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Original Article

Effect of different internal fixation devices on intertrochanteric fractures

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Abstract: Aims: To analyze the postoperative recovery effects of different internal fixations on intertrochanteric fractures, so as to select the best fixation method for clinical practice. Methods: This is a retrospective analysis. A total of 100 patients with intertrochanteric fractures hospitalized at The Affiliated Tai'an City Central Hospital of Qingdao University from March 2022 to March 2024 were grouped according to the treatment method. 43 patients received intramedullary fixation in an observation group and 57 patients underwent extramedullary fixation in a control group. We collected data including operation time, total length of the surgical incision, hospitalization time, postoperative reexamination rate, occurrence of reduction loss, coxa vara, infection, non-union of fractures, and postoperative imaging of the patients. Results: The total response rate of the observation group was 88.37%, which was statistically higher than that of the control group (85.96%, $P < 0.05$). The mean Harris hip joint score at six months after intervention was 88.3±5.3 in the observation group, significantly higher than 62.3±4.2 in the control group ($P = 0.006$). In terms of inflammatory reaction, the observation group showed significantly decreased serum concentrations of high-sensitive C-reactive protein and procalcitonin at one week after surgery compared to the control group ($P < 0.001$). After intervention, the observation group demonstrated significantly higher balance ability than the control group ($P < 0.05$). Conclusion: Intramedullary fixation for intertrochanteric fractures can significantly promote the postoperative functional recovery and fracture healing of patients, presenting a better fixation effect.

Keywords: Different internal fixation devices, intertrochanteric fractures, finite element analysis

Introduction

An intertrochanteric fracture is a break that occurs in the region between the greater and lesser trochanters of the femur. This type of fracture is particularly common in the elderly population [1]. Currently, intertrochanteric fractures make up approximately 3.13% of all fractures in adults and account for 50% of proximal femoral fractures [2]. The primary treatment method is surgical fixation, with various devices such as intramedullary nails or extramedullary plates being used depending on the specific case [3, 4].

Intramedullary fixation offers relatively stable support, has good load-bearing capacity, and is suitable for various fracture patterns [5]. It allows for early weight-bearing and rehabilitation, with the benefit of a smaller incision and less soft tissue damage [6]. However, the procedure can be more complex, with potential risks such as femoral cortex perforation during insertion. Complications related to the implant, including breakage or loosening, may also occur. In contrast, extramedullary fixation is simpler to perform and easier to apply, making it suitable for specific fracture scenarios [7]. However, its stability is generally lower compared to intramedullary fixation, and it may not support early full weight-bearing as effectively [8]. There is also a higher risk of fixation failure or displacement. Additionally, extramedullary fixation typically requires a larger incision, leading to more extensive soft tissue dissection, which could worsen soft tissue recovery [9]. Currently, there is no conclusive research comparing the postoperative outcomes of intramedullary and extramedullary fixation in intertrochanteric fractures.

Therefore, the aim of this study was to analyze the postoperative recovery outcomes of differ-

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ent internal fixation methods for intertrochanteric fractures, with the goal of identifying the best fixation technique for clinical practice.

Methods

Clinical data

This study is a retrospective analysis in which patients were grouped based on their treatment methods. A total of 100 patients with intertrochanteric fractures, who were hospitalized at The Affiliated Tai'an City Central Hospital of Qingdao University between March 2022 and March 2024, were included. Of these, 43 patients who received intramedullary fixation were assigned to an observation group, while 57 patients who underwent extramedullary fixation were placed in a control group. The study received approval from the Ethics Committee of The Affiliated Tai'an City Central Hospital of Qingdao University.

Inclusion and exclusion criteria

Inclusion criteria: 1) Age ≥ 18 years; 2) Meeting the diagnostic criteria for intertrochanteric fracture [10]; 3) No prior history of diseases or fractures affecting the normal function of both lower limbs before surgery; 4) Completion of surgical treatment followed by regular follow-up, including physical and imaging examinations; 5) Fracture treatment plans assigned based on the patient's condition.

Exclusion criteria: 1) Patients unable to complete follow-up after surgery (due to death or loss to follow-up); 2) Patients with pathologic fracture, congenital proximal femoral deformities, overly narrow medullary canals, or with unclosed epiphyses (e.g., adolescents or children); 3) Patients who did not follow postoperative functional exercise guidelines as prescribed by their doctor; 4) Patients with severe medical contraindications, such as advanced heart disease or diabetes, who are unable to tolerate surgery; 5) Patients with connective tissue diseases.

Methods

The control group underwent extramedullary fixation. After anesthesia took effect, the patients were positioned supine on a traction bed. Both lower limbs were placed in traction, with the affected hip padded and traction applied in an abducted and externally rotated position. Fracture reduction was achieved by adduction and internal rotation. Once satisfactory reduction was confirmed under C-arm fluoroscopy, the operative area of the affected limb was disinfected, and sterile drapes were applied. If reduction was unsatisfactory, a longitudinal incision approximately 8 cm long was made along the posterior edge of the tensor fasciae latae, on the lateral side of the greater trochanter. The skin and subcutaneous tissue were incised, bleeding was controlled with electrocoagulation, the deep fascia was incised, and muscles were separated. The surgical field was exposed with retractors. Two bone holders were used to clamp and manipulate the fracture ends horizontally and vertically for reduction. A second incision, about 10 cm long, was made from the point where a perpendicular line from the anterior superior iliac spine intersected with a parallel line from the greater trochanter. The skin and subcutaneous tissue were incised layer by layer, and the deep fascia and gluteus medius were bluntly separated to expose the femur. Using the piriform fossa between the femoral trochanters as the entry point, a positioning needle was inserted. Under C-arm fluoroscopy, the entry point and insertion angle were confirmed. The cortical bone of the piriform fossa was opened with a drill. A guide wire was then inserted through the insertion hole, and the medullary canal was reamed sequentially from fine to coarse with a reaming drill. The intramedullary nail (Tai'an Sino-Israeli Medical Devices Co., Ltd., Cat. No. 20230615) was inserted slowly into the medullary cavity. Fluoroscopy confirmed good fracture reduction. A separate incision was made proximally through the aiming device, and the guide wire was inserted into the femoral neck. Under fluoroscopy, the guide wire was positioned centrally in the femoral neck. A main locking screw drill was used, stopping 5 mm short of the subchondral bone of the femoral head, and the helical blade was hammered in to the same depth. Fluoroscopy confirmed correct placement. The distal aiming device was used to identify the position for the distal locking screw. A straight incision approximately 2 cm long was made, the skin and subcutaneous tissue were incised, and the bone cortex was drilled. After measuring the depth, a locking screw was inserted. Two distal screws were used for fixation. Fluoroscopy confirmed satisfactory fracture align-

ment, appropriate screw length, and reliable fixation. The incision was irrigated with normal saline, and gauze and instruments were accurately counted. The incision was closed in layers and bandaged with sterile dressings. After anesthesia wore off, the patients were returned to the orthopedic care unit in a conscious state.

The observation group received intramedullary fixation. The patients were positioned supine on a traction bed, with the affected hip elevated and both lower limbs in traction in an abducted and externally rotated position. Fracture reduction was achieved by adduction and internal rotation. Once satisfactory fracture reduction was confirmed by C-arm fluoroscopy, the operative area was disinfected, and sterile drapes were applied. If the reduction was not satisfactory, a longitudinal incision of approximately 8 cm was made along the posterior margin of the tensor fasciae latae at the level of the fracture. The skin and subcutaneous tissues were incised, and hemostasis was achieved using electrocoagulation. The deep fascia was incised, and the muscles were separated to expose the surgical field with retractors. Two bone holders were used to manipulate the fracture horizontally and vertically, and reduction was achieved using leverage. Next, the guide pin was inserted along the opener, and fluoroscopy confirmed its appropriate position. The bone cortex was drilled open, and the medullary cavity was reamed in sequence from fine to coarse using a reaming drill. After reaming, an InterTAN intramedullary nail (Tai'an Sino-Israeli Medical Devices Co., Ltd., Cat. No. 20230515) of appropriate length was selected and slowly inserted using a connecting holder. Fluoroscopy confirmed that the intramedullary nail was in the correct position, with good alignment and apposition of the fracture ends. Using a proximal aiming device, an incision was made under the trochanter, and the skin, subcutaneous tissue, and fascia were longitudinally incised. Blunt dissection exposed the bone surface, and a guide pin was inserted. Fluoroscopy confirmed the correct position and length of the guide pin. Sequential drilling and depth measurement were performed, and two screws were inserted obliquely into the femoral neck. The distal aiming device was then connected. At the projected locations of the distal locking screws on the body surface, small incisions (~1.0 cm) were made, and the skin and subcutaneous tissue were incised. Blunt dissection exposed the bone surface, and after sequential drilling and depth measurement, two locking screws were inserted distally. C-arm fluoroscopy confirmed that the lag screw was correctly positioned within the femoral neck cortex, with the screw thread crossing the fracture line, and the distal locking screw was well-positioned with an appropriate length. The alignment and apposition of the fracture were confirmed, and the tail cap of the intramedullary nail was screwed in. The surgical area was irrigated thoroughly with normal saline, and no active bleeding was observed. The count of gauze and instruments was verified. The incision was closed layer by layer. After surgery, upon awakening from anesthesia, the patients' lower extremity blood supply, sensation, and movement were normal, and the patients were transferred back to the orthopedic intensive care unit in a conscious state.

Data collection

We collected data on operation time, total surgical incision length, hospitalization duration, and postoperative reexamination outcomes for both groups of patients. We monitored for postoperative complications, including reduction loss, coxa vara, infection, and non-union of fractures, using imaging examinations. Additionally, patients underwent the Harris hip function score assessment between 6 months and 1 year postoperatively. The Harris Score [11] is used to evaluate hip joint function, with higher scores indicating better recovery. According to the score, hip function recovery was categorized as excellent (score $\geq$ 90), good (80 $\leq$ score < 90), fair (70 $\leq$ score < 80), or poor (score < 70).

Using EDTA-K2 anticoagulant vacuum blood collection tubes, 5 ml of blood was drawn from the cubital vein of each patient before surgery and again one week after surgery. The collected venous blood was divided, labeled, and stored in a 4°C refrigerator. The samples were promptly centrifuged at 4000 rpm for 10 minutes, and the serum was stored in a -70°C freezer. Once specimen collection was complete, the concentrations of high-sensitivity C-reactive protein (hsCRP), procalcitonin (PCT), and immunoglobulin G (IgG) in the serum were measured using ELISA. The detection protocols followed the instructions provided by the respective kits: hsCRP (Biovendor Co., Ltd., Cat. No.

Table 1. Comparison of clinical data between the two groups

	Observation group (n = 43)	Control group (n = 57)	t/χ^2	*P*
Age (years)	51.05±7.91	50.35±7.19	3.251	0.342
Sex			3.281	0.421
Male (n%)	32 (74.42%)	30 (52.63%)		
Female (n%)	11 (25.58%)	27 (47.37%)		
BMI	20.7±2.28	20.4±2.76	2.209	0.532
Smoking	33 (76.74%)	42 (73.68%)	2.363	0.551
Marital status			1.831	0.342
Married	11 (25.58%)	16 (28.07%)		
Single	14 (32.56%)	11 (19.30%)		
Divorced or separated	10 (23.26%)	12 (21.05%)		
Widowed	7 (16.28%)	13 (22.81%)		
Unknown/missing	1 (2.33%)	5 (8.77%)		
Chronic emphysema separated	14 (32.56%)	16 (28.07%)	2.762	0.693
Asthma	15 (34.88%)	20 (35.09%)	5.722	0.412
Diabetes	16 (37.21%)	20 (35.09%)	0.841	0.387
Hypertension	15 (34.88%)	16 (28.07%)	0.247	0.619
Hyperlipidemia	14 (32.56%)	18 (31.58%)	0.406	0.528
Coronary heart disease	10 (23.26%)	12 (21.05%)	0.597	0.487

740011), PCT (MEIMIAN Co., Ltd., Cat. No. MM-0817H2), and IgG (MEIMIAN Co., Ltd., Cat. No. MM-50796H1).

Sample size estimation

The sample size was calculated using power analysis, and the corrected sample size was estimated as follows: corrected sample size = sample size/(1 - [% attrition/100]) [12]. After applying this correction, we determined the final sample size to be approximately 100 patients. The number of patients in the two groups was obtained through careful screening and statistical analysis of the medical database. Specifically, based on the established inclusion and exclusion criteria, eligible cases were identified and classified individually in the database, resulting in 43 cases in the observation group and 57 cases in the control group.

Statistical analysis

SPSS 25.0 statistical analysis software was used for data analysis, with additional analyses conducted using GraphPad Prism (GraphPad Software Inc., CA, USA). Measured data with a normal distribution were expressed as mean ± standard deviation. The independent sample t-test was used for inter-group comparisons, and the paired sample t-test was used for intra-group comparisons. For measured data with a skewed distribution, values were expressed as M (Q25 to Q75), with the non-parametric Mann-Whitney U test used for inter-group comparisons, and the Wilcoxon signed rank sum test for intra-group comparisons. Counted data were presented as frequency and percentage, with the chi-square test or continuity correction applied for inter-group comparisons. A *p*-value < 0.05 was considered significant.

Results

Comparison of clinical data between the two groups

There were no significant differences between the two groups in terms of age, gender, body mass index, smoking, hypertension, diabetes, marital status, chronic emphysema, asthma, or coronary heart disease (**Table 1**).

Comparison of clinical efficacy between the two groups

The total response rate in the observation group was 88.37%, which was higher than that of the control group (85.96%), (P < 0.05). In the observation group, the markedly effective rate was 55.81% (24 cases), the effective rate was

Table 2. Comparison of clinical efficacy between the two groups

Group	Number of cases	Markedly effective	Effective	Ineffective	Total response rate
Observation group	43	24 (55.81%)	14 (32.56%)	5 (11.63%)	38 (88.37%)
Control group	57	24 (42.11%)	25 (43.89%)	8 (14.04%)	49 (85.96%)
t	-	4.128	8.527	14.261	12.348
P	-	0.005	0.031	0.003	0.006

Table 3. Comparison of Harris hip joint scores between the two groups

	Control group (n = 57)	Observation group (n = 43)	t	P
Before intervention	50.6±6.9	50.68±7.6	0.362	0.557
Six months after intervention	62.3±4.2	88.3±5.3	9.756	0.006

Table 4. Comparison of incidence of complications between the two groups

	Observation group (n = 43)	Control group (n = 57)	χ^2	P
Lower limb discomfort or fatigue	4	6	0.512	0.111
Infect	0/0.00	0/0.00	-	-
Bone marrow ischemic damage	0/0.00	0/0.00	-	-
Genital femoral neuritis	0/0.00	0/0.00	-	-
Total incidence	4	6	0.411	0.511

32.56% (14 cases), and the ineffective rate was 11.63% (5 cases). In the control group, the markedly effective rate was 42.11% (24 cases), the effective rate was 43.89% (24 cases), and the ineffective rate was 14.04% (8 cases) (**Table 2**).

Comparison of Harris scores between the two groups

The mean Harris hip joint scores before intervention were 50.68±7.6 for the observation group and 50.6±6.9 for the control group. The difference in Harris scores before intervention between the two groups was not significant (P = 0.557). However, the mean Harris scores at six months after intervention were 88.3±5.3 for the observation group and 62.3±4.2 for the control group, with a significant difference between the two groups (P = 0.006) (**Table 3**).

Comparison of incidence of complications between the two groups

A comparison of the incidence of complications between the observation and control groups is summarized in **Table 4**. The results showed that, compared to patients in the control group, those in the observation group had a lower incidence of complications (9.3% vs. 10.5%). However, no significant difference was found between the groups (P = 0.511).

Comparison of inflammatory factors between the two groups

Using ELISA, the serum levels of hsCRP, PCT, and IgG were measured in both groups before and after treatment. The results showed that, compared to those in the control group, the serum concentrations of hsCRP and PCT one week after surgery decreased significantly in the observation group (P < 0.001) (**Figure 1**).

Comparison of balance ability between the two groups

After the intervention, the observation group demonstrated significantly better balance ability compared to the control group (all P < 0.05) (**Table 5**).

Comparison of quality of life scores between two groups

SF-36 scores are shown in **Table 6**. Compared to the control group, the observation group had significantly higher scores in psychological function (66.69±13.27 vs. 37.63±11.27, P = 0.004), material life (78.69±10.89 vs. 62.62± 11.02, P = 0.003), physical function (84.82±

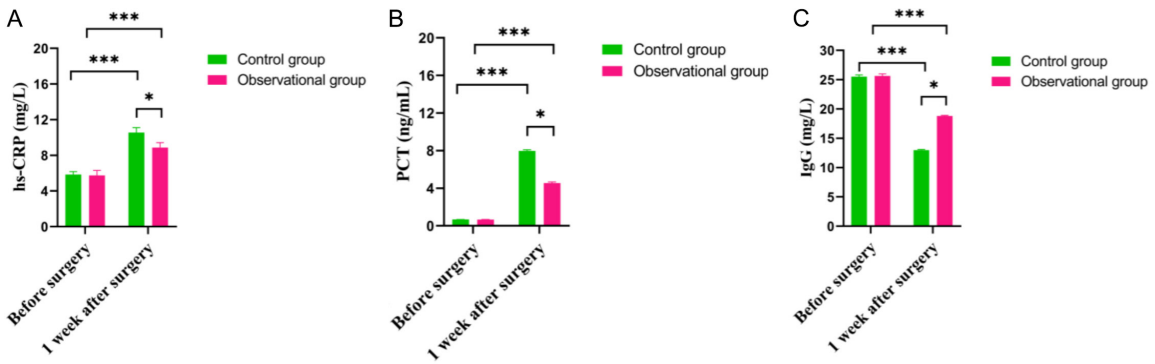

Figure 1. Comparison of inflammation indicators between the two groups. A: hs-CRP; B: PCT; C: IgG. Note: PCT: procalcitonin; IgG: Immunoglobin G; hs-CRP: high-sensitivity C-reactive protein. *$P < 0.05$ compared to control group, ***$P < 0.001$ compared to control group.

Table 5. Comparison of balance ability between the two groups

Group	Before surgery	One week after surgery	t	*P*
Observation group (n = 43)	22.65±12.76	38.76±9.98	9.892	< 0.001
Control group (n = 57)	22.08±10.01	28.32±9.83	7.218	< 0.001
t	3.377	9.874	-	-
P	0.760	< 0.001	-	-

Table 6. Comparison of quality of life scores between the two groups

Group		Control group (n = 57)	Observation group (n = 43)	t	P
Total score	Before surgery	67.12±9.65	65.48±9.26	0.321	0.746
	One week after surgery	68.48±10.36	82.56±12.03	6.987	0.006
Physical function	Before surgery	60.14±12.34	68.23±11.65	0.347	0.741
	One week after surgery	65.26±13.02	83.92±13.54	10.641	0.002
Psychological function	Before surgery	33.03±9.98	33.87±10.04	0.412	0.687
	One week after surgery	37.63±11.27	66.69±13.27	8.810	0.004
Social function	Before surgery	53.27±11.62	53.11±10.31	0.489	0.628
	One week after surgery	60.24±10.79	78.36±11.85	2.389	0.017
Material life	Before surgery	60.56±12.34	59.98±11.42	0.197	0.874
	One week after surgery	62.62±11.02	78.69±10.89	9.248	0.003

13.54 vs. 65.26±13.02, P = 0.002), social function (78.36±11.85 vs. 60.24±10.79, P = 0.017), and total scores (82.56±12.03 vs. 68.48±10.36, P = 0.006) after surgery. There were significant differences between the two groups (P < 0.05).

Comparison of operative data

The operative time in the observation group was significantly longer than that of the control group (P < 0.05). However, there was no significant difference between the two groups in terms of incision length or hospital stay duration (P > 0.05) (**Table 7**).

Discussion

In this study, we found that the use of intramedullary fixation in the treatment of intertrochanteric fractures significantly promoted postoperative functional recovery and fracture healing, with a better fixation effect. Regarding postoperative complications, there was no significant difference between the two groups. However, the operative time for intramedullary fixation was significantly longer than that for extramedullary fixation. Therefore, intramedullary fixation was shown to be a superior treatment option to extramedullary fixation.

Table 7. Comparison of operative data between the two groups

Group	Operative time	Length of incision	Length of hospital stay
Observation group (n = 43)	222.65±12.76	18.76±5.98	11.892±2.98
Control group (n = 57)	199.08±10.01	18.32±6.83	10.218±1.98
t	7.377	2.874	1.987
P	0.036	0.552	0.685

Our resulted showed that intramedullary fixation significantly promoted the postoperative functional recovery of patients with intertrochanteric fractures. Firstly, intramedullary fixation provides stable fixation, which helps maintain the alignment and stability of the fracture site. This allows for early mobilization and weight-bearing, reducing the risk of complications such as joint stiffness and muscle atrophy [13]. Secondly, it minimizes soft tissue damage during surgery, reducing the impact on surrounding tissues and blood supply, which is beneficial for the healing process [14]. Moreover, the design of intramedullary fixation devices is often more suited to the biomechanical characteristics of the hip joint, enabling better load transfer and distribution, and promoting the restoration of hip joint function [15]. Additionally, it stimulates the body's repair mechanisms, activating various growth factors and cellular responses that facilitate bone healing and functional recovery [16, 17]. Finally, proper intramedullary fixation can also improve the patient's psychological state, boosting their confidence and motivation in rehabilitation, which further contributes to better postoperative functional recovery [18-20].

Notably, intramedullary fixation also significantly promoted fracture healing in patients with intertrochanteric fractures after surgery. Intramedullary fixation provides relatively stable fixation [21, 22], which can better resist shearing and rotational forces at the fracture site, maintaining alignment and stability. This is crucial for the growth and union of bone tissues [20]. Additionally, intramedullary fixation helps reduce the stress-shielding effect. By allowing appropriate stress transfer to the fracture site, it stimulates osteogenesis and accelerates fracture healing [23, 24]. Furthermore, intramedullary fixation often features a well-designed biomechanical structure, allowing for more even load distribution, which reduces the risk of fixation failure or re-displacement, thereby creating a favorable environment for fracture healing [25-28]. Moreover, it minimizes soft tissue damage during the operation, preserving the blood supply around the fracture, which is essential for providing nutrients and oxygen to the healing bone, further promoting fracture repair. The early stability provided by intramedullary fixation enables patients to begin functional exercises sooner, improving local blood circulation and enhancing the process of fracture healing and functional recovery [29].

In our study, the clinical efficacy of intramedullary fixation in treating intertrochanteric fractures was significantly higher than that of extramedullary fixation. From a biomechanical perspective, intramedullary fixation offers superior stability. The intramedullary nail is positioned within the medullary cavity, where it is better able to resist shearing and rotational forces generated during weight-bearing and movement. This reduces the risk of implant displacement and fracture re-displacement [30]. Additionally, intramedullary fixation features a more centralized load-bearing axis, which facilitates more efficient force transmission and distribution, further promoting fracture healing [31]. Moreover, intramedullary fixation generally involves less soft tissue dissection, which helps preserve the blood supply around the fracture site [32]. Adequate blood supply is crucial for fracture healing, as it ensures the delivery of necessary nutrients and oxygen to the fracture site, accelerating the repair process [33]. The design of intramedullary fixation devices is often more anatomically appropriate for the intertrochanteric region, ensuring a more precise fit and stronger fixation [34]. This provides better fixation strength and stability, which is conducive to early postoperative rehabilitation and functional exercise. Furthermore, intramedullary fixation is associated with a lower incidence of complications such as implant failure and non-union, compared to extramedullary fixation. This, in turn, contributes to its superior clinical efficacy [35].

However, our study had several limitations. First, the sample size was relatively small,

which may affect the generalizability of the findings. Second, the follow-up period may not have been long enough to fully assess the long-term effects and potential complications associated with different internal fixation devices. Additionally, the study focused on a limited range of internal fixation devices, possibly overlooking emerging or less commonly used alternatives. Furthermore, factors such as patient compliance, as well as individual variations in bone quality and healing capacity, may not have been adequately considered, which may have influenced the interpretation of the results. Future multi-center collaborative studies would help enhance the generalizability of the findings.

In conclusion, our study demonstrated that intramedullary fixation significantly promoted postoperative functional recovery and fracture healing in patients with intertrochanteric fractures, offering superior fixation outcomes. These findings provide valuable insight for clinicians and can assist in decision-making for therapeutic intervention.

Disclosure of conflict of interest

None.

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References

[1] Fernandez MA, Achten J, Parsons N, Griffin XL, Png ME, Gould J, McGibbon A and Costa ML; WHiTE 5 Investigators. Cemented or uncemented hemiarthroplasty for intracapsular hip fracture. N Engl J Med 2022; 386: 521-530.

[2] Walter N, Szymski D, Kurtz SM, Lowenberg DW, Alt V, Lau EC and Rupp M. Epidemiology and treatment of proximal femoral fractures in the elderly U.S. population. Sci Rep 2023; 13: 12734.

[3] Qi H, Li Z, Ma T, Jiang Y, Ren C, Xu Y, Huang Q, Zhang K, Lu Y and Li M. Robot navigation system assisted PFNA fixation of femoral intertrochanteric fractures in the elderly: a retrospective clinical study. Clin Interv Aging 2024; 19: 11-19.

[4] Nahouli H, Bassil D, Mailhac A, Der-Boghossian A, Tamim H and Al Taki M. Association of hip fracture with the use of walking assistance devices post-surgery: a retrospective study comparing intertrochanteric and subtrochanteric hip fractures. Cureus 2023; 15: e36706.

[5] Wang BH, Zhang BB, Gong ZL, Mei J, Luo CF and Zhu Y. Biomechanical evaluation of different medial column fixation patterns for valgus pilon fractures. BMC Musculoskelet Disord 2024; 25: 533.

[6] Abdalla M, Elsagheir M, Ashry A, Elbannan M, Ragab A and Mohamad A. Is elastic stable intramedullary nailing a viable treatment option for diaphyseal fractures of the humerus in adults? A 29-case series prospective study. Ortop Traumatol Rehabil 2024; 26: 357-362.

[7] Pisoudeh K, Elahifar O, Alimoghadam S and Eslami A. Trans-table intraoperative fluoroscopic technique for obtaining a true lateral view of the proximal femur in the lateral decubitus position. Arch Bone Jt Surg 2023; 11: 531-534.

[8] Zeelenberg ML, Plaisier AC, Nugteren LHT, Loggers SAI, Joosse P, Verhofstad MHJ, Den Hartog D and Van Lieshout EMM; STABLE-HIP Study Group. Extramedullary versus intramedullary fixation of unstable trochanteric femoral fractures (AO type 31-A2): a systematic review and meta-analysis. Arch Orthop Trauma Surg 2024; 144: 1189-1209.

[9] Turabi RY, Wyatt D, Guerra S, O'Connell MDL, Khatun T, Sageer SA, Alhazmi A and Sheehan KJ. Barriers and facilitators of weight bearing after hip fracture surgery among older adults. A scoping review. Osteoporos Int 2023; 34: 1193-1205.

[10] He M, Liu J, Deng X and Zhang X. The postoperative prognosis of older intertrochanteric fracture patients as evaluated by the Chang reduction quality criteria. BMC Geriatr 2022; 22: 928.

[11] Meier ST. Construct validity of outcome rating scale (ORS) scores in clinical samples: extension of Harris, Murphy, and Rakes' (2019) narrative review. J Evid Based Soc Work (2019) 2020; 17: 648-661.

[12] Long Y, Liu N, Huang X, Liang W, Liu J, Huang Z, Zhang Y and Wang W. Biomechanical evaluation of ortho-bridge system and proximal femoral nail antirotation in intertrochanteric fractures with lateral wall fracture based on finite element analysis. Front Bioeng Biotechnol 2024; 12: 1368492.

[13] Hui YM, Zeng G, Liu PY and Chai B. Application of lesser trochanteric reduction fixator in the treatment of unstable intertrochanteric fractures. World J Clin Cases 2023; 11: 5863-5869.

[14] Ni XH, Zhu XY, Zhang ZY, Zhang L, Ren LB, Wu JS, Wang LJ, Zhao QM and Zhang F. Clinical effect of cement-enhanced APFN in the treatment of elderly osteoporotic intertrochanteric fractures. Eur Rev Med Pharmacol Sci 2022; 26: 3872-3877.

[15] Kozaki T, Lundberg HJ, Mell SP, Samartzis D, Kawakami M, Yamada H, Inoue N and An HS. Effect of lumbar fusion and pelvic fixation rigid-

ity on hip joint stress: a finite element analysis. Spine (Phila Pa 1976) 2023; 48: E355-E361.
[16] Wang S, Rice OM, Habet NA, CarlLee TL, Duemmler M, Wally M, Odum S and Moorman CT 3rd. Biomechanical assessment of bicortical suspension device fixation for proximal tibiofibular joint instability: single versus double device. Am J Sports Med 2023; 51: 3742-3748.
[17] Fan Y, Leape CP, Hugard S, McCanne M, Thomson A, Wojtkiewicz GR, Weaver MJ, Collins JE, Randolph M and Oral E. A longitudinal rat model for assessing postoperative recovery and bone healing following tibial osteotomy and plate fixation. BMC Musculoskelet Disord 2023; 24: 854.
[18] Badawi M, Anadani A, Sabboh M, Banna AT and Alloush H. Transport over a flexible nail to treat a tibial defect caused by shelling injury: a case report of a 13-year-old child. Int J Surg Case Rep 2023; 112: 108990.
[19] Fiz N, Delgado D, Sánchez X, Sánchez P, Bilbao AM, Oraa J and Sánchez M. Application of 3D technology and printing for femoral derotation osteotomy: case and technical report. Ann Transl Med 2017; 5: 400.
[20] Yong A, Zhao Y, Xu H, Liu Q and Huang C. Effects of specialized nursing intervention based on quantitative assessment strategy on psychological state and quality of life of patients with senile dementia. Acta Neurol Belg 2023; 123: 2213-2220.
[21] Qiu J, Jiang Z, Han L, Li X, Zhang R, Wu B, Zhu F and Zhao Y. Treatment of irreducible intertrochanteric femoral fracture with a minimally invasive clamp reduction technique via the anterior approach. J Orthop Surg Res 2023; 18: 167.
[22] Ryu HG, Shin DW, Han BS and Kim SM. Risk factors associated with fixation failure in intertrochanteric fracture treated with cephalomedullary nail. Hip Pelvis 2023; 35: 193-199.
[23] Wu W, Zhao Z, Wang Y, Yao B, Shi P, Liu M and Peng B. Clinical observation and finite element analysis of femoral stable interlocking intramedullary nail in intertrochanteric fractures. Int Orthop 2023; 47: 2319-2326.
[24] Wang C, Li X, Chen W, Wang C, Guo Y and Guo H. Three-dimensional finite element analysis of intramedullary nail with different materials in the treatment of intertrochanteric fractures. Injury 2021; 52: 705-712.
[25] Garvin PM, Wellington IJ, Connors JP, LeVasseur MR, Obopilwe E, Hawthorne BC, Trudeau M, Dorsey C and Mazzocca AD. Bicortical suspensory button fixation yields greater ultimate load to failure over unicortical all-suture anchor fixation in distal biceps brachii tendon repair. J Shoulder Elbow Surg 2022; 31: 2347-2357.
[26] Sears BW, Hatzidakis AM and Johnston PS. Intramedullary fixation for proximal humeral fractures. J Am Acad Orthop Surg 2020; 28: e374-e383.
[27] Wen Q, Gu F, Su Z, Zhang K, Xie X, Li J, Sui Z and Yu T. Gamma nail combined with one cannulated compression screw fixation for treating pauwels type III femoral neck fractures in young and middle-aged adults: clinical follow-up and biomechanical studies. Orthop Surg 2023; 15: 1045-1052.
[28] Wong Wei Kang N, Tan WPJ, Phua YMC, Min ATG, Naidu K, Umapathysivam K and Smitham PJ. Intramedullary nail: the past, present and the future - a review exploring where the future may lead us. Orthop Rev (Pavia) 2021; 13: 25546.
[29] Okike K, Chan PH, Prentice HA, Paxton EW and Burri RA. Association between uncemented vs cemented hemiarthroplasty and revision surgery among patients with hip fracture. JAMA 2020; 323: 1077-1084.
[30] Chen P, Fan Z, Xu N and Wang H. A biomechanical investigation of a novel intramedullary nail used to salvage failed internal fixations in intertrochanteric fractures. J Orthop Surg Res 2023; 18: 632.
[31] Perren SM, Regazzoni P and Fernandez AA. Biomechanical and biological aspects of defect treatment in fractures using helical plates. Acta Chir Orthop Traumatol Cech 2014; 81: 267-271.
[32] Tandioy-Delgado FA, Marcovici LL, Luchetti R and Atzei A. Arthroscopic assisted treatment of combined Trapezium and Bennett fracture-dislocation. Tech Hand Up Extrem Surg 2023; 27: 30-37.
[33] Zhang Y, Zhao X, Ge D, Huang Y and Yao Q. The impact and mechanism of nerve injury on bone metabolism. Biochem Biophys Res Commun 2024; 704: 149699.
[34] Radcliff TA, Regan E, Cowper Ripley DC and Hutt E. Increased use of intramedullary nails for intertrochanteric proximal femoral fractures in veterans affairs hospitals: a comparative effectiveness study. J Bone Joint Surg Am 2012; 94: 833-840.
[35] Wang J, Li H, Jia H and Ma X. Intramedullary versus extramedullary fixation in the treatment of subtrochanteric femur fractures: a comprehensive systematic review and meta-analysis. Acta Orthop Traumatol Turc 2020; 54: 639-646.