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Closed Rotational Prying Reduction vs. Limited Open Reduction With PFNA Internal Fixation for Difficult-to-Reduce Intertrochanteric Femoral Fractures in the Elderly: A Comparative Short- Term Outcome Study

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Closed Rotational Prying Reduction vs. Limited Open Reduction With PFNA Internal Fixation for Difficult-to-Reduce Intertrochanteric Femoral Fractures in the Elderly: A Comparative Short-Term Outcome Study

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Abstract: Objective To compare the short-term clinical efficacy of closed rotational poking reduction with PFNA internal fixation versus limited open reduction with PFNA internal fixation in the treatment of irreducible intertrochanteric fractures in elderly patients. **Methods** A retrospective analysis was conducted on 60 elderly patients with irreducible intertrochanteric fractures who were admitted from January 2021 to December 2023 and completed follow-up. They were divided into the poking reduction group (n=30, undergoing closed rotational poking reduction with PFNA internal fixation under G-arm fluoroscopy) and the limited open reduction group (n=30, undergoing limited open reduction with PFNA internal fixation) according to the surgical method. The operative time, intraoperative blood loss, total blood loss, fracture healing time, quality of fracture reduction, and Harris score at the last follow-up were compared between the two groups. **Results** The operative time, intraoperative blood loss, and total blood loss in the poking reduction group were significantly less than those in the limited open reduction group ($P<0.05$); there were no statistically significant differences in fracture healing time, Harris score at the last follow-up, and excellent and good reduction rate (93.3% vs. 96.7%) between the two groups ($P>0.05$). No serious complications occurred in either group. **Conclusion** Closed rotational poking reduction with PFNA internal fixation for the treatment of irreducible intertrochanteric fractures in elderly patients can achieve fracture reduction quality, fracture healing, and functional recovery comparable to limited open reduction, while significantly reducing surgical trauma and bleeding. It is easy to perform and is a safe and effective minimally invasive surgical procedure.

Keywords: Intertrochanteric Femoral Fracture; Irreducible Type; Closed Reduction;

Prying Reduction; Proximal Femoral Nail Anti-rotation (PFNA); Minimally Invasive Surgery

Intertrochanteric femoral fracture is one of the common elderly hip fractures encountered in clinical practice, characterized by numerous complications and a high mortality rate. Early surgical intervention is widely advocated clinically at present, with closed reduction and intramedullary nail fixation as the primary treatment modality[1]. Under traction on a traction table, most fractures can achieve satisfactory reduction through abduction, external rotation, adduction, internal rotation, or sequential external rotation. Nevertheless, a subset of fractures fail to attain anatomical alignment via closed reduction due to severe displacement of fracture fragments, interposition of soft tissues, or unstable bone blocks leading to loss of alignment in both coronal and sagittal planes; such injuries are defined as "difficult-to-reduce intertrochanteric femoral fractures"[2-3], accounting for approximately 17% of all intertrochanteric femoral fractures[4]. Current reduction strategies for this fracture type mainly include limited open reduction combined with joystick-assisted support technique, bone hook-assisted technique and other reduction methods[5-10], yet these techniques escalate surgical trauma and operative risks. Accordingly, it is of great clinical significance to develop a more minimally invasive and effective closed reduction technique. In our clinical practice, we adopted a minimally invasive technique of closed rotational lever reduction combined with PFNA (Proximal Femoral Nail Antirotation) internal fixation under G-arm fluoroscopy for the management of such fractures, and favorable clinical outcomes have been obtained. The relevant findings are reported as follows.

1 Clinical Data

1.1 General Data

A retrospective analysis was performed on elderly patients with irreducible intertrochanteric femoral fractures admitted to Shandong Wendeng Orthopedic Hospital from January 2021 to December 2023,Screen out all cases completed by the same senior surgical team and followed up systematically for 2 years. A total of 60

eligible patients were finally enrolled, including 26 males and 34 females, aged 60 to 95 years with a mean age of 75.8 years. The interval from fracture occurrence to surgery ranged from 2 to 8 days. Patients were divided into the lever reduction group (n=30, receiving closed rotational lever reduction and PFNA internal fixation under G-arm fluoroscopy) and the limited open reduction group (n=30, receiving limited open reduction and PFNA internal fixation) according to surgical methods. This study complied with the general ethical requirements of the Declaration of Helsinki. As a retrospective analysis with minimal risks to patients, this study was granted an exemption from informed consent by the Ethics Committee of Shandong Wendeng Orthopedic Hospital (Ethics Approval No.: LL-2023-12016).

Inclusion criteria: Patients meeting the classification criteria for irreducible intertrochanteric fractures; patients who could tolerate surgery and underwent closed rotational lever reduction combined with PFNA internal fixation; patients with complete clinical data and a follow-up duration of no less than 8 months.

Exclusion criteria: Patients inconsistent with the classification of irreducible fractures; patients complicated with subtrochanteric femoral fractures; patients with fractures sustained more than 2 weeks prior to surgery; patients with poor general conditions unable to tolerate surgery; patients with missing clinical and follow-up data.

1.2 Surgical Methods

Epidural anesthesia was administered to patients in both groups. After successful anesthesia, patients were placed in a supine position on a surgical traction table. The affected limb was traction-fixed in a neutral position with 10° adduction, followed by routine disinfection and draping.

Percutaneous Leverage Reduction Technique: Closed rotational percutaneous leverage reduction combined with PFNA internal fixation was performed. First, the insertion site of the helical blade was pre-estimated under G-arm fluoroscopy, and an incision was made at this site. A blunt periosteal elevator was advanced through the incision to the base of the femoral neck. An assistant externally rotated the affected limb while the surgeon levered the fracture ends with the periosteal elevator. Once the

step-off between the base of the femoral neck and the proximal femur disappeared under fluoroscopic visualization, the affected limb was internally rotated back to the neutral position. G-arm fluoroscopy was used to confirm satisfactory alignment and reduction of the fracture fragments. Subsequently, a 4 cm longitudinal surgical incision was made 3 cm above the apex of the greater trochanter along the femoral axis, cutting through the skin and subcutaneous tissue sequentially. Under fluoroscopic guidance, a femoral guide wire was inserted along the medial margin of the greater trochanter. After medullary reaming with a flexible reamer, an intramedullary main nail of appropriate size was implanted. An extramedullary aiming device was mounted, and the helical blade and distal locking screws were sequentially inserted for fixation.

Limited Open Reduction Technique: Limited open reduction combined with PFNA internal fixation was carried out. A limited incision was created over the proximal femur, and instruments including reduction forceps and bone-holding forceps were used to assist fracture reduction. After satisfactory reduction, PFNA implants were placed for internal fixation.

1.3 Routine Treatment and Efficacy Evaluation Indicators

Tranexamic acid was administered for hemostasis before and during surgery. Routine antibiotics were used for anti-infection after surgery, and enoxaparin sodium injection was given to prevent deep venous thrombosis of the lower extremities. After the patients regained consciousness from anesthesia, active plantar flexion and dorsiflexion exercises of the ankle joint as well as contraction and relaxation training of the quadriceps femoris and triceps surae were initiated. On the second postoperative day, patients were allowed to stand without weight bearing with crutches. One week after surgery, patients gradually shifted from non-weight-bearing walking to partial weight-bearing walking according to their rehabilitation status.

Data including operation duration, intraoperative blood loss, fracture healing and complications were collected. The total blood loss was calculated via the Gross equation [11]. Anteroposterior and lateral postoperative X-ray films were obtained, and the quality of fracture reduction was assessed based on the Baumgaertner criteria

[12]. Outpatient follow-ups were conducted at 1, 3, 6 and 12 months postoperatively. X-ray radiographs were used to evaluate fracture healing, and the Harris hip [13]score was adopted to assess the functional recovery of the hip joint.

1.4 Statistical Methods

Statistical analysis was performed using SPSS 23.0 statistical software. Measurement data were first tested for normal distribution and expressed as mean ± standard deviation（$\bar{x}\pm s$）. Intergroup comparisons of measurement data were conducted using the independent two-sample t-test. Enumeration data were presented as cases and analyzed by the chi-square χ^2 test. A P value less than 0.05 was considered statistically significant.

2.Results

There were no statistically significant differences between the two groups in terms of gender composition, age, time from injury to surgery, distribution of sagittal irreducible fractures, coronal irreducible fractures, and combined sagittal and coronal irreducible fractures ($P>0.05$). The baseline data of the two groups were balanced and comparable (see Table 1). During the follow-up period, no severe complications such as unhealed incisions, infection, deep venous thrombosis of lower limbs, or internal fixation failure occurred in patients of either group.

Table 1. Baseline characteristics of the two patient groups

Group	gender		age(years)	Time from injury to operation (days)	Clinical classification of refractory type		
	M	F			Sagittal refractory type	Coronal refractory type	Sagittal and coronal refractory types
Pry-and-reset group	13	15	76.39±9.86	4.25±1.8	17	8	5
Limited incision group	15	17	75.06±8.58	4.66±1.66	18	9	3
Statistical value	$\chi^2=0.002$	t=0.590	t=0.850	$\chi^2=0.034$	$\chi^2=0.001$	$\chi^2=0.259$	$\chi^2=0.002$
P value	0.964	0.560	0.400	0.854	0.972	0.611	0.964

The operation time, intraoperative blood loss and total blood loss in the percutaneous leverage reduction group were significantly lower than those in the limited open reduction group, with statistically significant differences ($P<0.05$). At the final follow-up, all patients in both groups met the fracture healing criteria, and there was no statistically significant difference in fracture healing time between the

two groups (P＞0.05). Hip joint function recovered well in all patients, and no statistically significant difference was observed in the Harris hip scores at the final follow-up (P＞0.05) (see Table 2).

Table 2. Comparison of Operation-Related Indicators, Fracture Healing Time and Harris Score at Last Follow-Up between Two Groups ($\bar{x}\pm s$).

Group	Operation duration(min)	Intraoperative blood los(L)	Total blood loss(L)	Fracture healing time (weeks)	Harris score at last follow-up
Limited incision group	53.44±10.35	0.294±0.028	0.669±0.198	9.96±1.58	86.39±8.60
Pry-and-reset group	39.29±7.66	0.159±0.018	0.314±0.078	9.50±1.62	86.14±7.65
t value	13.32	21.01	8.83	2.05	0.16
P value	0.01	0.03	0.03	0.05	0.87

Postoperative X-rays were used to evaluate the quality of fracture reduction. Fracture alignment and positioning were good in both groups of patients. According to the Baumgaertner criteria: in the Pry-and-reset group, 28 cases had excellent reduction, 2 had satisfactory reduction, and 0 had poor reduction, with an excellent-to-satisfactory rate of 93.3%; in the limited open group, 29 cases had excellent reduction, 1 had satisfactory reduction, and 0 had poor reduction, with an excellent-to-satisfactory rate of 96.7%. There was no statistically significant difference in the quality of fracture reduction between the two groups. Typical case imaging data are shown in Figure 1.

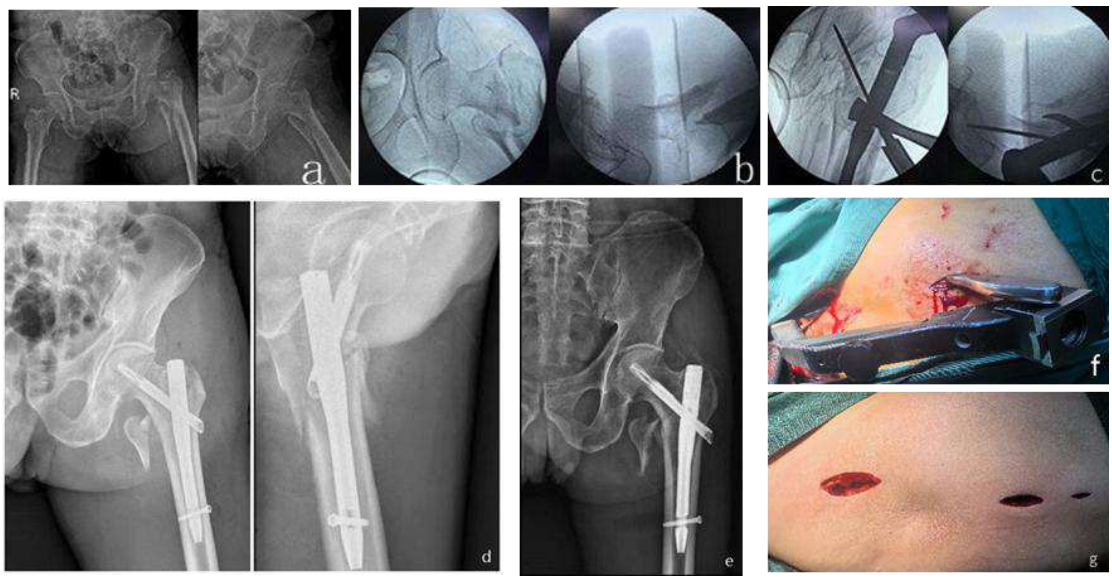


Figure 1. a. A 78-year-old elderly female patient with left intertrochanteric femoral fracture caused by a fall; b. Intraoperative fluoroscopic X-ray image after conventional closed reduction via traction and rotation. The fracture fragments showed poor alignment in both sagittal and coronal planes, making satisfactory reduction unattainable; c. A blunt narrow periosteal elevator was inserted through the lag screw incision with its tip reaching the proximal

fracture fragment. Lever reduction was performed with an assistant externally rotating and abducting the affected limb, followed by adduction and internal rotation of the limb. The fracture achieved satisfactory alignment in coronal and sagittal planes, and the main intramedullary nail was implanted thereafter; d. Postoperative X-ray showing well-aligned intertrochanteric femoral fracture in coronal and sagittal planes with a free lesser trochanter and PFNA internal fixation in place; e. Follow-up X-ray obtained 2 months after surgery demonstrating favorable fracture position, blurred fracture lines, and intact PFNA internal fixation; f. Gross appearance of lever reduction using a blunt narrow periosteal elevator placed through the lag screw incision; g. Appearance of the surgical incision. Only the lag screw incision was utilized without additional incisions created.

3.Discussion

3.1 Characteristics and Reduction Dilemmas of Irreducible Intertrochanteric Femoral Fractures

The difficulty in reducing irreducible intertrochanteric femoral fractures mainly stems from the following characteristics: (1) Muscle traction: Powerful iliopsoas traction causes flexion and external rotation displacement of the proximal fracture fragment, and the action of external rotator muscles further aggravates such displacement. This makes it difficult to effectively correct coronal and sagittal plane displacements under standard traction, especially the sagittal malalignment caused by anterior-posterior cortical separation [14-15]. (2) Fracture morphology: Some fracture lines extend to the coronal plane or are accompanied by severe posteromedial comminuted bone defects, resulting in the loss of stable medial support at fracture ends. No effective leverage can be generated during traction, thus increasing reduction difficulty [16]. (3) Osteoporosis: Elderly patients often suffer from severe osteoporosis with poor impaction capacity of fracture ends. Excessive force applied during traditional lever reduction may easily lead to iatrogenic fragmentation of bone fragments, further complicating fracture reduction [8].

3.2 Advantages of Closed Rotational Pry Reduction Technique

The core principle for treating intertrochanteric femoral fractures lies in achieving anatomical reduction and rigid internal fixation, which can guarantee early postoperative mobilization for patients. Although the traditional limited open reduction technique allows direct visualization to assist fracture reduction, it requires stripping soft tissues and, in some cases, incising the joint capsule. This damages the blood supply at the fracture site and increases surgical trauma, intraoperative blood

loss, and the risk of infection. The closed rotational pry reduction method adopted in this study is based on the TCM bone-setting principle of "separation precedes reunion, and reunion follows separation". It ingeniously integrates biomechanical principles and minimally invasive treatment concepts, and designs an accurate minimally invasive solution targeting the reduction difficulties of irreducible intertrochanteric femoral fractures. Its advantages are mainly reflected in the following two aspects:(1) Minimally invasiveness and high efficiency: The results of this study reveal that the pry reduction group achieved significantly better outcomes than the limited open group in terms of operative duration, intraoperative blood loss and total blood loss ($P<0.05$), which fully demonstrates the minimally invasive merits of this technique. The core mechanisms are as follows: First, the pre-planned entry point of the helical blade is used to insert a blunt periosteal elevator for pry reduction with existing surgical incisions and instruments. No additional surgical incisions or specialized instruments are required, which minimizes soft tissue injury and extra trauma. Second, precise and effective mechanical manipulation is performed. On the basis of traction, the affected limb is abducted and externally rotated first to relax tense soft tissues. Afterwards, the periosteal elevator is inserted through the helical blade incision and propped against the base of the femoral neck to form a fulcrum. On one hand, the lever principle enables reduction of displaced fracture fragments with minimal force. On the other hand, dynamic rotation of the affected limb triggers the "self-reduction" of fracture ends under the coordination of muscle tension. This effectively corrects anteroposterior cortical separation, restores supportive apposition of the medial cortex, and realizes accurate reduction under dynamic conditions.(2) Biomechanical stability: Satisfactory fracture reduction not only restores general anatomical alignment but also provides sufficient mechanical stability to meet the demands of early postoperative functional exercise for patients[16]. In this study, there was no statistically significant difference between the two groups in fracture healing time and Harris hip score at the final follow-up, indicating that both groups achieved favorable long-term functional recovery. Nevertheless, closed rotational pry reduction combined with the PFNA system also achieves immediate mechanical

stability, with its functional mechanisms elaborated as follows: First, this indirect pry reduction maneuver effectively restores cortical contact in the calcar femorale region to obtain positive support and reconstruct the stability of the fracture site[8][10][16]. Second, the main nail of PFNA establishes a favorable mechanical axis through intramedullary central fixation, while the helical blade delivers robust angular stability and anti-rotational capacity. The synergistic effect of the two components forms a stable mechanical system that can effectively resist physiological stress and create favorable conditions for fracture healing.

3.3 Limitations of This Study

This is a single-center retrospective study with a limited sample size. Selection bias cannot be completely avoided during data collection. In addition, postoperative CT scans were not adopted to achieve more accurate assessment of rotational alignment of fractures. Future multi-center, large-sample, prospective randomized controlled trials adopting precise imaging examinations such as three-dimensional CT reconstruction to evaluate reduction quality are required to further verify the efficacy and general applicability of this technique.

In conclusion, closed rotational pry reduction combined with PFNA internal fixation for the treatment of irreducible intertrochanteric femoral fractures in the elderly makes full use of the existing surgical channels and achieves effective minimally invasive reduction through sophisticated mechanical design. The technique features simple and feasible operations, significantly alleviated surgical trauma and intraoperative blood loss. Combined with PFNA internal fixation, it can provide satisfactory biomechanical stability and clinical outcomes. Therefore, it is a minimally invasive treatment technique worthy of clinical promotion and application.

Abbreviations：

PFNA Proximal Femoral Nail Antirotation

TCM Traditional Chinese Medicine

CT Computed tomography

Declarations

Ethics approval and consent to participate：

This study has been approved by the Ethics Committee of Shandong Wendeng Orthopedic Hospital and followed the guidelines for Good Clinical Practice and the Declaration of Helsinki;As a retrospective analysis with minimal risk to patients, this study was granted exemption from informed consent by the Ethics Committee of Shandong Wendeng Orthopedic Hospital (Ethics Approval Number: LL-2023-12016).

Consent for publication:

Consent for publication: Not Applicable. This manuscript does not contain any identifying images or other personal or clinical details of individual participants.In addition, all authors have read and agreed to the publication of the manuscript.**Availability of data and materials ：**

The datasets generated and analyzed during the current study are not publicly available due to limitations of ethical approval involving the patient data and anonymity but are available from the first author (Zhang Zhongyuan) on reasonable request.

Competing Interests：

All authors declare no conflicts of interest.

Funding：

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Authors' contributions：

ZZY and GGL participated in study design, literature analysis and article writing.ZJW participated in data collection and measurement. SL participated in data processing and analysis.HZY prepared Table 1,2 and Figs. 1.

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References:

[1] Chang S M,Hou Z Y,Hu S J,et al.Intertrochanteric femur fracture treatment in Asia:What we know and what the world can learn[J]. Orthop Clin Nort

h Am,2020,51(2):189-205.DOI:10.1016/j.ocl.2019.11.011

[2] Zhang S M, Hu S J, Du S C, et al. A New Comprehensive Classification of Femoral Intertrochanteric Fractures[J]. Chinese Journal of Reparative and Reconstructive Surgery,2022,36(9):1056-1063.DOI: 10.7507/1002-1892.202204080

[3] Zhao Y F, Zhu F H, Chang Q H, et al. Study on Classification Criteria of Femoral Intertrochanteric Fractures Based on Reducibility[J]. Chinese Journal of Reparative and Reconstructive Surgery,2021,35(9):1086-1092. DOI:10.7507/1002-1892.202103233

[4] Tong D K, Ding W B, Wang G C, et al. Clinical Classification and Treatment of Irreducible Femoral Intertrochanteric Fractures[J]. Chinese Journal of Orthopaedic Trauma,2017,19(2):109-114. DOI:10.3760/cma.j.issn.1671-7600.2017.02.004

[5] Ma K L,Wang X,Luan F J,et al.Proximal femoral nails antirotation, Gamma nails, and dynamic hip screws for fixation of intertrochanteric fractures of femur: A meta-analysis[J].Orthop Traumatol Surg Res,2014,100(8):859-866. DOI:10.1016/j.otsr.2014.07.023

[6] Qiu W H, Wang J W, Huang L, et al. Bone Hook-Assisted Closed Reduction with Proximal Femoral Anti-Rotation Intramedullary Nail Fixation for Difficult-to-Reduce Senile Valgus Femoral Intertrochanteric Fractures[J]. Chinese Journal of Bone and Joint Injury,2022,37(12):1291-1293. DOI:10.7531/j.issn.1672-9935.2022.12.014

[7] Huang S M, Lan S H, Wu Q Z, et al. Gun-Type Forceps-Assisted Reduction and Intramedullary Fixation for Mediolaterally Irreducible Femoral Intertrochanteric Fractures[J]. Chinese Journal of Basic Medicine in Hospitals,2019,26(9):1037-1041. DOI:10.3760/cma.j.issn.1008-6706.2019.09.004

[8] Wang Y T, Zhang L Y, Gong W H, et al. Short-Term Efficacy Comparison of Positive and Negative Support at Fracture Ends After Proximal Femoral Anti-Rotation Intramedullary Nail Fixation for Senile Intertrochanteric Fractures[J]. Chinese Journal of Bone and Joint Surgery,2021,14(3):205-209.

DOI:10.3969/j.issn.2095-9958.2021.03.09

[9] Sun F P, Liu X X, Zhang T Y, et al. Analysis of Application Effect of P ush Rod Support Reduction in the Treatment of Irreducible Femoral Intertr ochanteric Fractures[J]. Chinese Journal of Orthopaedic Trauma,2021,23(9): 782-787. DOI:10.3760/cma.j.cn115530-20210712-00334

[10] Liang Z Q, Sun J M, Lin Y Y, et al. Percutaneous Pry Reduction Combi ned with Proximal Femoral Anti-Rotation Intramedullary Nail Fixation for Femoral Intertrochanteric Fractures with Difficult Closed Reduction[J]. Chin ese Journal of Bone and Joint Injury,2022,37(2):184-186. DOI:10.7531/j.iss n.1672-9935.2022.02.022

[11] Liu Z G, Yang C, Song G R, et al. Effect of Different Grades of Hypert ension on Perioperative Blood Loss in TKA[J]. Journal of Practical Orthop aedics,2020,26(7):655-658. DOI:10.13795/j.cnki.sgkz.2020.07.020

[12] Baumgaertner M R,Curtin S L,Lindskog D M,et al.The value of the tip-ap ex distance in predicting failure of fixation of peritrochanteric fractures of the hip[J].J Bone Joint Surg Am,1995,77(7):1058-1064. DOI:10.2106/00004 623-199507000-00012

[13] Dai Maorong. Modern Joint Surgery [M]. Beijing: Science Press, 2007: 12 19-1220.

[14] Chen Z L, Li H H, Chen M L, et al. Lateral Incision Plate-Assisted Red uction and Fixation Combined with Intramedullary Nail in Lateral Decubit us Position for Complex Subtrochanteric Femoral Fractures[J]. Chinese Jou rnal of Reparative and Reconstructive Surgery,2022,36(8):957-962. DOI:10.7 507/1002-1892.202203064

[15] Wei W Q, Gu Z R, Cui J, et al. Morphological Analysis of Coronal Fem oral Intertrochanteric Fractures and Its Influence on Reduction and Internal Fixation Techniques[J]. Chinese Journal of Reparative and Reconstructive S urgery,2021,35(9):1093-1099. DOI:10.7507/1002-1892.202103067

[16]Lu C J, Gao X, Han L, et al. Mechanical Analysis of Three Types of M edial Support for Femoral Intertrochanteric Fractures[J]. Chinese Journal of

Orthopaedics,2021,29(14):1308-1312. DOI:10.3977/j.issn.1005-8478.2021.14.14