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Flexible reamer use to overcome entry point errors in proximal femoral nail application in severe obese intertrochanteric fracture patients

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Abstract

Introduction Proximal femoral nailing (PFN) offers biomechanical benefits for intertrochanteric fractures but can lead to higher complication rates from poor reduction and technique errors, particularly in obese patients. Incorrect entry points may cause reduction loss, iatrogenic fractures, and misplaced lag screws. The study aims to investigate the effect of using an oriented flexible reamer instead of a rigid reamer on clinical and radiological results to obtain a medial entry point and better positioning of the nail in the intramedullary area in obese intertrochanteric fracture patients.

Materials and methods A retrospective analysis was conducted on patients aged 65 years and older who underwent PFN treatment between March 2020 and June 2022 at a single institution, with at least 1-year postoperative follow-up. Patients were divided into two groups: those applied with a flexible reamer and a rigid reamer. Parameters analyzed from postoperative radiographs included tip-apex distance (TAD), calcar-referenced tip-apex distance (CalTAD), reduction quality, femoral neck-shaft angle, and lag screw placement. Complication rates and types were recorded for each group.

Result The analysis included 91 patients, with 45 treated using a flexible reamer and 46 treated using a rigid reamer. There was no statistical difference between the two groups regarding age, gender, BMI, and AO class distributions of the patients ($p > 0.05$). The Femur neck shaft angle was significantly higher in the flexible reamer group ($p < 0.001$). As a result of the reduction types analysis, medial type reduction was significantly higher in the group where the flexible reamer was applied ($p < 0.001$). The CalTAD was shorter in the Flexible reamer group ($p = 0.005$). Complications and the need for reoperation were statistically significantly higher in the rigid reamer group ($p < 0.048$).

Conclusion The oriented flexible reamer reduces application-related errors in patients undergoing proximal femoral nail (PFN) treatment due to intertrochanteric fracture. The oriented flexible reamer technique allows a more medial entry point. Oriented flexible reamer creates enough space on both fracture sides at the level of intertrochanteric fracture to avoid nail pass-related complications.

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Level of evidence Level III, Case-control study.

Keywords Intertrochanteric fracture, Cephalomedullary nailing, Cut-out, Reduction loss

Introduction

Intertrochanteric fractures are a common type of osteoporotic hip fracture among the elderly population, comprising approximately 50% of all hip fractures [1]. The incidence of these fractures has been observed to rise with the aging global population [2]. Intramedullary fixation has become increasingly popular for treating intertrochanteric fractures [3]. While intramedullary fixation methods offer biomechanical and clinical advantages, incorrect reduction and inappropriate fixation can lead to failure or serious complications [4]. Complication development is more frequent in obese patients undergoing orthopedic surgery, attributed to surgical technique and other factors [5–7]. Obesity is a well-established risk factor for complications in intertrochanteric fractures, specifically entry point-related issues [8]. One of the primary concerns is the difficulty in achieving appropriate entry point placement. Excessive soft tissue complicates the accurate identification of anatomical landmarks and increases the risk of malpositioning the entry point [8]. Mechanical failure ranges from 2 to 13% at intertrochanteric fractures fallow-up [9]. Some common mechanical failure causes are lateral femoral wall fracture and fixation in the varus position [9, 10], which can subsequently lead to implant-related problems. Iatrogenic varus displacement can be seen after applying the nail during the surgery [11]. Complications arise from the use of rigid reamers in intertrochanteric patients with obesity. The mechanical stress exerted on the rigid reamer during the procedure may be magnified due to the increased load-bearing requirements in obese patients, raising concerns for potential instrument breakage or damage. New awl and guide systems are being developed for the appropriate entry point and correct nail positioning in proximal femoral nail (PFN) applications [12, 13]. It can be used in accessory incisions to achieve and maintain reduction during cephalomedullary nailing of severe obese intertrochanteric fractures [14]. There is a very limited literature on the use of a directed flexible reamer to provide an appropriate entry point in PFN nail application, and only one study suggested that the guide wire and reamer be directed from lateral to medial for appropriate nail positioning [15].

The study aims to investigate the effect of using an oriented flexible reamer instead of a rigid reamer on clinical and radiological results to obtain a medial entry point and better positioning of the nail in the intramedullary area in obese intertrochanteric fracture patients.

Materials and methods

A retrospective analysis was conducted on patients aged 65 years and older who underwent PFN treatment for intertrochanteric fracture between March 2020 and June 2022 at a single institution, with at least 1-year postoperative follow-up. Inclusion criteria were patients aged over 65 with BMI > 35, and isolated intertrochanteric fracture. Exclusion criteria included follow-up duration < 1 year, intertrochanteric fractures involving the lateral wall or subtrochanteric extension, pathologic fractures, non-ambulatory patients, treatment with methods other than a single lag screw PFN, and presence of multiple fractures, open fractures, or injuries from high-energy trauma. Patients who met the criteria were divided into two groups. The first group was designated as the group in which the entry point and medullary canal were prepared with a flexible reamer, while the second group served as the control group in which the rigid reamer was used. All participants and legal guardians were clearly informed about this new procedure. Informed consent forms for surgery were obtained from all subjects and their legal guardians before surgery. Institutional review board approval was obtained prior to commencing the study. No funding was received for the study.

Radiographic measurement and analysis

The classification of fracture type relied upon the AO Foundation/Orthopedic Trauma Association (AO/OTA) intertrochanteric fracture classification system. The researchers recorded the surgical duration and intraoperative complications. The quality of reduction [16], lag screw position, reduction type [17], distance of the tip of the lag screw to the femoral head apex [tip-apex distance (TAD) measured in millimeters] [18], CalTAD (calcar referenced tip-apex distance measured in millimeters), neck/ shaft angle was evaluated. The type of reduction, quality of reduction, and position of the lag screw within the femoral head were assessed using intraoperative fluoroscopic images. Parameters such as anterior and medial cortical continuity, anteversion, and restoration of the femoral neck/shaft angle, as defined by Yoon et al. [16], were evaluated based on immediate postoperative radiographic images. Additionally, the reduction type in the coronal plane—medial (extramedullary), lateral (intramedullary), and anatomical—was evaluated using intraoperative fluoroscopy, following the criteria established by Ito et al. [17]. Immediate postoperative radiographs were obtained using a mobile x-ray system in the operating room, with the patient positioned comfortably under anesthesia. Radiographic assessments were conducted in both the anterior-posterior (A/P) and lateral planes. Each radiograph was calibrated using the known diameter of the lag screw to ensure accurate measurements. A/P hip radiographs were taken with the patella centered between the condyles and facing forward. Lateral hip radiographs were obtained with the femoral lateral cortex parallel to the image intensifier and the femoral neck perpendicular to the lens. CalTAD and TAD measurements were performed on immediate postoperative radiographs. CalTAD refers to the distance from a line drawn adjacent to the medial cortex parallel to the TAD line, as previously described by Kuzky et al. [19]. Fracture healing time and complications were assessed using follow-up plain radiographs. All measurements were conducted utilizing the Picture Archiving and Communication System (PACS, Pi View Star, Infinitt, Seoul, Korea).

Surgical procedure

All surgeries were performed by a single board-certified surgeon with 10 years of experience at a level 1 trauma center (L.H.). All surgeries were conducted on the fracture table with reduction verified under fluoroscopy, utilizing both anterior-posterior and lateral views. The technique described by Fisher et al. [5] is used to position patients on the fracture table. The patient's upper torso and pelvis are tilted to the opposite side, and the abdominal panniculus and excess soft-tissue are pulled toward to the opposite side with the help of tape. Standard proximal femoral nail anti-rotation (PFNA) was employed. A 5 cm longitudinal incision was made proximal to the greater trochanteric tip, with mini open or closed reduction techniques utilized to achieve reduction. The hook leverage technique was applied to accomplish reduction, ensuring alignment in both coronal and sagittal planes. Following reduction confirmation, a curved awl was used to prepare the nail entry point, with its position verified under fluoroscopy control. The starting wire was then inserted through the awl into the intramedullary space, with attention paid to the abundant medial soft tissue and the iliac wing, which may influence wire positioning, causing it to lie on the lateral wall. Previously, the surgeon (L.H.) used a rigid reamer in the surgical technique for intertrochanteric fractures. However, later on, the surgeon opted to use a flexible reamer to better accommodate obese patients and ensure optimal positioning during the procedure.

In the flexible reamer group, we employed a double prolonged Hohmann retractor along with sequential flexible reamers following guide wire insertion (Fig. 1). However, when initiating the rigid starter reamer after guide wire insertion for intramedullary space preparation, medial pressure impeded reaming in the intended direction (Fig. 2). This resulted in the relocation of the start point laterally due to medial soft tissue pressure, hindering proper reaming of the intertrochanteric fragment at the start point. Despite achieving reduction with

Fig. 1 Flexible reamer application with Double prolonged Hohmann retractor

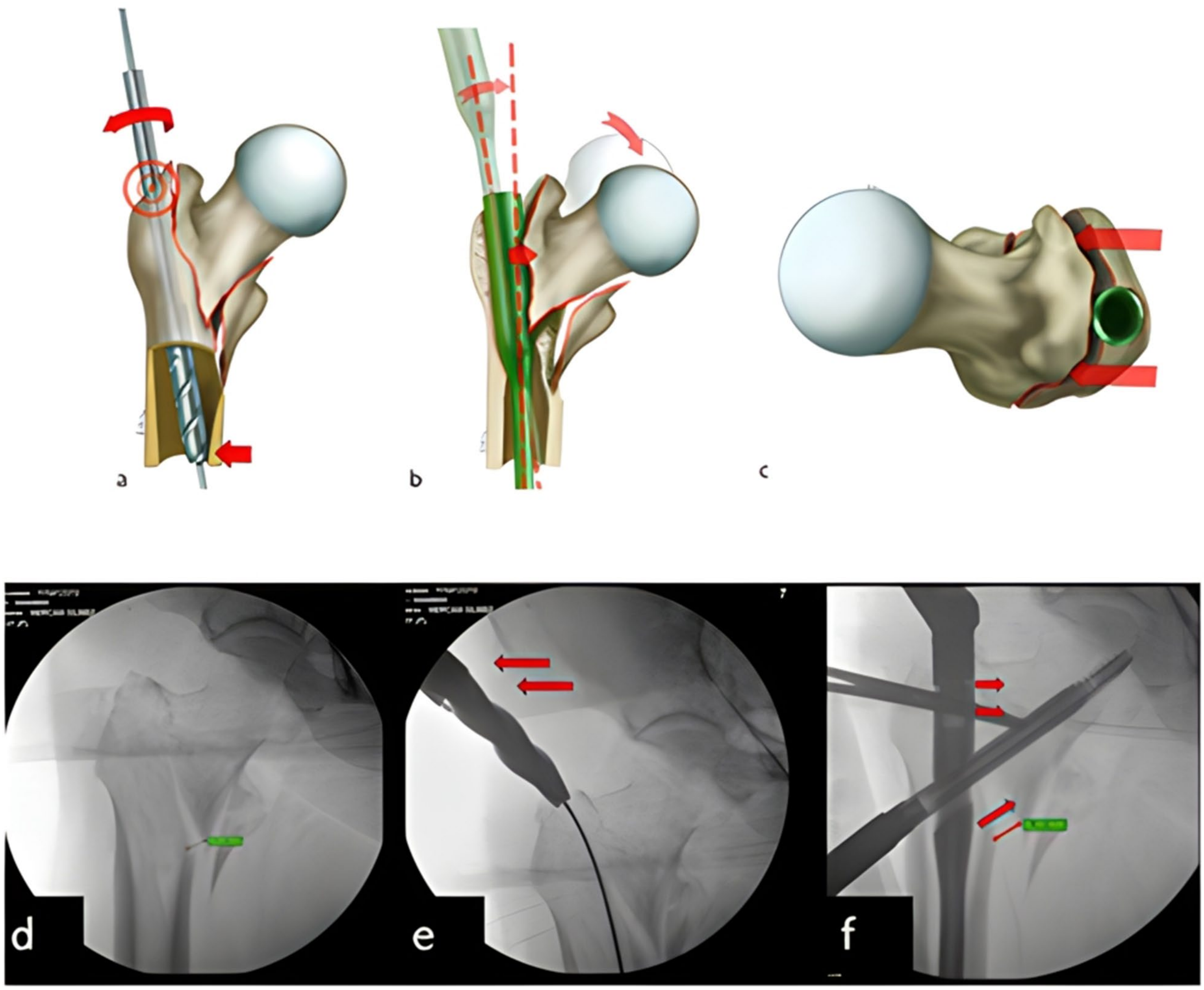

Fig. 2 Illustration and the fluoroscopic result of rigid reamer-related entry point failure and loss of reduction after the nailing process; **a**) The lateral entry point developed after a laterally directed reaming due to medial soft tissue pressure; **b**) loss of reduction after nail application; **c**) Opening of the fracture gap and reduction losses due to insufficient reaming of the intertrochanteric fragment; **d**) Fracture gap before nail application was 4.1 mm; **e**) Insufficient reamerization of the intertrochanteric fragment after reaming with a rigid reamer; **f**) Medialization of the intertrochanteric fragment and increased fracture gap after nail passes(fracture gap = 8.3 mm)

a mini-open technique, it was difficult to maintain due to inadequate reaming during rigid reamer or nail application. The rigid reamer, under medial soft tissue pressure, inadvertently led to laterally directed reaming, causing lateral placement of the entry point. Consequently, this disrupted reduction and could sometimes result in lateral wall fractures. Additionally, the incorrect trajectory of the rigid reamer could lead to insufficient reaming of the intertrochanteric fragment, potentially causing varus displacement during nail insertion.

To address these challenges, we employed a flexible reamer and double-prolong Hohmann retractor to exert medial pressure on the starter wire, preventing lateral deflection (Fig. 3). Even if there is lateral orientation due to medial soft tissue pressure in the proximal part of the flexible reamer, the distal part is medialized around the entry point with the application of a double prolonged Hohmann retractor from the distal end. Because the reamer is flexible, its rotation remains unaffected during the orientation process. The lateralization of the flexible reamer caused by medial soft tissue pressure during advancement in the medullary space is prevented by the double prolonged Hohmann retractor, which ensures that the reamer maintains a central position within the femoral shaft during advancement. In contrast, rigid reamers can cause lateralization of the femoral shaft while advancing in the intramedullary area due to pressure from the proximal medial soft tissue and the iliac crest. The flexible reamer and Hohmann retractor enabled precise control of the reamer trajectory while alleviating pressure on the lateral wall. In the surgical procedure, soft tissue protector is used in all cases, and before

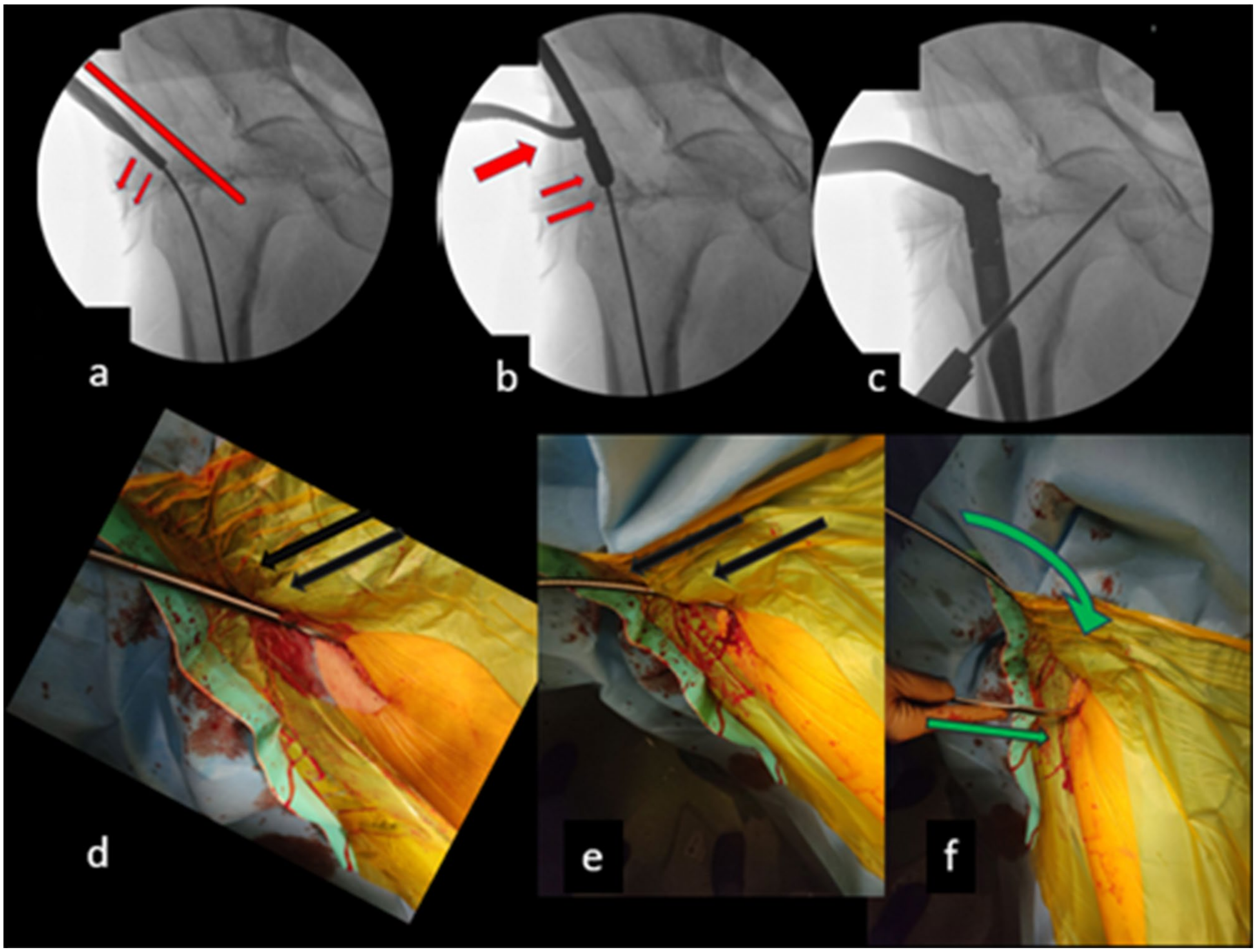

Fig. 3 Correction of starter reamer orientation; **a**) Lateral orientation of the rigid reamer by aberrant medial soft tissue pressure and load on the lateral cortex; **b**) Medial orientation of the reamer with the double prolonged Hohmann retractor and removal of the load on the lateral cortex; **c**) Non-disruption of reduction after nail passage; **d**) Medial pressure over the rigid reamer; **e**) Medial pressure on the flexible reamer; **f**) Correction of the flexible reamer direction with prolonged double Hohmann

the use of reamer, the soft tissue protector is advanced immediately proximal to the double prolonged Hohman retractor. We initiated with a 9 mm flexible reamer, followed by sequential applications of flexible reamers, and concluded with a 16 mm flexible reamer for proximal femur reaming. During sequential flexible reamer applications, the entry point was medialized by pushing the guide wire medially within the reamed area. A Hohmann retractor was utilized to apply force on the reamer in a lateral-to-medial direction throughout all reamer steps to ensure an accurate trajectory (Fig. 4). Subsequently, we inserted the PFNA and verified reduction on both anterior-posterior and axial lateral views.

Following this, the guide wire was introduced for the helical blade under fluoroscopic guidance, and static locking screws were placed distally over the guide. In the control group, reaming on the guide wire was conducted with the rigid reamer according to the standard procedure, with all subsequent steps proceeding similarly. Wounds were closed in the usual manner in both groups. Postoperative care consisted of rehabilitation with full unrestricted weight-bearing and the use of assistive devices as tolerated, beginning 48 h after surgery.

Statistical analyses

Data were analyzed with SPSS 29.0 IBM. Categorical variables are shown with frequency and percentage values, and numerical data with mean, standard deviation, minimum, and median values. Categorical data in each group were compared using Chi-square and Fisher's exact test. Independent t-test was used for parametric data, and the Mann-Whitney U Test was used for non-normally distributed parametric and nonparametric data to analyze data between two groups. One-way ANOVA was used for parametric data, and the Kruskal Wallis Test was used for non-normally distributed and nonparametric data to analyze the data between the three groups.

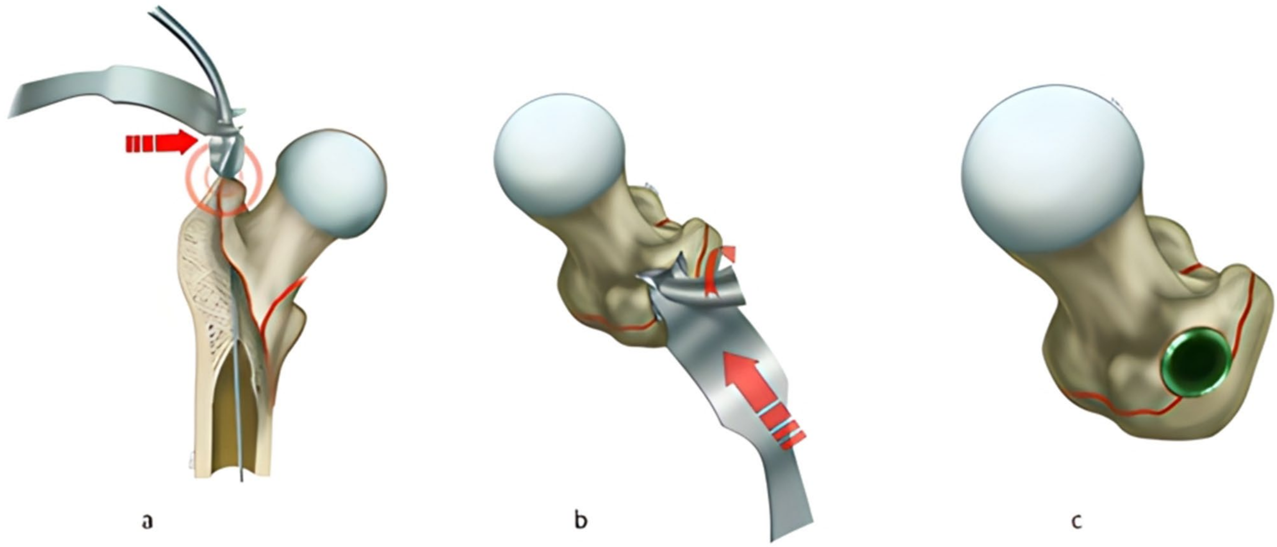

Fig. 4 Illustration of the surgical tip and flexible reamer use **a**) Medialization of the flexible reamer with Hohmann retractor forced against medial soft tissue pressure; **b**) axial view of the medially oriented flexible reamer to achieve medial entry point; **c**) axial view of the nail placement after sufficient reaming on intertrochanteric fragment

The Spearman test was used for correlation evaluations. The significance level was taken as $p<0.05$ for all tests.

Result

A total of 532 patients from the database who underwent PFN for intertrochanteric fracture were initially identified. Among them, 144 patients had a Body Mass Index (BMI) ≥ 34. Subsequently, 53 patients were excluded from the study due to various criteria, including application of double lag screw PFN ($n=22$), subtrochanteric extension ($n=12$), multiple fractures ($n=3$), and loss to follow-up ($n=16$). This left a cohort of 91 patients who were then divided into two groups. The first group ($n=45$) comprised patients in whom the entry point and medullary canal were prepared with a flexible reamer, while the second group ($n=46$) served as the control group, with a rigid reamer utilized for preparation (Fig. 5).

Among the participants, 84 individuals (92.3%) were female, while 7 (7.7%) were male. The average age of the patients was 75.73 ± 6.55, with a mean BMI of 35.93 ± 0.84. There were no statistically significant differences between the two groups regarding age, gender, BMI, and AO classification distribution (Table 1).

When the patients' fractures were examined in terms of union, a statistically significant difference was found compared to the control group ($p=0.012$). There was no difference between the two groups regarding the reduction of quality in intraoperative and immediate postoperative radiographic evaluations ($p=0.136$). A statistically significant difference between the two groups regarding the reduction types. Medial type reduction in postoperative radiographic evaluation was significantly higher at flexible reamer applied group ($p<0.001$). The lag screw was observed to be located inferiorly in 32 patients in the flexible reamer group ($p<0.001$). When the immediate postoperative radiographs are evaluated the femoral neck shaft angle was statistically significantly higher in the flexible reamer group ($p<0.001$). As a result of intraoperative and postoperative radiographic evaluations, Cal-TAD values were found to be significantly lower in the flexible reamer applied group. ($p=0.005$). Complications and the need for reoperation were found to be statistically significantly higher in the control group ($p<0.048$) (Table 2).

In addition, one patient in the control group underwent arthroplasty because of the development of varus collapse due to unacceptable reduction quality. When patients who developed complications were examined, nonunion was observed in 7 (70%), and delayed union was observed in 3 (>six months). When the complications were discussed, it was observed that reduction losses (varus collapse) developed in 6 patients, lateral wall fracture in 2 patients, excessive sliding (pull-out) in the lag screw in 1 patient, and nail breakage in 1 patient. Eight patients had arthroplasty, and 2 had exchange nails (Table 3). Age and gender were not correlated with the development of complications, but a positive correlation was found between BMI.

Discussion

Our study revealed that the femoral neck/shaft angle was restored to a higher degree in the group where nails were applied using a flexible reamer. Achieving a more medial entry point with the oriented application of a

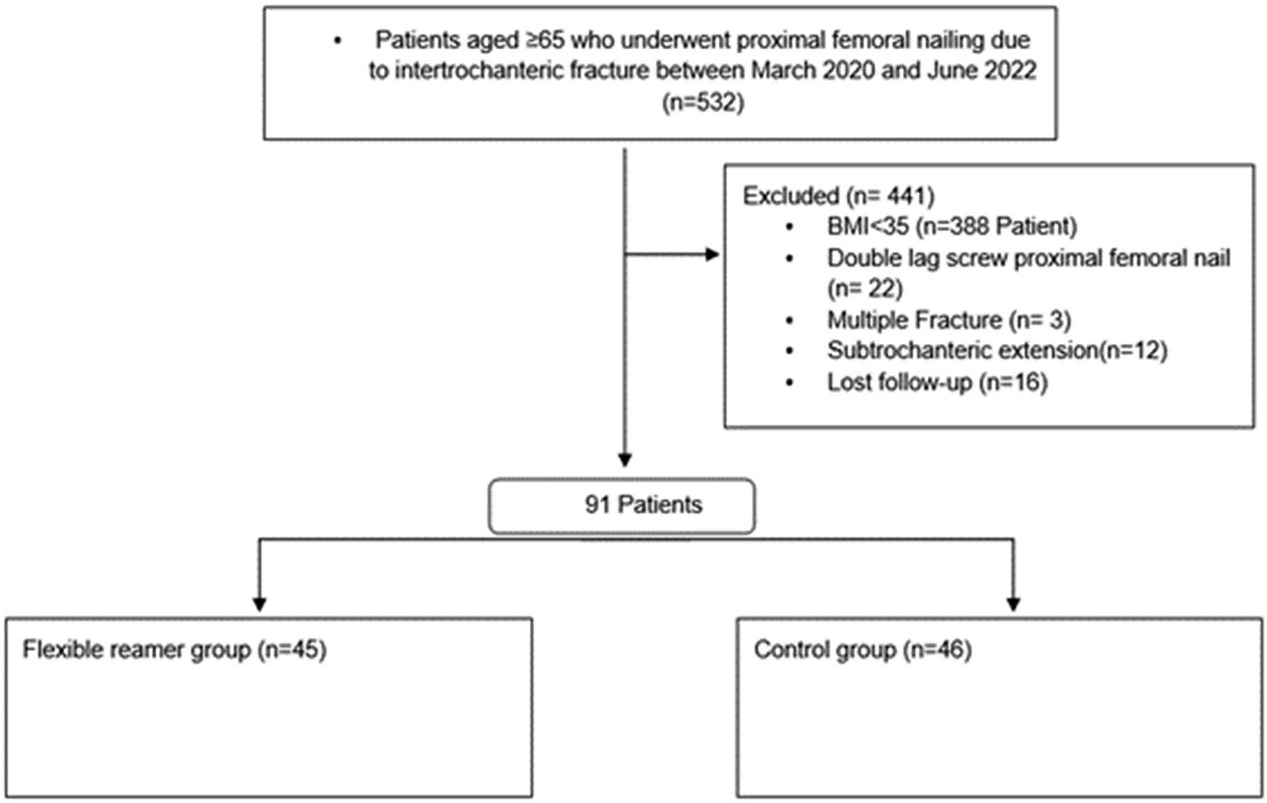

Fig. 5 Flow diagram of the patient

Table 1 Patient demographics

Group	Flexible reamer group	Control group	*p*-value
Sex n(%)			
Female	42 (93.3%)	42 (91.3%)	0.716
Male	3 (6.7%)	4 (8.7%)	
Age			
Mean ± SD	75.58 ± 6.37	75.87 ± 6.80	0.833
BMI			
Mean ± SD	35.80 ± 0.81	36.07 ± 0.85	0.133
AO/OTA class n(%)			
31A1.2	6 (13.3%)	6 (13.0%)	0.849
31A1.3	22 (48.9%)	20 (43.5%)	
31A2.1	17 (37.8%)	20 (43.5%)	

BMI: Body Mass Index AO/OTA; AO Foundation/Orthopedic Trauma Association

flexible reamer and better positioning of the nail within the intramedullary canal led to improved outcomes. For fixing unstable intertrochanteric fractures, a slightly valgus fixation (not exceeding 10 degrees) is recommended [4, 20–22]. In the group using the flexible reamer, fixation was achieved with a slightly valgus position (mean 132.09°±3.11°), and lower complication rates were observed during postoperative follow-ups. The incidence of medial-type reduction was significantly higher in the flexible reamer group, facilitated by the slight valgus fixation. Studies have consistently shown improved outcomes with medial-type reduction, particularly in cases where medial cortical integrity is compromised [23–25]. Lim et al. demonstrated the positive effects and favorable clinical outcomes associated with medial (extramedullary) type reduction in influencing the sliding of the lag screw in intertrochanteric fractures lacking medial calcar support [26]. Our study similarly found a higher frequency of medial-type reduction in the flexible reamer group, with fewer instances of cut-out complications observed compared to other groups. Park et al. reported that in intertrochanteric fractures without medial cortical support, intramedullary reduction can lead to higher screw sliding and reduced fixation strength [27]. Given the higher medial load transfer, particularly in obese patients with these fractures lacking medial calcar support, we anticipate a higher risk of varus collapse, even with intramedullary and anatomical reduction. Extramedullary medial-type reduction mitigates varus collapse and reduces fixation failure by creating a medial fulcrum through lateral load transfer.

Another consideration in the fixation of intertrochanteric fractures is the optimal placement of the lag screw within the femoral head [28–30]. In the group where nails were applied using a flexible reamer, lag screws were placed inferiorly in the coronal plane in 71.1% of cases. Studies have indicated that placing the lag screw in either the inferior or central position within the coronal plane

Table 2 Intraoperative, immediate postoperative radiographic evaluation, and clinical outcomes

Group	Flexible reamer group	Control group	*p*-value
Reduction quality n (%)			
Optimal	22(48.9%)	29 (63.0%)	0.136
Acceptable	23 (51.1%)	16 (34.8%)	
Reduction type n (%)			
Anatomic	17 (37.8%)	43 (93.5%)	< 0.001*
Medial	28 (62.2%)	3 (6.5%)	
Neck/shaft Angle			
Mean ± SD	132.09 ± 3.11	126.70 ± 1.95	< 0.001*
Lag screw position(Coronal Plain) n (%)			
Center	13 (28.9%)	43 (93.5%)	< 0.001*
Inferior	32 (71.1%)	3 (6.5%)	
TAD			
Mean ± SD	19.09 ± 3.38	15.74 ± 4.60	< 0.001*
CalTAD			
Mean ± SD	16.20 ± 2.82	18.50 ± 4.52	0.005*
Surgical Time			
Mean ± SD	77.62 ± 8.13	80.61 ± 6.93	0.062
Miniopen reduction requirement n (%)			
No	16 (35.6%)	12 (26.1%)	0.328
Yes	29 (64.4%)	34 (73.9%)	
Union Time n (%)			
≤ 6 months	40 (88.9%)	31 (67.4%)	0.012*
> 6 months	5 (11.1%)	8 (17.4%)	
Fail	-	7 (15.2%)	
Follow-up(months)	13.7 ± 1.1	13.2 ± 0.8	0.625
Complication n (%)			
No	43 (95.6%)	38 (82.6%)	0.048*
Yes	2 (4.4%)	8 (17.4%)	

does not significantly impact clinical outcomes, with fixation failure rates ranging from 1.3 to 4.8% [31]. Biomechanical studies have shown that placing the lag screw in the inferior position reduces the stress distribution in the posteromedial cortex, decreases the cut-out rates, and increases the fixation strength [32, 33]. Our study observed better clinical outcomes and a fixation failure rate of 4.4% in obese patients with high medial load transfer. This improvement was attributed to placing the lag screw in an inferior position (71.1%) and achieving slightly valgus fixation in the group treated with the flexible reamer. Garabano et al. [34] demonstrated a strong correlation between TAD values above 25 mm and mechanical complications. In our study, the average TAD distance in the flexible reamer group was found to be 19.09±3.38 mm. Additionally, the CalTAD values in the flexible reamer group were relatively smaller than the TAD values, averaging 16.20±2.82 mm. It has been shown that Cal-TAD values are more valuable in predicting postoperative mechanical complications, with mechanical complication rates increasing significantly when these values exceed 23 mm [21, 35]. Based on our study, we found that the probability of failure was higher in obese patients with intertrochanteric fractures lacking medial calcar support, primarily due to anatomical and intramedullary fixation. Excess soft tissue can exert pressure on the rigid reamer, leading to a lateral entry point or causing a lateral wall fracture during surgery. The integrity of the lateral trochanteric wall is crucial for stability in intertrochanteric fractures, as a fracture of this wall significantly increases the risk of implant failure [36, 37]. İatrogenic lateral wall fracture can occur during the nailing [38, 39]. In the rigid reamer group, two patients developed iatrogenic lateral wall fractures. This issue is primarily related to an incorrect entry point, leading to impingement at the lateral wall. We observed that these fractures occurred because the rigid reamer was directed towards the lateral wall, causing impingement and subsequent fractures.

The guide wire is applied from the fracture line due to trochanteric tip fracture, and failures are seen as a result of lateral entry nail applications [40, 41]. As a result of insufficient medial reaming, the nail pushes the intertrochanteric fragment into the medial and causes a distraction at the intertrochanteric fracture line. In addition, the nail may cause the varus to collapse as it passes into the canal. This problem was highlighted by Hak DJ et al. [42]. More lateral entry points can cause medial impingement at the end of the nail, acting as a lever arm at the proximal fragment, distracting the fracture gap [40]. A flexible reamer forced with a double prong Hohmann retractor allows us to drill intertrochanteric fragments to achieve this problem. In the literature, mechanical complication rates of intertrochanteric fractures treated with PFNA range from 2.6 to 13% [4]. In our study, the complication rates in the flexible reamer group were 4.4%, while in the control group were 17.4%. We think the high rate of mechanical complications was because only obese patients were included in the study. No significant difference was observed between the two groups when the

Table 3 Complication data

	Flexible reamer group (*n*)	Control group (*n*)	Re-operation
Reduction Losses (Varus collapse, cut-out)	0	6	Arthroplasty
Excessive sliding (pull-out)	1	0	Exchange nail
Lateral Wall Fracture	0	2	Arthroplasty
Nail Breakage	1	0	Exchange nail

operation times were examined. It was observed that the flexible reamer application did not affect the operation time. It was observed that the most critical factor affecting the operation time was BMI, regardless of the groups. In obese patients, pelvis positioning or hip adduction can be applied during proximal femur nail application [5]. Adduction of the hip during rigid reamer application causes varus displacement, increased cranial fracture gap opening, and results in insufficient reaming of the proximal fragment. As a result of insufficient reaming varus displacement becomes inevitable during nail application.

This study is subject to several limitations that warrant consideration. Firstly, its retrospective nature and relatively small sample size, stemming from the study's focus on a specific patient group, may restrict the generalizability of the findings. Secondly, the absence of a comprehensive evaluation of clinical outcomes, including the utilization of clinical scoring systems, represents a significant limitation. Given the study's focus on investigating surgical techniques, perioperative and early postoperative data were prioritized over factors such as systemic diseases and patient mobilization, which could impact union time but were not extensively addressed. Thirdly, the surgeon's experience may affect surgical outcomes. However, all patients in the study were operated at the region's only level 1 trauma center by a single experienced trauma surgeon, which helped minimize this variable's influence. Additionally, the transition from utilizing a rigid reamer to a flexible reamer for positioning the intramedullary nail may introduce bias into the results. However, efforts were made to mitigate this potential bias by ensuring an adequate number of patient cohorts. These limitations underscore the need for further research and caution in generalizing the study's findings to broader patient populations.

Conclusion

The use of a directed flexible reamer has been demonstrated to reduce the incidence of inappropriate entry point errors in severely obese patients undergoing proximal femoral nailing (PFN) for intertrochanteric fracture. The oriented flexible reamer technique allows a more medial entry point. Oriented flexible reamer creates enough space on both fracture sides at the level of intertrochanteric fracture to avoid nail pass-related complications.

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Author contributions
A.I. Kilic: Manuscript prep and revision and is accountable for all aspects of work. L. Horoz: Manuscript prep and revision, final approval and is accountable for all aspects of work. C. Kircil: Manuscript revision, final approval and is accountable for all aspects of work. M.F. Cakmak: Manuscript revision, final approval and is accountable for all aspects of work.

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Data availability
The data and materials supporting the findings of this study are available upon request from the corresponding author.

Declarations

Ethics approval and consent to participate
Ethical approval from the institutional ethics committee of Kirsehir Ahi Evran University was obtained prior to onset of investigation (IRB approval number 2023-02/05). Participation in the research was voluntary, without coercion. Participants provided consent for their involvement in the study. It was communicated that identities would remain confidential, and the results would be published. All participants and legal guardians were clearly informed about the procedure. Informed consent forms for surgery were obtained from all subjects and their legal guardians before surgery. The study design and procedures adhere to ethical standards outlined in the Helsinki Declaration.

IRB approval
This study has been approved by the local ethics committee. IRB number and approval date: IRB 2023-02/05–24/01/2023.

Consent for publication
A statement confirming informed consent was obtained from all participants and legal guardians to publish identifying information and images in an online open-access publication.

Disclaimer
None.

Competing interests
The authors declare no competing interests.

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