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ORIGINAL ARTICLE

A Comparative Study of Proximal Femoral Nail Antirotation in Peri-trochanteric Fractures in Lateral Decubitus and Supine Position*

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ABSTRACT

Objectives. One of the most widely used cephalomedullary devices for unstable peri-trochanteric fractures is the Proximal Femoral Nail Antirotation (PFNA). Adequate reduction and fixation are crucial to achieving ideal function and fracture union. Many factors can contribute to the ease of reduction; one of these is the positioning technique. Numerous reports have addressed the advantages and disadvantages of the positioning techniques for antegrade femoral nailing. This study aimed to compare the quality of fixation, adequacy of reduction, bony union, and functional outcomes in PFNAs done in the lateral decubitus and supine position.

Methodology. This study was a retrospective cohort study conducted at the Philippine Orthopedic Center. Adult male and female (21 to 65 y/o) patients who underwent open reduction with a PFNA either in the supine or lateral position were included in this study. Thirty-nine (39) patients were identified, where six were lost to follow-up, and four did not have retrievable postoperative radiographs. A total of 29 patients were included. The data were analyzed using the T-test in two population means and Fisher's Exact Test.

Results. At a 95% level of confidence, the study showed no significant differences in the distribution of Tip-Apex Distance (TAD), adequacy of reduction, and bony union at six months post-operatively between the lateral and supine position. In contrast, there was a significant difference in the distribution of the Cleveland index score. Regarding the Harris Hip Score (HHS), there was also a significant difference in the average score between the two groups, but all had an excellent functional outcome.

Conclusion. The preferred surgical position for performing an open reduction and fixation with a PFNA remains controversial. This study showed that the surgical position did not affect the TAD, adequacy of the reduction, and bony union. All patients from both groups had excellent functional outcomes at six months post-operatively, but the lateral position group had superior Cleveland index scores. Surgery with the PFNA in the lateral decubitus position can be performed in small rural hospitals that lack a fracture table. With proper surgical technique, this may be safe, executable, and may benefit more patients with peri-trochanteric fractures.

Keywords. peri-trochanteric fractures, subtrochanteric fractures, cephalomedullary nail, PFNA, hip surgery

INTRODUCTION

Peri-trochanteric fractures are fractures occurring between the extracapsular part of the neck to a point 5 cm distal to the lesser trochanter. They include intertrochanteric and subtrochanteric fractures and make up about 50% of hip fractures. Subtrochanteric fractures pose a challenge to surgeons because of their anatomical peculiarity. This is an area of great stress concentration and is subjected to several deforming forces due to its muscular insertions. Complex fractures with medial support failure more often lead to fixation failure and reoperation.[1,2]

In addition to the obstacles faced in obtaining an anatomic reduction, the surgeon must maintain the reduction throughout the healing process using an appropriate fixation device.[3] Given the shorter lever arm and load-sharing characteristics of IM nails, they are the most commonly used

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**This study earned 3rd Place at the POC 25th Residents Research Forum on February 18, 2022. It was a presented at a podium during the Philippine Orthopaedic Association Annual Convention on June 16, 2022 and as an e-poster at the 5th AO Trauma AP Scientific Conference on May 28, 2022.*

devices in unstable fractures. One type of cephalomedullary device is the Proximal Femoral Nail Antirotation (PFNA). The Proximal Femoral Nail is a promising minimally invasive implant, with better biomechanical stability, minimum soft tissue dissection, minimal blood loss, minimal infection, and wound complications.[4,5] This surgical treatment aims to provide stable fixation that allows an early range of motion. However, proper placement of the blade is essential to avoid the risk of screw or blade cut-out. The tip of the blade should be 10 mm from the joint line in the anteroposterior and lateral projections. This corresponds to a tip-apex distance (TAD) of 20 mm. A study by Nikoloski et al., suggested that the optimal TAD for a PFN is between 20 to 30 mm. Another way of assessing the quality of implant placement is the Cleveland index. This assesses the position of the compression screw of a PFN and the helical blade of a PFNA. A center-center or center-inferior placement of the compression screw or helical blade is considered optimal.[6]

The Harris Hip Score (HHS) was developed to assess functional outcomes following hip surgery and is intended to evaluate various hip disabilities and treatment methods in an adult population. The domains covered are pain, function, absence of deformity, and range of motion. The pain domain measures pain severity and its effect on activities and the need for pain medication. The function domain consists of daily activities (stair use, using public transportation, sitting, and managing shoes and socks) and gait (limp, support needed, and walking distance). Deformity considers hip flexion, adduction, internal rotation, and extremity length discrepancy. Range of motion measures hip flexion, abduction, external and internal rotation, and adduction.

It is also essential to assess the bony union objectively. The University of Toronto and McMaster University teams developed the radiographic union score for hip (RUSH) which increases agreement among surgeons and radiologists in assessing fracture repair. The RUSH is a standardized radiographic assessment of hip fracture union based on callus bridging and the appearance of the fracture line. It may provide prognostic information that could predict healing outcomes in patients with hip fractures.[7]

Adequate reduction and fixation are crucial to achieving ideal function and radiographic healing post-operatively. Many factors can contribute to the ease of reduction; one of these is the positioning technique. Numerous reports have addressed the advantages and disadvantages of the positioning techniques for antegrade femoral nailing. The supine position on a fracture table offers sustained longitudinal traction without the need for an assistant, and circumferential access to the injured extremity. However, it is difficult to establish the correct starting point and to accommodate obese patients and patients with multiple injuries.[8] Complications include pudendal nerve neuropraxia, erectile dysfunction, perineal sloughing due to continuous traction, pressure necrosis, and compartment syndrome of the opposite leg.[9] A study by Ganjale et al., stated that it was difficult to reduce comminuted subtrochanteric fractures (where different fragments and segments are being pulled by strong muscles around the hip) in the supine position. This caused prolonged operative time, higher risks of conversion to open technique, more bleeding, higher chances of infection, and longer anesthesia time.[10]

In contrast, in the lateral position, the muscles around the hip are relaxed, and the distal limb is free for easier mobilization. Reduction and fixation of proximal femoral fractures in the lateral position with fluoroscopy in rural hospitals that lack a fracture table may be executable and probably safe.[10] Aside from this, the lateral position allows improved access to both the piriformis fossa and the trochanteric entry points in obese patients and allows conversion to an open approach. Also, there was no significant difference in the functional outcome and out-of-bed activity time in the lateral position compared to the supine position.[8]

The Proximal Femoral Nail Antirotation (PFNA) is widely used in our setting. To our knowledge, there are no local studies published about peri-trochanteric fractures treated with PFNA in the lateral decubitus position, and the choice of position is solely surgeon-based. There have been international studies concerning the complications brought about by the supine position. The lateral decubitus position does not require a fracture table, (so it can be used in primary hospitals), avoids additional set-up time, and is easier to convert to open reduction.

OBJECTIVES

The objectives of this study were to compare the quality of fixation (tip-apex distance and Cleveland index), adequacy of reduction, bony union, and functional outcomes in PFNAs done in the lateral decubitus position and supine position. We also aimed to describe the incidence of complications and difficulties (malreduction, non-union, screw malrotation, difficulty in establishing an entry point, pudendal nerve neuropraxia, perineal sloughing, and compartment syndrome of the contralateral leg, helical blade cut-out) encountered.

METHODOLOGY

This study was a retrospective cohort conducted at the Philippine Orthopedic Center (POC). Convenience sampling through records review of the patient census was done to acquire a sample of patients with peri-trochanteric fractures (from trauma and adult orthopedic services at the Philippine Orthopedic Center) who underwent open reduction and internal fixation with PFNA between January 01, 2018 and December 31, 2020. The participants were nonrandomly assigned to two groups – lateral or supine position – as the attending physician saw fit. A total sample size of at least 18 patients (n = 17.48), 9 patients for each treatment group, was calculated based on a 5% level of significance (95% level of confidence) and a 6.4% coefficient of variation, with a margin of error of at most 0.[11] Specifically, the sample size, n, was computed using the following formula:

$$n = [(Z_{\alpha/2}\ CV)/\varepsilon]^2$$

where $Z_{\alpha/2}$ is the tabular value at alpha level of significance; CV is the coefficient of variation (usually <0.10); ε is the margin of error.

After IRB approval, we included patients based on the following criteria: 1) adults (21 to 65 years old), 2) patients who underwent open reduction PFNA either in the supine or lateral position, and 3) patients with unstable type intertrochanteric fractures with or without subtrochanteric extension and subtrochanteric fractures (AO/AOTA 31A2, 31A3, 32A1, 32A2, 32A3 and 32B2). Patients with significant co-morbid conditions (American Society of Anesthesiologists Physical Status classification III–V), open peri-trochanteric fractures, polytrauma patients, and patients with pathologic fractures were excluded from this study. Thirty-nine (39) patients were included in the study, where six were lost to follow-up, and four did not have any retrievable postoperative radiographs on the picture archiving and communication system (PACS). A total of 29 patients were included.

Demographic characteristics were taken, such as age, gender, height, weight, BMI, comorbidities, the timing of surgery, injured side (laterality), intraoperative blood loss, and intra-operative time.

Surgical technique

Patient position and reduction of the fracture:

Supine positioning

The patient was positioned supine on a fracture table. The ipsilateral arm was elevated in a body strap or taped to the trunk while the uninjured leg was secured on a leg holder. The torso was pushed 10° to 15° to the contralateral side to ensure that the ipsilateral hip was in an adducted position (Figure 1). After positioning, the surgical site was prepared aseptically, and sterile drapes were then applied. The fracture was exposed, reduced, and fixed using a direct lateral approach.

Lateral positioning

The patient was positioned in a lateral position on a radiolucent top operating table, with the fractured limb on top and freely movable at the hip. Trunk-supporting bolsters were placed anteriorly and posteriorly and were well secured with body straps to stabilize the patient in a lateral position, (Figure 2A). The C-arm was placed contralateral to the surgeon (Figure 2B). To avoid any bony overlap on the lateral view, the contralateral hip was maximally flexed with the knee in 90 degrees of flexion. After positioning, the surgical site was prepared aseptically, and sterile drapes were then applied. The fracture was exposed (Figure 3), reduced (Figure 4), and fixed using a direct lateral approach.

Insertion of the nail

The C-arm was used to guide nail insertion (Figure 5). In the AP view, the nail insertion point was on the tip or slightly lateral to the tip of the greater trochanter. The guidewire was inserted laterally at an angle of 6° to the shaft. In the lateral view, the guidewire was placed in the center of the medullary canal to a depth of about 15 cm.

A cannulated drill bit was used over the guidewire to open the entry point; reaming was done manually through the protection sleeve. The nail was then inserted manually. The guidewire for the helical blade was then inserted superomedially, using the C-arm for positioning. The final position of the guidewire was at the inferior part of the femoral neck. In lateral view, the wire was positioned in the center of the femoral neck. The correct screw length was indicated on the measuring device and calculated to end approximately 5 mm before the tip of the guidewire. A hole was drilled, and the femoral neck helical blade was inserted (Figure 6). Distal

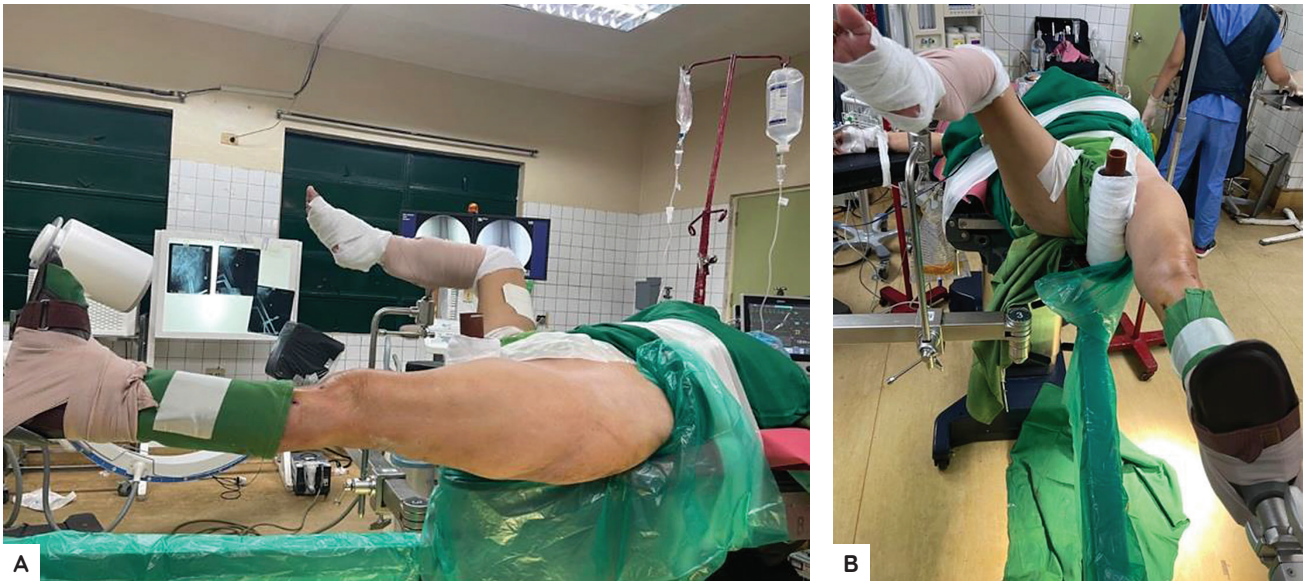

Figure 1. Supine position. **(A)** Patient placed on a fracture table with both leg secured with contralateral hip flexed and abducted. **(B)** Placement of the perineal post.

Figure 2. Lateral positioning with placement of a bolster to secure the body **(A)**; contralateral hip maximally flexed (under the green plastic drape) and positioning of the C-arm **(B)**.

Figure 3. Direct lateral approach preoperative surgical markings.

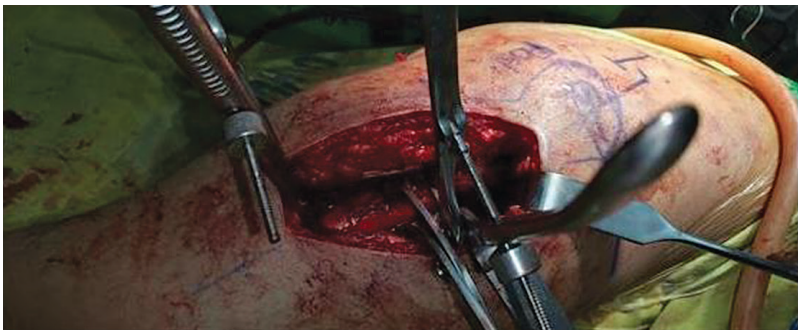

Figure 4. Direct reduction of the fracture using bone clamps.

locking screws were then placed. After proper placement of the nail, copious washing and hemostasis were done. Surgical wounds were primarily closed, and a dressing was applied.

Outcome measures (TAD, Cleveland index, adequacy of reduction, bone union, and functional outcome at six months post-operatively) were recorded and compared.

Quality of fixation

The quality of fixation was assessed using the tip-apex distance for PFN described by Nikoloski et al., and the Cleveland index by Cleveland et al. They suggest that a tip-apex distance for helical blade-based proximal femoral nails should be 20 to 30 mm. A TAD of less than or equal to 20 results in a possible axial cut-out (medial migration), and a TAD of more than or equal to 30 mm results in a cephalad cut-out. The Cleveland index was used to assess the position of the compression screw in PFN and the helical blade in PFNA. A center-center or center-inferior placement of the compression screw or helical blade was considered optimal.[12]

Adequacy of reduction

Adequate reductions were defined as displacements less than 5 mm and angulations deviating less than 10 degrees from the normal neck-shaft angle.[13]

Table 1. Demographic and clinical characteristics of patients by treatment group

Characteristics	Lateral decubitus position		Supine position	
	Mean ± SD / n	%	Mean ± SD / n	%
Sex, n (%) Male Female	 9 4	 69.2 30.8	 14 2	 87 12
Age*, *Mean ± SD	50.77 ± 13		38.69 ± 11	
Height*, *Mean ± SD	160.08 ± 8		167.06 ± 10	
Weight*, *Mean ± SD	64.00 ± 10		61.94 ± 10	
BMI*, *Mean ± SD	24.77 ± 2		22.25 ± 2	
Comorbidities, n (%) Normal health Mild systemic disease Diabetes Missing	 9 3 1 0	 69.2 23.1 7.7 0	 9 5 1 1	 5 3 6.3 6.3
Intraoperative time*, *Mean ± SD	158.62 ± 51		171.6 ± 60	
Intraoperative blood loss*, *Mean ± SD	808.46 ± 410		785.6 ± 742	

Table 2. Average scores of quality of reduction and functional outcome

	Lateral Mean ± SD	Supine Mean ± SD
Tip-apex distance (mm)	21.69 ± 3.5	22.25 ± 7.5
Harris hip score (points)	92.24 ± 5.2	94.70 ± 3.4

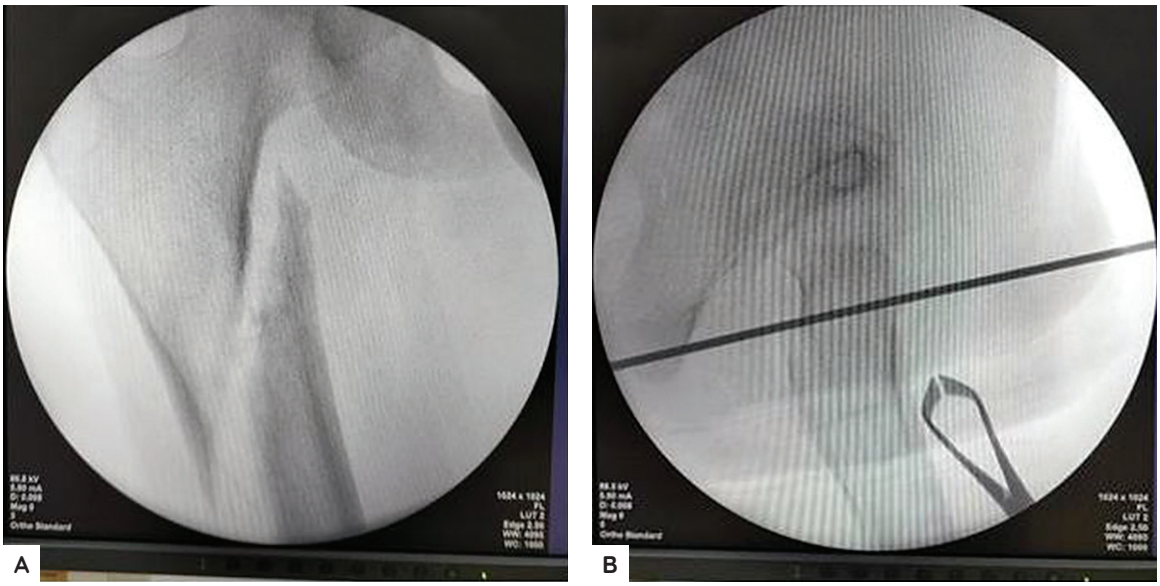

Figure 5. Intraoperative radiographs (Lateral position), AP view **(A)** and lateral view **(B)**.

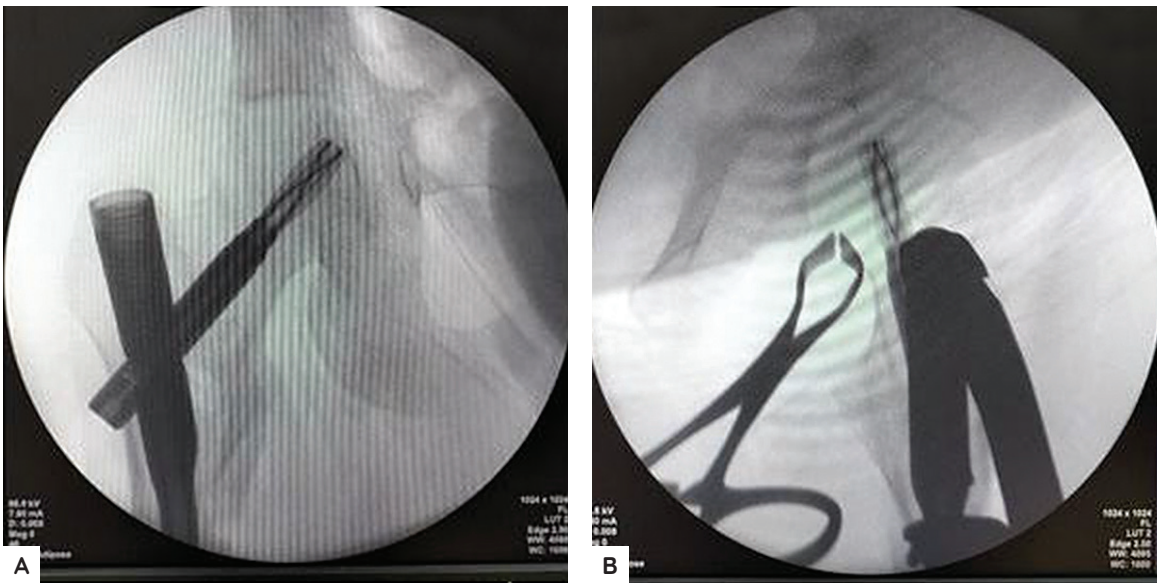

Figure 6. Final placement of the helical blade on AP **(A)** and lateral view **(B)** (lateral group).

Table 3. Distribution of categorical outcomes

Categorical outcomes	Lateral decubitus position		Supine position	
	Count	Percentage (%)	Count	Percentage (%)
TAD				
Acceptable	9	69.2	7	43.8
Not acceptable	4	30.8	9	56.3
Cleveland Index				
Optimal	13	100.0	9	56.3
Sub-optimal	0	0.0	7	43.8
Adequacy of reduction				
Acceptable	12	92.3	11	68.8
Not Acceptable	1	7.7	5	31.3
Bone union (RUSH score)				
Complete bony union	10	76.9	15	93.8
Inadequate bony union	3	23.1	1	6.3

Table 4. Result of T-test and Fisher's exact test

Outcomes	Test	*p*	Interpretation
Tip- apex distance	Fisher's exact test	0.2642	Not significant
Cleveland index	Fisher's exact test	0.0084	Significant
Harris hip score	T-test	0.0001	Significant
Adequacy of reduction	Fisher's exact test	0.1834	Not significant
Bone union (Rush score)	Fisher's exact test	0.2994	Not significant

Bony union at six months post-op

The RUSH score assesses four component scores of cortical bridging, cortical disappearance, trabecular consolidation, and trabecular disappearance. The four cortices (anterior, posterior, medial, lateral) were each given a score from 1 to 3 for cortical bridging, and a score from 1 to 3 for cortical fracture disappearance. Trabecular consolidation and trabecular disappearance were each given a score of 1 to 3. The maximum score is 30 (perfect healing) and the minimum score is 10 (no signs of healing).[7]

Functional outcome six months post-op

Functional outcome was assessed using the Harris Hip score at six months post-op. A score of <70 indicates a poor outcome, 70–79 fair, 80–89 good, and 90–100 excellent.

Complications encountered during the follow-up period such as infection, non-union, implant failure, and pudendal nerve injury were documented.

Statistical analysis

Descriptive statistics such as counts, percentages, means, and standard deviations were used to describe patients' demographic and clinical characteristics in each treatment group. After the data for each population were gathered, the data were analyzed using the T-test procedure in two population means and Fisher's exact test assuming that the data gathered follows a normal distribution.

RESULTS

Most patients in both groups were male (70% for the lateral group, and 88% for the supine group). On average, patients in the supine group were younger (mean, 39 years old vs 51 years old), slightly taller, weighed slightly less, and had slightly lower BMIs. Few patients had mild systemic disease. The mean intraoperative time was 158.62 minutes for the lateral group, while it was 171.63 minutes for the supine group. Intraoperative blood loss was higher for the lateral group, albeit with high variability. One patient in the supine group experienced pudendal nerve palsy postoperatively that completely resolved after three months.

The results showed no significant differences in the average TAD scores for the supine group (21.69 mm) compared to the lateral group (22.25 mm) (Table 2). However, a higher percentage of patients in the lateral group had an acceptable TAD (69.2% vs 43.8%, $p = 0.2642$), Cleveland index (100% vs 56.3%, $p = 0.0084$), and adequacy of reduction (92.3% vs 68.8%) compared to the supine group (Table 3). The supine group had higher RUSH scores (93.8% vs 76.9%, $p = 0.2994$) and Harris Hip scores ($p = 0.0001$).

DISCUSSION

Davis et al. in 1969 used the lateral position to facilitate reduction and exposure for the first time in intertrochanteric and subtrochanteric fractures of the femur. Ozkan et al. used this position for proximal femoral nailing in 2010, and Connelly et al., for complex proximal femur locked plating in 2012.[13] In our study, the lateral position group had shorter intraoperative times. This is consistent with other studies that reported difficulties in reducing the fragments in supine on a fracture table. The difficulties were attributed to the pull of strong muscles around the hip, specifically in subtrochanteric fractures. In the lateral position, all the muscles around the hip are relaxed, and the affected limb is freely draped and

movable. Muscular forces around the hip in the sagittal plane are more effectively neutralized in the lateral position, whereas the coronal plane forces are easily neutralized with a firm pillow between the legs.[13] Although placing the patient on a fracture table gives the advantage of sustained traction with less manpower, the lateral position offers the advantage of moving the distal segment to align with the proximal freely with gentle longitudinal traction. In contrast to other studies, our lateral position group had more intraoperative blood loss. This may be due to the difficult reduction in chronic fractures, requiring a longer incision for better exposure.

This study had eight overweight patients managed in the lateral position and two in the supine position. A higher average BMI was reported in the lateral group, as this position may have been chosen by the surgeon to facilitate nail insertion. In the supine position, it is difficult to insert a nail and jig assembly for obese patients or patients with a sagging abdomen.

There were no significant differences in the TAD, adequacy of reduction, and six-month bony union. In this study, no incident of cut-out was recorded, even in patients with unacceptable TAD. We noted significant differences in the Cleveland index and Harris Hip Scores. All patients in the lateral position group had a center-center or center-inferior helical blade placement. Despite the significant difference in terms of the HHS, the average score of each group was >90, which was excellent. There was also one reported case of pudendal nerve palsy in the supine position group due to a prolonged intraoperative time due to the perineal pressure on the fracture table.

CONCLUSION

The preferred surgical position for open reduction PFNA remains controversial. Regardless of the position, the main goal is still to achieve a good reduction with stable fixation and early return to pre-morbid function. This study shows that the surgical position did not affect the TAD, adequacy of the reduction, and bony union. All patients from both groups had excellent functional outcomes at six months postoperatively, but the lateral position group was superior in terms of the Cleveland index.

Performing PFNA in the lateral decubitus position can be safely and effectively done in small rural hospitals without a fracture table, potentially benefiting more patients with peri-trochanteric fractures.

Limitations of this study include the lack of follow-up for most patients, lack of randomization, different senior surgeons, and a short follow-up period. We also did not consider the fracture configuration in our analysis. A randomized controlled trial with an increased sample size is recommended to strengthen the power of this study.

STATEMENT OF AUTHORSHIP

All authors certified fulfillment of ICMJE authorship criteria.

AUTHORS DISCLOSURE

The authors declared no conflict of interest.

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