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Comparison of PFNA and DHS in the treatment of sarcopenia with Seinsheimer type V subtrochanteric fracture

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Abstract. – OBJECTIVE: We aimed at comparing the curative effect of proximal femoral nail antirotation (PFNA) and dynamic hip screw (DHS) in the treatment of Seinsheimer type V (type V) subtrochanteric fractures with sarcopenia.

PATIENTS AND METHODS: A retrospective analysis was performed on 59 patients with type V subtrochanteric fractures complicated with sarcopenia admitted to the Department of Orthopedics of the affiliated Jiangning Hospital with Nanjing Medical University from January 2016 to December 2021. Sarcopenia was diagnosed based on grip strength and skeletal muscle index (SMI). According to different surgical methods, they were divided into PFNA group (32 cases) and DHS group (27 cases). The age, gender, time from injury to operation, SMI value, incision length, operation time, intraoperative blood loss, fluoroscopy times, perioperative blood transfusion, lower limb full weight-bearing time, visual analogue scale (VAS) for pain at 3 months after operation and at the last follow-up, Harris score as well as postoperative complications were compared between the two groups.

RESULTS: There were no significant differences in age, gender, time from injury to operation, and SMI between the two groups. The length of surgical incision, blood loss and blood transfusion in the PFNA group were less than those in the DHS group; however, the number of intraoperative fluoroscopies was more than that in the DHS group. The PFNA group had earlier full weight-bearing time, lower VAS score and higher Harris score at 3 months after operation, while there was no statistically significant difference in VAS score and Harris score between the two groups at the last follow-up. The incidence of complications in the PFNA group was lower than that in the DHS group, and the difference was statistically significant.

CONCLUSIONS: Both PFNA and DHS are effective methods for the treatment of type V subtrochanteric fractures complicated with sarcopenia. Strikingly, PFNA is preferred because of its short surgical incision, less blood loss, faster recovery, and lower incidence of complications.

Key Words:
Sarcopenia, Hip fracture, Femoral fracture, PFNA, DHS.

Introduction

Subtrochanteric fractures generally refer to fractures that occur within 5 cm below the lesser trochanter of the femur, accounting for about 5% to 34% of proximal femoral fractures[1]. Young people mostly suffer from high-energy injuries, while middle-aged and elderly people mostly suffer from low-energy injuries. Due to the relatively concentrated stress at the fracture site, it is difficult to maintain the fracture end after reduction, and the incidence of complications such as nonunion and refracture is relatively high[2]. The Seinsheimer classification of subtrochanteric fractures is widely used, and type V refers to fractures that involve both the subtrochanteric and intertrochanteric fractures[3]. This type of fracture is difficult to treat due to the instability of the fracture end. Clinically, surgical methods are divided into intramedullary fixation and extramedullary fixation, which at present are still the gold standard. The representative surgical approach of the former is proximal femoral nail antirotation (PFNA),

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and the commonly used surgical method of the latter is dynamic hip screw (DHS).

Intramedullary fixation is axial fixation, which can provide good stability. Although extramedullary fixation is eccentric, fracture reduction can be performed under direct vision, making it easier to achieve a more satisfactory fracture alignment. Compared with extramedullary fixation, intramedullary nailing has less blood loss and shorter incision. Nevertheless, some scholars believe that DHS has more advantages, especially in the treatment of comminuted fractures[4,5].

Currently, with the continuous development of research on elderly patients, sarcopenia combined with hip fracture has become a hot spot. Research demonstrated that elderly patients with hip fragility fractures with sarcopenia had poorer postoperative functional recovery and quality of life[6]. Sarcopenia is defined by the European Working Group on Sarcopenia in Older People 2 (EWGSOP2) as a decrease in muscle mass and quantity associated with increasing age. According to the latest diagnostic criteria, grip strength < 27 kg for men and < 16 kg for women is the precursor condition for the diagnosis of sarcopenia[7]. Sarcopenia is strongly associated with an increased risk of falls, fracture nonunion, and death[8-11] (Figure 1). There are no studies comparing the surgical efficacy of PFNA or DHS in the treatment of sarcopenia complicated with Seinsheimer type V (type V) subtrochanteric fractures. In this study, by analyzing the differences in the main outcome indicators between the two surgical methods, we determined the more suitable approach for patients with sarcopenia, in order to improve the quality of life and prolong the survival time of elderly patients.

Patients and Methods

Patients

This is a retrospective analysis of 59 patients with sarcopenia and V-type subtrochanteric fracture treated with PFNA or DHS in the department of Orthopedics of the Jiangning Hospital affiliated to Nanjing Medical University from January 2016 to December 2021. This study was approved by the Ethics Committee of the affiliated Jiangning hospital with Nanjing Medical University (No. 201401015). In addition, this research was performed in accordance with the Declaration of Helsinki. The informed consent was obtained from all participants. All patients have signed informed consent. The following are the inclusion and exclusion criteria of this study.

Inclusion criteria: (1) meeting the diagnostic criteria for sarcopenia, (2) type V subtrochanteric fracture, (3) aged ≥ 50 years, (4) low-energy injury, (5) receiving PFNA or DHS surgery, (6) 14-18-month follow-up.

Exclusion criteria: (1) combined with other fractures or organ injuries, (2) combined with serious underlying diseases that affect the patient's life, (3) previous lower limb dysfunction or history of lower limb surgery, (4) perioperative lower limb venous thrombosis requiring a filter treatment, (5) pathological fractures, (6) open fractures, (7) combining factors that affect fracture healing, such as long-term alcoholism or hormone use, (8) fractures caused by zoledronate in the past three years.

Diagnosis of Sarcopenia

After the patient was admitted to the hospital, the grip strength of the patient's dominant hand was detected with a hand gripper (Kangdu, Guangdong, China). The patient's dominant hand

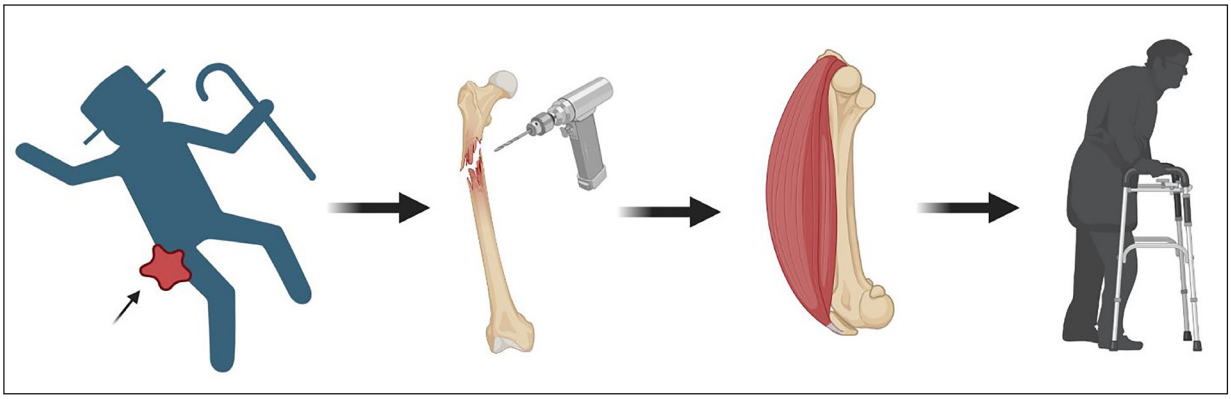

Figure 1. Sarcopenic patients are prone to falls leading to fractures and have poorer recovery from surgery.

grip strength was measured three times, and the average value was taken. The diagnostic cut-off value of grip strength is < 27.0 kg for men and < 16.0 kg for women. When the diagnostic threshold of grip strength was met, the skeletal muscle index (SMI) was calculated based on chest computed tomography (CT), which is the sum of the muscle area measurements divided by the square of the patient's height (cm^2/m^2). On CT images at the level of the pedicles of the 12th thoracic vertebrae (T12), the muscle area including the erector spinae, latissimus dorsi, internal obliques, external obliques, rectus abdominis, external intercostal muscles, and intercostal muscles was measured (the CT value muscle tissue is –29 - +150 HU). Images were analyzed using PACS 3.6 software (Philips, Hamburg, Germany). All data were independently measured by three physicians with more than three years of work experience. In addition, the measurers were blinded to the patients. SMI values < 42.6 cm^2/m^2 for males and < 30.6 cm^2/m^2 for females were diagnosed as sarcopenia[12]. Patients meeting the diagnostic criteria for sarcopenia were included in this study.

Surgical Approach

In the PFNA group, briefly, patients were placed in the supine position under general anesthesia. The orthopedic traction table was used for continuous traction, and the operation began after the fracture reduction was satisfactory under C-arm fluoroscopy. The skin was disinfected three times with povidone iodine, and a 2-3 cm longitudinal incision was made at the proximal end of the femur greater trochanter. After touching the apex of the greater trochanter, insert the main nail 0.5 cm medial to the apex of the greater trochanter. Subsequently, drive in the helical blade and the distal locking screw as required. The fracture reduction and internal fixation position were confirmed by fluoroscopy again. The intramedullary nail system is provided by Watson (Changzhou, China).

The DHS group adopted the same position and anesthesia as the PFNA group. After povidone iodine disinfection, a longitudinal incision about 10 cm long was made downward from the apex of the greater trochanter. Pull the muscle laterally to expose the proximal femur. The lower extremity was abducted and internally rotated, and the fracture was reduced under direct vision. Kirschner wires were used to temporarily fix the fracture, and a 135° locator was placed about 2 cm below the greater trochanter. Drive in positioning pins, then screw in goose-head nails, place steel plates and screws for fixation in sequence. Finally, a hollow nail was implanted in the greater trochanter. The DHS system is provided by DeMedia (Shenzhen, China).

All patients received symptomatic and supportive treatment such as prevention of infection, prevention of venous thrombosis, and pain relief after operation. Instruct patients to perform quadriceps isometric contraction exercise and lower extremity joint function exercise. After discharge from the hospital, regular follow-up visits were made in the outpatient clinic. X-rays were reviewed and rehabilitation exercises were guided.

Clinical Results

The general characteristics of the patients included age, gender, time from injury to operation and SMI. The total length of surgical incision, operation time (from the beginning of closed reduction to the end of operation), intraoperative blood loss, number of fluoroscopies, perioperative blood transfusion, time of full weight-bearing of lower limbs, visual analog scale (VAS) at 3 months after operation and last follow-up were compared between the two groups. Additionally, the Harris score as well as postoperative complications, including infection, internal fixation failure, and nonunion, were evaluated.

Statistical Analysis

Statistical analysis was performed using SPSS 22.0 (IBM Corp., Armonk, NY, USA) software. The Kolmogorov-Smirnov test was used to test whether the measurement data conformed to the normal distribution, and the normal distribution was expressed as mean ± standard deviation (). When the variances were equal, the *t*-test was used for comparison between groups (age, time from injury to operation, SMI, incision length, operation time, intraoperative blood loss, fluoroscopy times, perioperative blood transfusion, lower extremity full weight-bearing time, Harris score). When the variances were not homogeneous, the rank sum test was used. Chi-square test was used for enumeration data (sex). A value of $p < 0.05$ on both sides was considered statistically significant.

Results

Comparison of General Conditions Between the Two Groups

A total of 52 patients with sarcopenia complicated with V-type subtrochanteric fracture met the inclusion and completed the follow-up. There were 32 cases in the PFNA group, including 20 males

and 12 females. The average age was 66.19 ± 7.74 years old, the time from injury to operation was 3.47 ± 1.50 days, and the average SMI was 28.73 ± 5.95 cm^2/m^2. There were 27 cases in the DHS group, including 17 males and 10 females. The average age was 66.00 ± 9.49 years old, the time from injury to operation was 3.41 ± 1.28 days, and the average SMI was 31.12 ± 7.19 cm^2/m^2. There were no significant differences between the two groups in terms of age (t = 0.084, $p = 0.934$), gender composition ($\chi^2 = 0.001$, $p = 0.971$), time from injury to surgery ($t = 0.167$, $p = 0.868$), and SMI values ($t = -1.392$, $p = 0.169$) (Table I).

Comparison of Operation-Related Indicators Between the Two Groups

The total length of surgical incision in the PFNA group was 6.53 ± 0.88 cm. The intraoperative blood loss was 175.63 ± 110.98 ml, correspondingly, the perioperative blood transfusion was 206.25 ± 218.41 ml. The operation time was 99.53 ± 41.10 min with intraoperative fluoroscopy 19.91 ± 6.59. As a comparison, the total length of surgical incision in the DHA group was 11.33 ± 1.66 cm. The intraoperative blood loss was 434.81 ± 200.00 ml, and the perioperative blood transfusion was 385.19 ± 241.32 ml. The operation time was 95.37 ± 47.27 min with intraoperative fluoroscopy 7.07 ± 2.66. Compared with the DHS group, the PFNA group had shorter surgical incision ($t = -13.490$, $p = 0.000$), less blood loss ($t = -5.952$, $p = 0.000$) and less blood transfusion ($t = -2.988$, $p = 0.004$); however, the more intraoperative fluoroscopy times ($t = 10.084$, $p = 0.000$), the difference was statistically significant. There was no significant difference in operation time between the two groups ($t = 0.362$, $p = 0.719$) (Table II).

Comparison of Postoperative Fracture Healing and Hip Joint Function

The full weight-bearing time of the lower limbs in the PFNA group was 14.94 ± 2.37 w. The VAS score was 1.91 ± 1.53 and 0.56 ± 0.76 at 3 months after operation and at the final follow-up, respectively. The Harris score was 80.03 ± 4.16 and 87.91 ± 3.06 at 3 months after operation and at the last follow-up, respectively. Correspondingly, the full weight-bearing time of the lower limbs in the DHS group was 118.56 ± 3.90 w. The VAS score was 2.81 ± 1.82 and 0.70 ± 0.72 at 3 months after operation and at the final follow-up, respectively. The Harris score was 73.04 ± 2.61 and 86.93 ± 4.13 at 3 months after operation and at the last follow-up, respectively. Compared with the DHS group, the postoperative weight-bearing time in the PFNA group was earlier ($t = -3.874$, $p = 0.000$), the VAS score was lower ($z = -2.083$, $p = 0.042$), and the Harris score was higher at 3 months after operation ($t = 7.139$, $p = 0.000$), the difference was statistically significant. Nevertheless, there was no significant difference in VAS score ($z = -0.727$, $p = 0.470$) and Harris score ($t = 0.733$, $p = 0.468$) between the two groups at the last follow-up (Table III).

Table I. Comparison of general conditions of patients.

	PFNA	DHS	Statistics	*p*-value
Cases	32	27		
Age	66.19 ± 7.74	66.00 ± 9.49	0.084	0.934
Gender (Male : Female)	20 : 12	17 : 10	0.001	0.971
Time from injury to operation (days)	3.47 ± 1.50	3.41 ± 1.28	0.167	0.868
SMI (cm^2/m^2)	28.73 ± 5.95	31.12 ± 7.19	-1.392	0.169

SMI: Skeletal Muscle Index.

Table II. Comparison of surgery-related indicators between the two groups ($\bar{x}\pm s$).

	PFNA	DHS	Statistics	*p*-value
Incision length (cm)	6.53 ± 0.88	11.33 ± 1.66	-13.490	0.000
Blood loss (ml)	175.63 ± 110.98	434.81 ± 200.00	-5.952	0.000
Blood transfusion (ml)	206.25 ± 218.41	385.19 ± 241.32	-2.988	0.004
Fluoroscopy times	19.91 ± 6.59	7.07 ± 2.66	10.084	0.000
Operation time (min)	99.53 ± 41.10	95.37 ± 47.27	0.362	0.719

Table III. Comparison of fracture healing and hip joint function between the two groups.

	PFNA	DHS	Statistics	*p*-value
Weight-bearing time (weeks)	14.94 ± 2.37	18.56 ± 3.90	-3.874	0.000
VAS (3 months after surgery)	1.91 ± 1.53	2.81 ± 1.82	-2.083	0.042
VAS (the last follow-up)	0.56 ± 0.76	0.70 ± 0.72	-0.727	0.470
Harris (3 months after surgery)	80.03 ± 4.16	73.04 ± 2.61	7.852	0.000
Harris (the last follow-up)	87.91 ± 3.06	86.93 ± 4.13	1.019	0.313
Complications (cases) (%)	2 (6.25%)	8 (29.63%)	4.174	0.042

VAS: Visual Analogue Scale.

In the PFNA group, internal fixation loosened in 2 cases, and the complication rate was 6.25%. In the DHS group, wound infection occurred in 3 cases, and internal fixation loosened in 5 cases, with a complication rate of 29.63%. The difference was statistically significant ($\chi^2 = 4.174$, $p = 0.042$) (Table III). The X-ray examinations of patients in the two groups during the perioperative period and postoperative follow-up are shown in Figure 2.

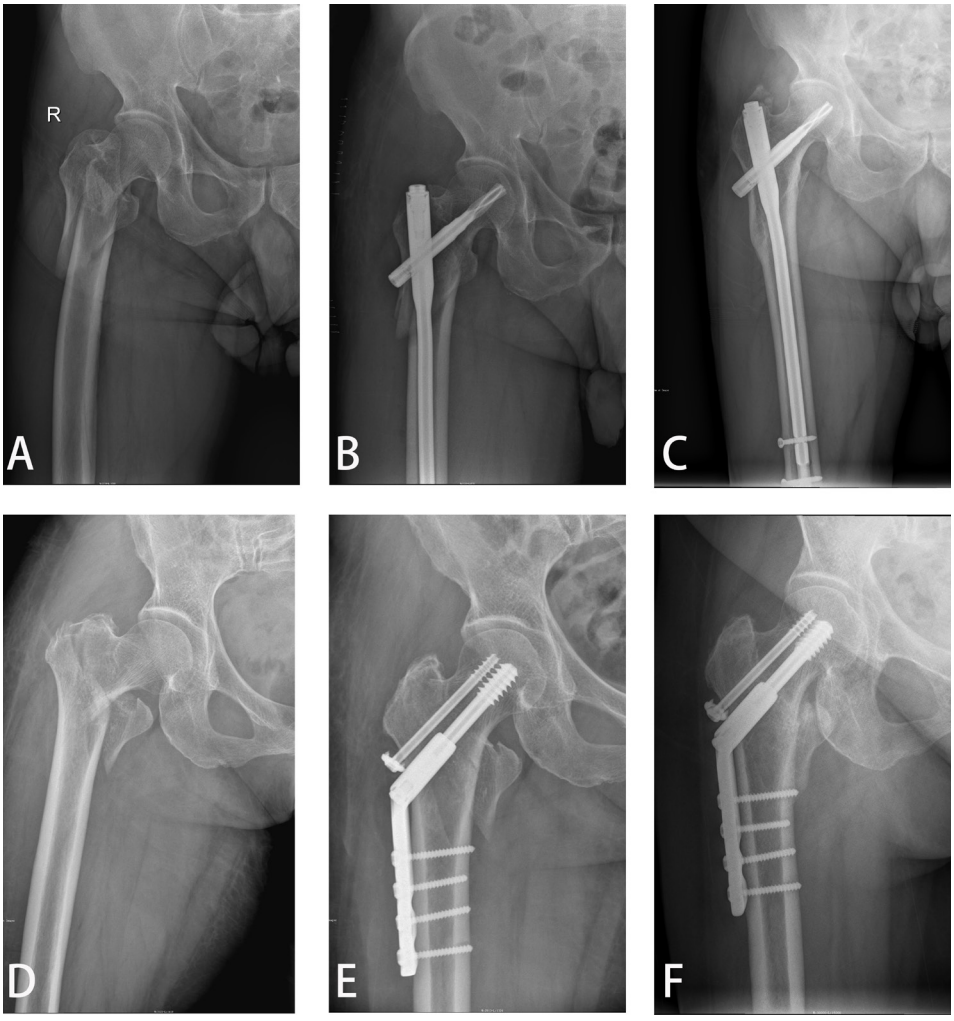

Figure 2. Imaging examinations of patients with sarcopenia in the perioperative period and postoperative follow-up of the two groups. **A-C**, Male, 56 years old, diagnosed with subtrochanteric fracture complicated with sarcopenia, underwent PFNA surgery. **A**, Preoperative X-ray film, (**B**) Re-examination X-ray film on the second day after operation, (**C**) Re-examination X-ray film at the last follow-up. **D-F**, Female, 72 years old, diagnosed with subtrochanteric fracture with sarcopenia, underwent DHS surgery. D, Preoperative X-ray film, (**E**) Re-examination X-ray anteroposterior film on the second day after operation, (**F**) Re-examination X-ray film at the last follow-up.

Discussion

Population aging poses enormous challenges to public health. The incidence of sarcopenia increases with age and is becoming more prevalent in the elderly[13]. Sarcopenia is a syndrome characterized by progressive and pervasive loss of skeletal muscle mass and strength, which not only affects patients' ability to perform daily activities, but also leads to increased surgical complications, mortality, and morbidity[14]. As the importance of sarcopenia has grown in awareness, it has become a focus of public policy. Studies[15-17] have revealed that sarcopenia is associated with cancer, cardiovascular disease[18], liver and kidney disease[19], and even high mortality among the elderly in the community[20]. Bone is the organ most closely associated with muscle. Patients with sarcopenia are at increased risk of adverse outcomes after hip and spine fractures[21,22].

Subtrochanteric fractures are a special type of hip fracture that are more difficult to treat. The subtrochanteric region is the transition zone from cancellous bone to cortical bone, where local stress is concentrated. Since the medial cortical bone bears a large varus stress and vertical pressure, coupled with strong surrounding muscles, when a fracture occurs, the proximal femur is pulled by the iliopsoas and external rotators, resulting in flexion, abduction, and external rotation shift. However, due to the pull of the adductor muscles, the distal fracture end is adducted and displaced proximally, leading to extremely instability, difficulty in reduction, and damage to the force line of the lower limbs. The nonunion rate of subtrochanteric fractures is about 4% to 5%[23]. Type V fractures refer to subtrochanteric fractures accompanied by intertrochanteric fractures. The treatment options for subtrochanteric fractures are not exactly the same as those for intertrochanteric fractures. Intramedullary fixation, extramedullary fixation, or a combination of the two are most commonly used for surgical treatment of subtrochanteric fractures. Intramedullary fixation methods include PFNA, InterTan and Gamma 3, etc. In comparison, extramedullary fixation approaches include DHS (Richards nail) and proximal femur anatomical plate. At present, there is no unified standard for surgical treatment.

Although both extramedullary fixation and intramedullary nailing are effective surgical methods for the treatment of subtrochanteric fractures, the impact of sarcopenia on the prognosis of patients has not been considered in previous studies. In this study, the length of surgical incision, blood loss and blood transfusion in the PFNA group were smaller than those in the DHS group, but the number of intraoperative fluoroscopies was more in the PFNA group. The difference was statistically significant, mainly because PFNA needed multiple fluoroscopies to adjust the alignment of the fracture ends during closed reduction. Compared with DHS, which requires open reduction, PFNA is minimally invasive, with less surgical trauma and intraoperative blood loss. The operation time was calculated from the time of closed reduction. Although the time for PFNA nail placement was shorter, the time for reduction was longer, therefor there was no statistically significant difference in operation time between the two groups. The weight-bearing time and VAS score at 3-month after operation in the PFNA group were less than those in the DHS group. The Harris score in the PFNA group was higher than that in the DHS group at 3-month after operation, which indicated that the patients in the PFNA group recovered faster, and the joint function regained better. Interestingly, there was no statistically significant difference in VAS score and Harris score between the two groups at the last follow-up, which suggested that the two surgical approaches could achieve satisfactory clinical efficacy after the fracture finally healed. Nevertheless, the incidence of complications in the DHS group was higher, which may be due to the relatively large surgical trauma and more damage to the blood supply in the DHS group, thereby reduced the supply of growth factors and nutrients to the injured site in patients. Patients with sarcopenia often suffer from osteoporosis, and the stress concentration caused by the eccentric fixation of DHS is more likely to cause internal fixation failure, fracture malunion or nonunion[24]. However, for fractures with obvious displacement and difficult closed reduction, open reduction can achieve better reduction and provide stable fixation.

Muscle tissue regulates with bone tissue through endocrine factors and nutritional factors. One research[25] implied that loss of skeletal muscle negatively affects bone strength indices in elderly patients with sarcopenia. Implementing strategies to increase SMI may help reduce the incidence of fragility fractures. Therefore, the management of patients with fractures and sarcopenia is a multidisciplinary challenge. It not only requires clinicians to treat the disease itself, but also to pay attention to the nutritional status of patients. Avola et al[26] believed that physical rehabilitation and di-

etary supplementation are the basic treatment options for sarcopenia. In addition, erythropoietin and bisphosphonates may be effective treatments. Muscle tissue provides nutrients for fracture healing. Muscle relaxation and contraction can also promote the healing of fractures. Consequently, in the selection of surgical methods, choose operations that cause less damage to muscle tissue as much as possible. In the treatment of patients with sarcopenia complicated with type V subtrochanteric fractures, intramedullary fixation such as PFNA is more advantageous.

Limitations

A unified classification was chosen in this study to reduce selection bias. Furthermore, atypical subtrochanteric fractures due to bisphosphonate use were excluded. However, this study also has certain limitations, such as a relatively small sample size in a single-center study. Follow-up time is not long enough. Moreover, the impact on long-term complications such as patient mortality was not analyzed. There are many diagnostic criteria for sarcopenia, and different diagnostic methods may also make a certain impact on the results. Multi-center and larger sample studies are needed to further understand the role of sarcopenia in the surgery of hip fractures.

Conclusions

Both PFNA and DHS are effective approaches for the treatment of sarcopenia with Seinsheimer type V subtrochanteric fractures. PFNA has the advantages of less trauma and faster recovery, which is more suitable for patients with sarcopenia. While the closed reduction operation of PFNA is sometimes difficult, accompanied by more intraoperative radiation, which requires more experience of the surgeon.

Conflict of Interest

The authors declare no conflict of interest.

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Informed Consent

All patients provided written informed consent for their clinical records to be used for research purposes.

Ethics Approval

The study obtained approval from the Affiliated Jiangning Hospital with Nanjing Medical University Faculty of Medicine Ethics Committee (No. 201401015). The study was conducted in line with the Declaration of Helsinki.

Availability of Data and Materials

The data and material can be made available from the authors.

Authors' Contributions

Wei Liu planned the study. Guoping Guan and Xiang Wang collected the data. Jian Yin and Xiang Wang did the analysis. Guoping Guan and Wei Liu wrote the draft paper. Jian Yin, Guoping Guan, Xiaolong Jia and Chao Wang involved in operation. Special thanks to Xinhui Liu for his guidance on the writing of the paper. All authors contributed to and approved the final version of the manuscript.

Data Availability

The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

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