used rank sum tests. Differences were statistically significant at $p < 0.05$.

Results

42 patients were followed up for 12-16 months. The operation time of 69.6 ± 13.8 minutes in the APFN group was longer than that in the PFNA group (52.7 ± 10.3 minutes), due to the injection of bone cement, and the difference was statistically significant ($p < 0.05$). The intraoperative blood loss of the APFN group was 139.2 ± 36.7 ml, while that of the PFNA group was 132.8 ± 32.5 ml, and there was no significant difference between the two groups ($p > 0.05$). The fracture healing time was 12.3 ± 2.1 months in the APFN group and 12.8 ± 2.6 months in the PFNA group, and there was no significant difference ($p > 0.05$). The postoperative weight-bearing time of 8.3 ± 2.5 weeks and hospital stay of 9.5 ± 1.8 days in the APFN group were significantly shorter than those in the PFNA group of 12.8 ± 2.3 weeks and 16.3 ± 3.2 days, respectively, and the difference was statistically significant ($p < 0.05$). In addition, according to the Harris score of hip joint function, the excellent and good rate was 92.6% in the APFN group and 88.7% in the PFNA group. Typical cases are shown in Figure 1.

Discussion

Intertrochanteric fractures of the femur are more common in the elderly and are generally associated with basic medical diseases. Conservative treatment requires long-term limb immobilization and bed rest. Quality of life cannot be guaranteed, and patients are prone to severe complications, such as lung infections, urinary system infections and bedsores. The mortality rate is high; fractures cannot be reduced well and often heal in the deformity of shortening and coxa varus, resulting in abnormal gait and functional limitation among patients[11]. Surgical internal fixation has become the basic principle for the treatment of femoral intertrochanteric fractures, and its purpose is to produce well-reduced fractures, firm internal fixation and early postopera-

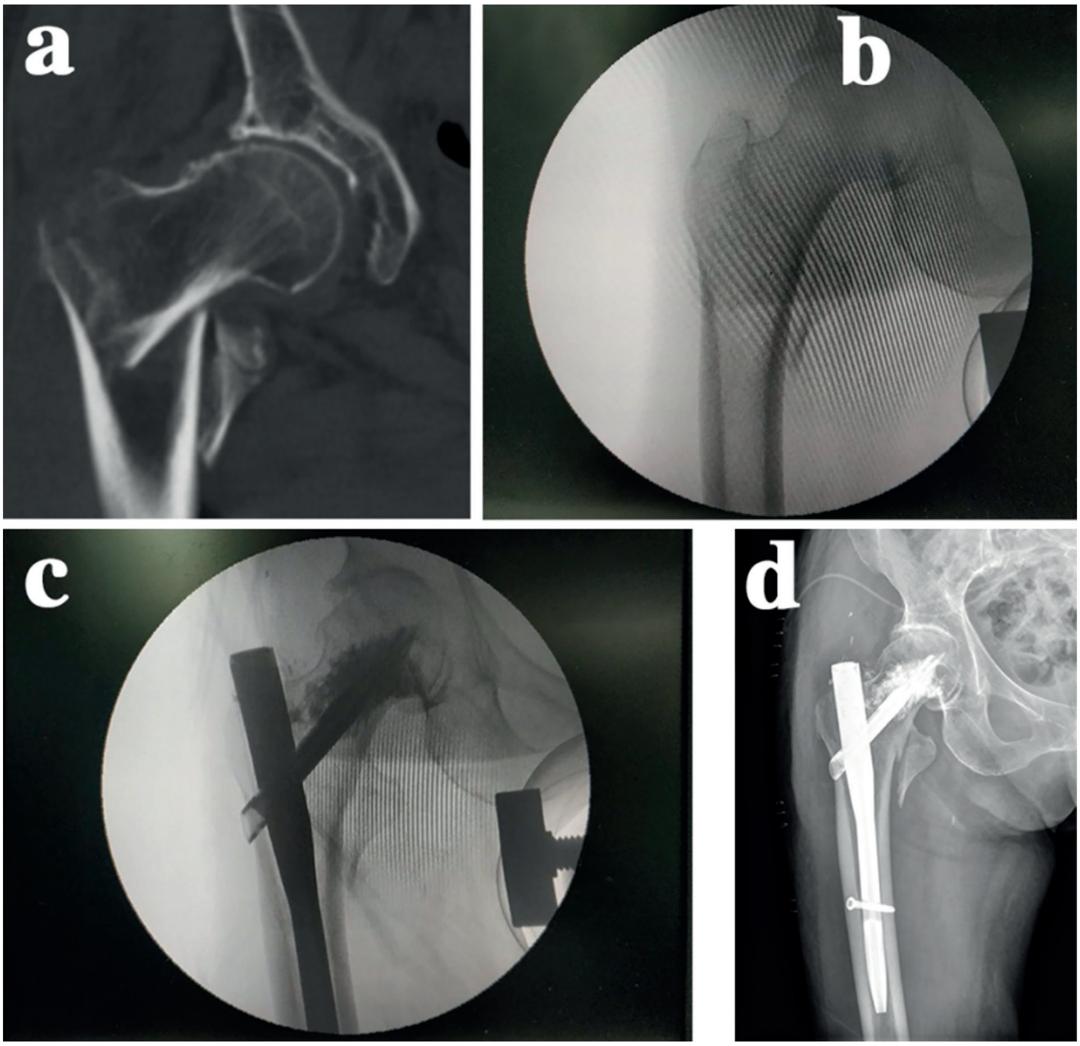

Figure 1. A 68-year-old man with right hip pain and limited movement due to a fall was admitted to the hospital for one day. **a,** Preoperative hip X-ray film showed a right femoral intertrochanteric fracture. **b,** Images after intraoperative fracture reduction. **c,** Intraoperative internal fixation and bone cement-enhanced imaging. **d,** The postoperative hip X-ray showed that the fracture reduction was good, and the bone cement was evenly dispersed in the femoral head.

tive functional exercises. However, elderly people often have different degrees of osteoporosis, surgical treatment can be difficult, the failure rate of postoperative internal fixation is high, and it is difficult for clinical effects to meet expectations[12]. Therefore, choosing the appropriate surgical plan and internal fixation equipment to reduce postoperative complications and improve the treatment effect is still a hot topic in the treatment of femoral intertrochanteric fractures in the elderly.

The biomechanical advantage of PFNA lies in its short force arm, strong resistance to bending under load and sliding pressure. The design of PFNA is close to the anatomical shape of the proximal femur of Asians, which facilitates the insertion of the main nail into the medullary cavity through a small incision, reduces damage to the blood circulation and bone quality of the femoral head and neck, and is more suitable for the stress distribution of the proximal femur, preventing the occurrence of a femoral head. At the same time of necrosis, it is also conducive to fracture reduction and healing[13]. The spiral blade-like PFNA screw has a spiral cross design with a large surface area and gradually increasing core diameter, which can embed the surrounding bone instead of removing the limited bone when it is driven. The large screw surface area and the special spiral blade-like design make it fit firmly to the cancellous bone and have good resistance to rotation. The spiral blade-like screw is driven in instead of screwed in during the surgical operation, which can avoid the rotation and collapse of the femoral neck, can bear more load than the lag screw and has angular stability to prevent hip varus. Although PFNA has good anti-rotation and biomechanical properties, it still has a certain failure rate[14], which is closely related to the patient's osteoporosis.

The cement-enhanced APFN internal fixation system is a new type of system that was developed based on PFNA in recent years. The internal fixation system can further enhance internal fixation through specific channels, such as bone cement, on the basis of internal fixation. The patient's weight-bearing time on the ground is advanced, and postoperative complications are significantly reduced. The cement-enhanced APFN internal fixation system is more suitable for elderly patients with severe osteoporosis, unstable fracture comminution and the inability to tolerate long-term surgery and allows early postoperative activities and weight bearing[15]. In this study, our hospital used the cement-enhanced APFN internal fixation system to treat patients with osteoporotic femoral intertrochanteric fractures. During the follow-up DR imaging examination, there was no internal fixation failure, spiral blade cut out or nail withdrawal.

Complications, such as fractures and nonunion, were observed. Patients were encouraged to get out of bed early after surgery, and the time to get out of bed was significantly shorter than that of traditional PFNA patients. More importantly, according to the Harris score of hip joint function, the excellent and good rate of the APFN group was better than that of the PFNA group, proving that the use of a cement-enhanced APFN internal fixation system for the treatment of elderly osteoporotic femoral intertrochanteric fractures can achieve a relatively satisfactory early clinical effect. As bone cement can become a strong adhesive force after solidification, it can further effectively increase the mechanical stability of the internal fixation system and the strength of the bone around the fracture, thereby allowing the patient to get early out of bed postoperatively for weight-bearing activities.

Conclusions

In short, compared with the traditional PFNA internal fixation system, cement-enhanced APFN internal fixation can solve the related complications caused by osteoporotic femoral intertrochanteric fractures. For example, it can allow patients to get out of bed as soon as possible after surgery, effectively preventing the complications caused by long-term bed rest. This reduces the likelihood of nail removal caused by the patient's osteoporosis, secondary fractures and coxa varus deformity caused by premature movement, and the function of the patient's hip joint after surgery recovery is more satisfactory.

However, bone cement-enhanced APFN internal fixation also has certain shortcomings. For example, it increases the operation steps and prolongs the operation time. Second, the bone cement may cause a certain toxic reaction, which further increases the intraoperative risk. In addition, the shortcomings of this retrospective study are that it is not as scientific as a prospective study, and the heterogeneity of fracture types in the two groups inevitably biased the results. The risk of long-term femoral head necrosis still needs further observation.

Conflict of Interest

The Authors declare that they have no conflict of interests.

Acknowledgements

This work was supported by the Yancheng Science and Technology Planning Project [grant number YK20100054], General Program of Jiangsu health committee (M2020008) and Scientific Research Projects of Wuxi Health Committee [grant number M202040 and 2020ZHYB09].

Informed Consent Statement

The informed consent requirement was waived because this was a retrospective analysis.

Authors' Contribution

Fei Zhang and Quan-Ming Zhao conceived and designed the study. Xiao-hui Ni, Xing-yuan Zhu and Zhi-Yong Zhang performed the investigation, collected the data and wrote the manuscript. Lu Zhang, Liu-bao Ren and Jie-Shi Wu contributed to the interpretation of the data and analyses. All authors read and approved the final manuscript.

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