

# EFFECT OF POSTEROINFERIOR LAG SCREW POSITION FOR CEPHALOMEDULLARY NAIL ON IMPLANT FAILURE AND FUNCTIONAL OUTCOME COMPARED TO THE CENTER-CENTER POSITION IN INTERTROCHANTERIC FRACTURE



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## ABSTRACT

### *Background*

Intertrochanteric fracture (ITF) is one of the most common injuries in older people and is more prevalent in females. Thus, we aimed to compare two proximal femoral nail screw positions (centre-centre and posteroinferior) in stable ITF types.

### *Objectives*

To determine better techniques for screw placement, especially in the emergency department.

### *Patients and Methods*

Prospectively and retrospectively, 76 (33 males and 43 females) patients aged > 55 years were registered; 44 of them were treated with proximal femoral nails with screw positions centre-centre inside the femoral neck (group A), and 32 patients treated with proximal femoral nail with screw positions posteroinferior inside the femoral neck (group B). They were followed up after 3, 6, and 12 months postoperatively to compare screw position effect on implant failure and functional outcome using MHHS. The reduction quality was assessed using neck-shaft angle (NSA), while the quality of Fixation was assessed using tip-apex distance (TAD) and calcar tip-apex distance (CalTAD). Singh index (SI) was used for osteoporosis assessment.

### *Results*

The mean age of patients was 72.93±8.4 (group A) and 70.13±6.86 (group B). There was no significant correlation in incidences of implant failure among TAD (<25 mm) and CalTAD (>25 mm) in group A. For group B in Cleveland index (CI) areas 8 and 9, TAD and CalTAD were ≥ 25 mm, and there were no correlations with end-result and implant failure. In group A, 2 cases of implant-related complications were recorded; in group B, one patient was recorded. The functional score was higher in group B. Fixation quality between the two groups remained comparable.

### *Conclusion*

The functional outcome of group B was better with optimal surgical conditions. Both groups had comparable radiological and Fixation failure outcomes.

**Keywords:** *proximal femoral nail, tip apex distance, intertrochanteric fracture, Singh index, Cleveland index.*

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## INTRODUCTION

Intertrochanteric fracture (ITF) is a common fragility fracture occurring continuously with increasing incidence, especially in elderly populations. ITF accounts for half of all hip fractures due to osteoporosis during ageing. The annual incidence of 63 and 34 per 100,000 populations was found for elderly females and males, respectively <sup>(1)</sup>.

Intertrochanteric fracture treatment aims to restore function and decrease complications with early stable fixation. If ITF is not adequately treated, deterioration of quality of life (QoL) and increased morbidity and mortality may result <sup>(2)</sup>. Therefore, surgery is the mainstay of successful treatment using conventional devices such as sliding hip screws, cephalomedullary nails, gamma nails, blade plates, and rarely arthroplasty <sup>(3)</sup>. The proximal femoral nail (PFN), introduced first in 1996 by AO/ASIF, became a prevalent implant of choice, especially in unstable ITF, as it offers an additional antirotating screw to the primary lag screw <sup>(4)</sup>.

There are several classifications for ITF; each has a principle based on (planning management, fracture pattern, and prognosis). In this regard, Dr G.S. Kulkarni et al./Modified Jensen-Evans Classification was commonly used by orthopaedics in Iraqi Kurdistan due to its easy application and its adorable for research purposes <sup>(5)</sup>.

Intertrochanteric fracture is a brittleness fracture that occurs from greater to lesser trochanter. This extra-capsular fracture is more frequent than femoral neck fractures in elderly groups, especially in females. The fracture has a bimodal appearance, especially in the elderly, that occurs by low-energy simple falls due to osteoporosis, while in young patients, it occurs by high-energy trauma <sup>(6)</sup>.

Nonunion and malunion rates are low, with 20-30% mortality risk in the first year following a fracture. Factors that increase mortality are ITF, operative delay of >2 days, age >85 years,  $\geq 2$  pre-existing medical conditions, and higher ASA classification. On the other hand, surgery within 48 hours; decreases 1-year mortality, while early medical optimization and co-management with medical hospitalists or geriatricians can improve outcomes <sup>(7)</sup>.

Attention should be drawn to the number, size, shape, location, and degree of ITF displacement. Unstable

fractures, mainly designated by posteromedial comminution, are a significant risk factor in implant selection and failure. In which the fractures with multiple posteromedial comminutions displace in varus and retroversion, and it's unstable <sup>(8)</sup>.

Intertrochanteric fracture has a large surface area and rich vascular supply that makes the union rate very high; however, care should be taken to avoid varus malunion, which ends in limb shortening and limitation of movements. Non-operative treatment of the ITF is indicated for an elderly patient with an excessive risk of perioperative morbidity/mortality and non-ambulatory patients with minimal discomfort. The management includes skeletal traction for 8-12 weeks with intensive medical and nursing care to prevent pressure sore, urinary tract infection (UTI), venous thromboembolism (VTE), pneumonia, and pin tract infection (PTI) <sup>(9)</sup>.

It is logical to see a higher rate of complications related to implant types in ITF that might be local, systemic, and implant-related. Thus, this study was conducted to compare the position of the lag screw in stable ITF fixation between centre-centre and posteroinferior femoral neck lag screw placement. The comparison was in radiological assessment of implant failure and cut-out, functional outcome, and effect of body mass index (BMI) and osteoporosis on them. Also, to determine better techniques for screw placement, especially in the emergency department.

## PATIENTS AND METHODS

### Study design

The prospect/retrospective and comparative study enrolled 100 registered patients with femoral ITF who received single-type osteosynthesis in Sulaimaniyah Shar Teaching Hospital and other hospitals in Sulaimaniyah province, Iraq, from Jun 1 2020, to Jun 25 2021. However, only 76 patients remained due to failure to follow up and death. The admitted patients to the emergency department with ITF were classified randomly into two groups (50% chance of selection). Group A (44 patients) was managed by positioning the femoral neck lag screw in the centre-centre position. In comparison, group B (32 patients) was managed by positioning the femoral neck lag screw in a posteroinferior position.

### **Inclusion criteria**

Patients with recent fracture (not > one week), aged >55 years, single type osteosynthesis (PFN) with a lag screw and de-rotation screw, type 1A, 1B, 1C Kulkarni fractures, Cleveland index (CI) area 5, 8, and 9 were included in this study.

### **Exclusion criteria**

Patients with pathological fractures, coxa-vara/coxa-valga, reverse obliquity fractures, subtrochanteric extension, open fractures, polytrauma, infection, and non-ambulatory patients were excluded from the study.

### **Scores**

Modified Harris Hip Score (MHHS) <sup>(10)</sup> has been used preoperatively for functional status. In contrast, the Singh index (SI) <sup>(11)</sup> was used for bone quality assessment and Kulkarni classification/Modified Jensen-Evan's classification was used for the classification of the fractures.

### **Radiographic assessment**

Standard intraoperative fluoroscopy (AP and Lateral) was taken for each patient before and after the osteosynthesis implantation. Patients were followed at 3-, 6-, and 12-month intervals after surgery. Routine radiographs were arranged for each follow-up visit.

### **Parameters applied during radiographic assessment** <sup>(12)</sup>

**Tip-apex distance (TAD):** To determine the lag screw tip distance on AP and lateral view to the intersection area of the femoral head cortex and a tangential line bisecting the femoral head. The actual implant diameter was used to avoid image magnification.

**Calcar tip-apex distance (CalTAD):** To determine the distance between the lag screw tip and femoral head cortex in an area intersected by a line parallel to the medial femoral neck cortex on AP and lag screw tip distance to the femoral head apex on the lateral view.

**2.6.3. quality of reduction:** To measure the neck shaft angle (NSA) and compare it to the contralateral side. In this regard, good reduction means <5-degree varus-valgus angulation, accepted angulation means 5-10 degrees, and poor reduction means >10 degrees' angulation <sup>(13)</sup>.

**Cleveland index (CI):** It was used for the lag screw tip

position in the femoral head. Both AP and lateral were taken for determination.

**Femoral neck shortening:** To determine the femoral neck length (NL), defined as the distance from the cross point of the shaft axis and central axis of the femoral neck to the head centre measured along the central axis of the femoral neck <sup>(14)</sup>. The shortening distance was measured between the last visit and immediate postoperative X-rays, with correction done using true implant diameter.

**Fixation on failure:** It was defined as a lag screw cut-out or femoral head progressive varus collapse that necessitates revision.

### **Preoperative evaluation**

A primary survey was done for all the patients once they arrived emergency department. After history taking and examination, imaging was arranged. Once medical conditions were optimized, the orthopaedic teams operated on all patients within 48 hours of the fracture. The clinical assessments included general conditions, associated injuries, co-morbidities, and other related specialities in the emergency. Then, the patient's age, gender, BMI and its classifications, history of chronic diseases (such as diabetes mellitus, hypertension, ischemic heart disease), side of the fracture, fracture classification, and NSA in comparison to the contralateral side was recorded using a well-designed, self-created questionnaire and analyzed with counting the pre-fracture status, early and late postoperative functional status and outcomes. Additionally, complete blood count (CBC), virology, renal function tests (RFT), and random blood sugar (RBS) were performed. All patients' echocardiography (ECG) was taken, and if any patient needed medical stabilization, a call for internists was made, then seen by anesthesiologists. The Intensive Care Unit (ICU) was available if any patient's condition was critical. Pelvic X-rays and fractures of the hip AP were also taken for all of them.

### **Intra-operative technique**

The patients were supine on orthopaedic tables with the affected limb on the traction table, perineal post used. The fracture reduction was made in AP first, then in the lateral plane; then, nail diameter size was determined using a radiographic ruler. The C-arm was placed in AP view; proper nail size was determined. Next, a lateral incision of 3-5 cm long and 3-5 cm proximal

to the tip of the greater trochanter was done with an extension when needed. For obese patients, starting the incision more proximally was tricky for easier handling and nail insertion. After making the incision, gluteus maximus aponeurosis was incised, and the entry point was determined, which was a greater trochanter entry point on the lateral view. A long femoral shaft line on AP view is because the PFN nail has mediolateral bending of 6 degrees with slight anterior bowing. Most of the patient's entry point was made using medial and posterior as it aids in excellent nail position, reduces surgical complications, and enables early hip function recovery<sup>(15)</sup>. After finding the entry point, a guide wire or awl was used to enter the greater trochanter, and the position was checked on both the AP and lateral plane using C-arm. Sometimes, a honeycomb guidewire was used to save time and assist in the entry position.

After guide wire insertion, reaming over the guide wire was done using a 17 mm reamer over a sleeve to a lesser trochanter level, and the size of the nail was determined. The nail was inserted to a level that permits a centre-centre lag screw position and more distally to the shaft for the inferior-posterior lag screw position in the femoral neck. The handle device was attached to the nail handle; the incision site was marked by pressing the sleeve over the skin, and then an incision (2-3 cm) was made. The sleeve was advanced to the bone through skin and fascia; the nail was rotated 15 degrees posteriorly to allow the guidewire to parallel the neck inside the neck to facilitate centre-centre and posteroinferior guidewire position more easily. The sleeve was in contact with the lateral cortex of the femur; then the ball tip type guide wire was pulled out, threaded guide wire pin advanced until it reached 10 mm subchondral bone in the femoral head; the position was checked in both AP and lateral using the C-arm.

Later, the lag screw was measured, and then reaming of the lateral cortex was performed to 10 mm shorter than the measured length to enhance screw purchase. Then, the femoral neck screw is advanced manually using a screwdriver as far as possible to the femoral head using C-arm till the end. Next, the same steps were repeated for placing the de-rotational lag screw in the femoral neck. Finally, the PFN design with proximal compression (11 mm) screw and de-rotational (6.5 mm) screw that was self-tapping was done. Before repeating the steps of the femoral de-rotational screw, the table traction was released to allow compression of the 11 mm femoral neck screw. The two distal interlocking screws were placed in static or dynamic mode. When

the nail's proximal end was inside the bone, a zero or 5 mm, or 10 mm cup was used to lengthen the nail. After hemostasis, the fascia was repaired using absorbable suture materials, and then the skin and subcutaneous tissues were repaired in layers.

### **Postoperative protocol**

The patient's vital signs were checked postoperatively. All patients received intravenous (IV) antibiotics after surgery for three consecutive days with subcutaneous low molecular weight heparin (Clexane) for one month as VTE prophylaxis. They were discharged home on the first or second day of surgery, and the stitches were removed within approximately 12 days or two weeks. They were allowed to sit on the second day, with partial weight bearing using frames. They were followed up clinically and radiologically at 3-, 6-, and 12-month intervals. In addition, they were assessed for implant position (comparing NSA), complications, pain, walking, and functional status.

### **Statistical analysis**

The analysis was conducted using SPSS (version 28). Continuous variables were analyzed as the mean and standard deviation (SD), while the categorical variables were reported as frequency and percentage. All variables were coded, labelled in the software, and presented in descriptive and comparative forms. P-values were analyzed by calculating the categorical variables compared to a continuous variable using an independent t-test. One-way nova was used for categorical variables of >2 values compared to constant variables. The chi-square test was used for categorical vs categorical comparisons, while for continuous variable correlations, the Pearson p-value was used via bivariate correlation analysis. P values of <0.05 were considered significant.

## **RESULTS**

### **Patient's socio-demographic data**

The mean age of the studied patients was 71.75±8.4, with 72.93±9.26 for group A and 70.13±6.83 for group B. For the gender distribution, 33 patients (43.4%) were males, and 43 (56.6%) were females. Group A had 21 (63.6%) males, and 23 (53.5%) females, while group B had 12 (36.4%) males and 20 (46.5%) females (p=0.374). Regarding the body build of the patients, BMI was measured in kg/m<sup>2</sup>, and its mean was 23.717±3.36 with 23.4±2.915 for males and 23.960±3.6 for females. There was no significant association between gender and BMI

( $p=0.317$ ). Most patients ( $n=50$ , 65%.8) had normal BMI (18.5 - 24.9), followed by 19 (25%) overweight (BMI=25-29.9), while 4 (5.3%) were obese (BMI=30-34.7) and only 3 (3.9%) patients had BMI of <18.5.

### **Clinical assessment and scoring system**

During the mentioned follow-up period, the patients were examined for pain, walking, and gait using MHHS, a modification of HHS that assesses functional status depending on the pain and gait. It allows patient assessment even when there is no face-to-face contact; telephone contact allows nearly as accurate as face-to-face contact assessment. It is crucial to use this score as it saves us from failure to follow up, especially after the COVID-19 pandemic, and minimizes the risk of exposure for the patients and research team. The total scoring points were equal to 91, and we multiplied the results by factor 1.1 to get the target score out of 100. The score variable in SPSS was labelled as <70= poor; 70-80= fair; 80-90= good, and 90-100= excellent.

### **Radiological assessment**

All patients were assessed through AP and lateral fluoroscopy to verify the implant position and reduction quality by measuring TAD, CalTAD, and NSA on each follow-up. TAD and CalTAD were divided into groups for each centre-centre and posteroinferior position. TAD was <25 mm in group A, while CalTAD in group B recorded >25 mm with a trial to get a reading near 25 mm. In this study, the union rate skipped as nonunion was very rare.

### **Other parameters**

The patient's BMI was significantly correlated to NSA after one-year follow-up ( $p=0.012$ ) but less correlated to NSA after a 6-month follow-up ( $p=0.077$ ) and much less after a 3-month follow-up ( $p=0.355$ ) (Table 1).

There was a significant correlation between BMI and MHHS after 3 and 6 months and one-year follow-up. Most patients had a left-side fracture ( $n=44$ , 57.9%), and 32 (42.1%) had a right-side fracture. As the samples were from the elderly, most had at least one chronic disease ( $n=70$ , 92.1%) (Figure 1).

For the SI that was used for bone quality assessment, the highest record was for grade 3 ( $n=39$ , 51.32%), followed by grade 2 ( $n=34$ , 44.74%), then grade 4 ( $n=3$ , 3.95%), while other grades recorded zero percentages, (Figure 2).

Regarding Kulkarni's classification for fractures, we used only type I fracture, categorized into three stable fractures (A, B, and C). Type IB ( $n=35$ , 46.1%) recorded the highest, followed by type IA ( $n=23$ , 30.26%), then type IC ( $n=18$ , 23.7%). There was no significant association of the fracture type distribution among both patient groups of screw position ( $p=0.412$ ) (Figure 3).

TAD and CalTAD assessed the fixation quality. TAD mean of  $20.98\pm 3.82$  was achieved in group A and  $29.31\pm 2.14$  for group B, with a significant association between them ( $p<0.001$ ). The CalTAD's mean in group A was  $26.56\pm 2.47$ ; in the group B was  $25.56\pm 1.98$  without a significant correlation ( $p=0.02$ ) (Table 2). The tip position inside the femoral head affected the measurement greatly, so TAD and CalTAD were significantly different between groups with neck screw positions ( $p=0.001$ ).

CI was used for the optimal tip of the lag screw position inside the femoral head. For group, A neck screw position, the optimal tip of lag screw position [area 5 ( $n=35$ , 79.5%)] was achieved, followed by area 6 ( $n=7$ , 15.9%), and then area 4 position ( $n=2$ , 4.5%). For group B neck screw position, optimal tip lag screw position was achieved in area 9 ( $n=21$ , 65.6%), followed by area 8 ( $n=10$ , 31.3%), then area 6 position ( $n=1$ , 2.3%). CI was significantly associated with TAD and CalTAD ( $p=0.003$  and  $0.018$ , respectively). NSA assessed the reduction quality. In group A, the NSA means was  $131.61\pm 4.06$ , and in group, B was  $131.84\pm 4.45$  postoperatively without a significant difference ( $p=0.816$ ). Also, no significant differences among follow-up periods (3, 6, and 12 months) were found in both groups (Table 3).

In the postoperative period, the mean MHHS in group A was  $50.86\pm 10.39$ ; in group, B was  $55.50\pm 7.40$  ( $p=0.034$ ). After 3 months of follow-up, the mean in group B was  $72.44\pm 4.08$ , while for group A was  $67.18\pm 7.32$  ( $p<0.001$ ). After the 6-month follow-up, the mean in group A was  $74.20\pm 7.97$ , and in the group B was  $78.06\pm 6.66$  ( $p=0.029$ ). After one year of follow-up, the mean in group A was  $82.09\pm 8.01$ , and in the group B was  $87.13\pm 3.37$  ( $p=0.002$ ). MHHS was improved in group B in all follow-up periods significantly improved, (Table 4).

Postoperative ITF complications were either implant/non-implant related. This study excluded non-implant-related complications such as infection, and only implant-related complications were studied. In group

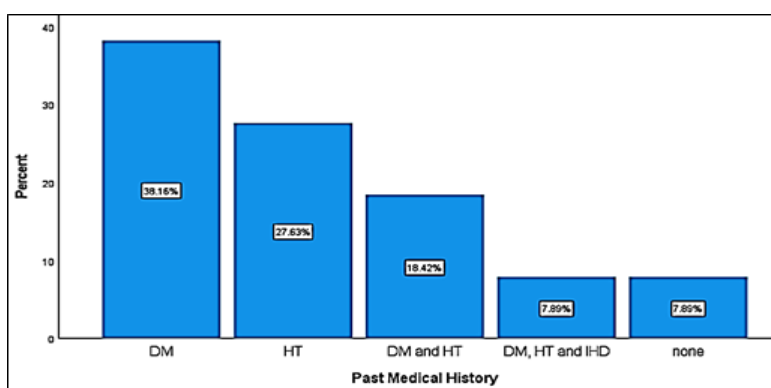
A, a femoral neck shortening (1.2 cm) only in one patient (2.3%) that developed into varus deformity at 12 months follow-up was found. Each group had one patient who suffered from screw cut-out at six months

follow-up. At the final follow-up, each group had one patient with a femoral neck shortening of 1.0 cm, (Figure 4).

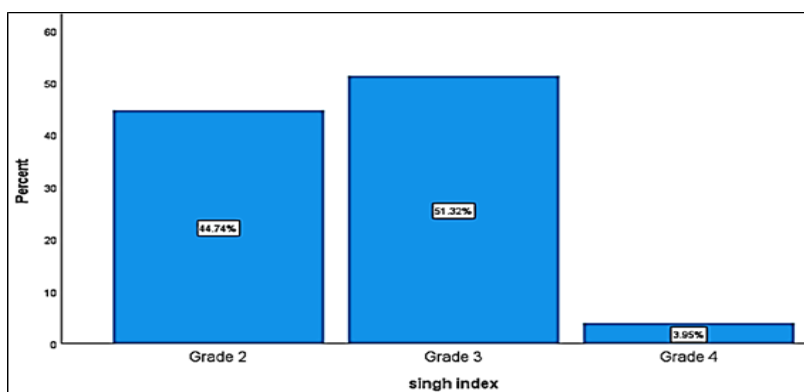
**Table 1. Correlation between BMI and NSA in studied patients.**

Variable	No.	Mean±SD	P-value
<b>BMI Score</b>	76	23.717± 3.36	
<b>NSA after three months</b>	76	130.64± 4.39	<b>p=0.355</b>
<b>NSA after six months</b>	76	129.541± 5.0	<b>p=0.077</b>
<b>NSA after 12 months</b>	74	28.84±5.33	<b>p=0.012*</b>

\*: Significant difference, BMI: body mass index, NSA: neck-shaft angle.



**Figure 1. Patient's past medical history. DM: diabetes mellitus, HT: hypertension, IHD: ischemic heart disease).**



**Figure 2. The SI correlation with grades among patients.**

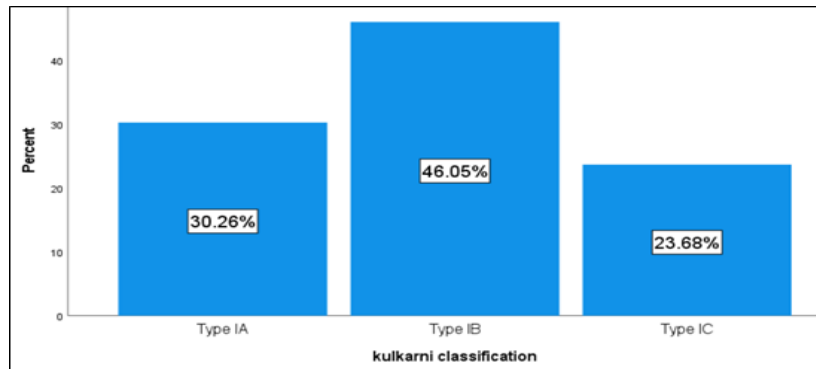


Figure 3. Records of Kulkarni classification for fractures among patients.

Table 2. Correlation between TAD and CalTAD among groups of studied patients.

Variable	Position	No.	Mean±SD	P-value
Tip Apex Distance	Center-center	44	20.98±3.82	p<0.001*
	Postero-inferior	32	29.31±.2.14	
Calcar Tip Apex Distance	Center-center	44	26.56±2.47	p=0.02*
	Postero-inferior	32	25.56±1.98	

\*Significant difference.

Table 3. The follow-up results of neck shaft angle between two groups after 3, 6, and 12 months.

Variable	Position	No.	Mean±SD
NSA after three months follow-up	Center-center	44	130.41±4.11
	Posteroinferior	32	130.97±4.79
NSA after six months follow-up	Center-center	44	129.23±4.62
	Postero-inferior	32	129.97±5.54
NSA after 12 months follow-up	Center-center	43	128.23±5.35
	Postero-inferior	31	129.68±5.26

NSA: neck shaft angle

Table 4. The follow-up results of MHHS between two groups after 3, 6, and 12 months.

Variable	Position	No.	Mean±SD	P-value
MHHS after three months follow-up	Center-center	44	67.18±7.32	P< 0.001*
	Postero-inferior	32	72.44±4.08	
MHHS after six months follow-up	Center-center	44	74.20±7.97	p=0.029*
	Postero-inferior	32	78.06±6.66	
MHHS after 12 months follow-up	Center-center	43	82.09±8.01	p=0.002*
	Postero-inferior	31	87.13±3.37	

\*Significant difference, MHHS: modified hip score

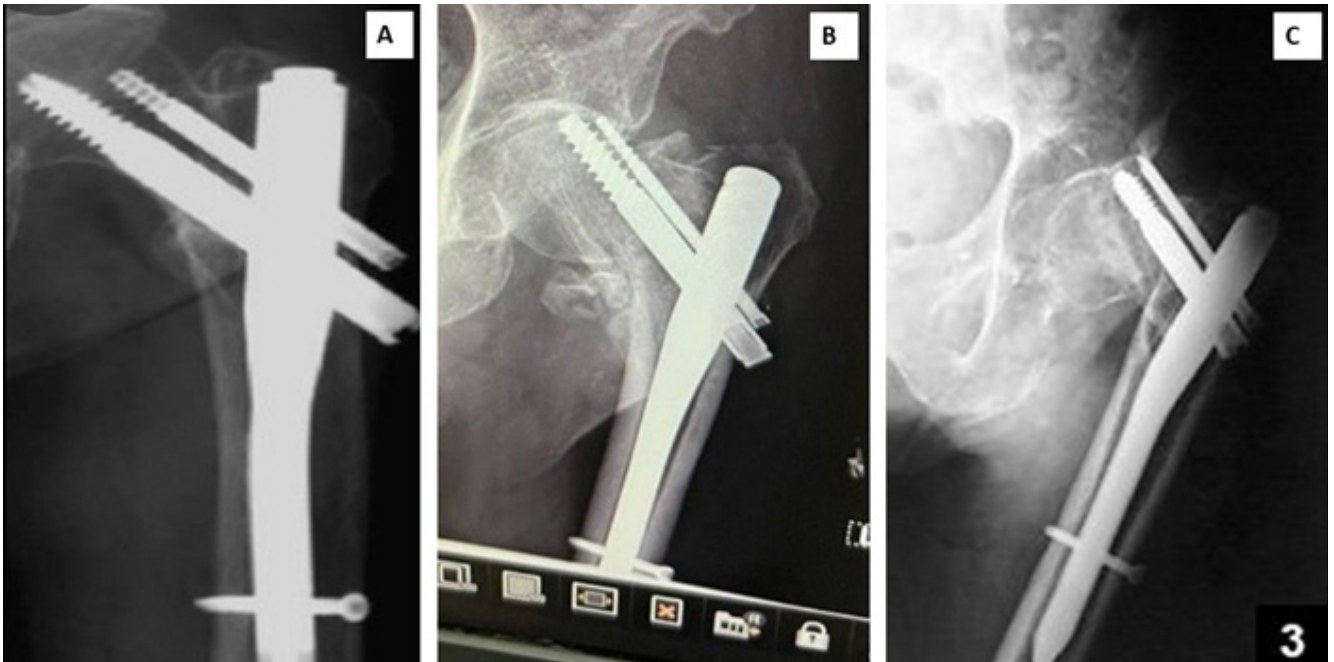


Figure 4. Femoral neck shortening (A) with varus collapse and screw cut-out (B) and (C).

## DISCUSSION

Even though ITF are among the most common fractures in older adults, their management carries many controversies. Early Fixation is a well-accepted standard of care worldwide to reduce mortality and morbidity, but there needs to be a consensus regarding which implant to choose. Many factors are associated with this, such as biomechanical features, stress distribution, fracture pattern, deformities, and bone quality, so stable rigid Fixation as early as possible is crucial in enhancing the quality of life <sup>(16)</sup>.

Proper implant selection is essential and yet is affected by bone quality. For this reason, an intramedullary device (PFN) was designed by AO\ASIF. PFN carries more stability with fewer complications, with ease of insertion, and biomechanically is better in axial telescoping, rotational stability, and buttress against medialization of the femoral shaft <sup>(17)</sup>. In this study, to minimize the bias and focus more on the title, which compares the position of femoral neck lag screw between centre-centre and posteroinferior groups and their effect on implant failure, only PFN with femoral neck lag screw (11 mm) and de-rotation screw (6.5 mm) were used.

In this study, the mean age of the patients was  $71.75 \pm 8.4$  years ( $p=0.152$ ), so the SI, NSA follow-up, and MHHS

between the two groups were not significant. These results were comparable to Kunderna et al., who had 72% of the patients >60 years with an average age of 68 years <sup>(18)</sup>. Regarding the genders of the patients, the females ( $n=43$ , 56.6%) were more than males ( $n=33$ , 43.4%), and this could be explained by senile postmenopausal osteoporosis which is comparable to Alpantaki et al. (62.3% of patients were females and 59.3% were males) <sup>(19)</sup>.

The patients' body builds affected the implants' operation results and durability. The patients' mean BMI was  $23.96 \pm 3.36$ , with significant differences between males and females and between the screw position groups ( $p=0.959$ ). About 5.3% of patients were obese, and a BMI of >25 was found to be significantly associated with complications and affected MHHS at all follow-up times. Also, it was found that BMI had a significant correlation with NSA in the final follow-up ( $p=0.004$ ). These results agreed with the outcomes of Santanu Bhattacharya et al.<sup>(20)</sup>. All our screw cut-outs related to BMI overweight and obese patients, but we could not find comparable results in the literature.

Regarding the SI, the frequency and percentage for grade 3 were highest, followed by grade 2, then grade 4. They were comparably distributed among the two groups ( $p=0.285$ ). The complications of screw cut out were among the obese patients despite having better

SI. However, in non-obese patients, SI significantly correlated to NSA at one-year follow-up, as a higher index resulted in better NSA ( $p=0.012$ ). Unfortunately, we could not find data correlation in the literature.

Concerning the fracture side, there was a higher frequency of left side fracture ( $n=44$ , 57.9%), and the reason behind this could not be found. This result was comparable to a study done by Chandak et al. on unstable ITF epsilon type 3, in which most fractures were on the left side (60%)<sup>(21)</sup>. Also, Yeh, Yu-Cheng & Liu's study on ITF compared the centre-centre to inferior-centre lag screw position; the left side fracture (56.8%) was higher than the right side<sup>(22)</sup>.

Regarding fracture type and classification, stable fracture types are preferred to minimize conflicts using the Kulkarni classification. Type IA was stable with non-displacement (30%), type IB (46%) was stable with minimal displacement, and type IC (23.7%) was stable with minimal displacement with a small fragment of the lesser trochanter. The centre-centre and posteroinferior groups were comparable to each other with regard to the classification ( $p=0.412$ ).

In group B's neck screw position (posteroinferior), the nature of the screw position inside the femoral neck was inferior and posterior. Thus, we preferred inferior and posterior tip position inside the femoral head (area 9 Cleveland) (65.6%), which makes the screw usually parallel to the neck inside the femoral neck, followed by area 8 (centre- inferior) (31.3%), and only one patient with area 6 faced no complication.

In this aspect, Liang et al. stated that the centre-centre area in the femoral neck was the area of crossing the principal compressive trabeculae and principal tensile trabeculae, any screw below that area significantly reduces screw tip cut-outs<sup>(23)</sup>. They also reported that principal compressive trabeculae start medially, posteriorly, and inferiorly going superiorly falls below compressive, tensile trabeculae.

Each area has a different TAD to fall into or below the centre-centre region. For the centre-centre region, TAD <25 mm is ideal; thus, we could have TAD <25 mm in group A with means of  $20.98\pm 3.82$ . On the other hand, CalTAD was unsuitable for group A because the bisector in AP was not centre but inferior and parallel to the medial femoral cortex, which increases the sum. The CalTAD mean was  $26.82\pm 2.14$ , so a CalTAD >25mm measure does not necessarily mean that the screw tip is above compressive tensile intersection.

Thus, in group B, most tip positions were in area 9 (postero-inferior) and area 8 (centre-inferior), according to CI. TAD measure was high because, in AP view, the screw was inferior and deviated from the central midline femoral bisector, which makes the reading more elevated than normal. In the lateral view, the bisector was in the midline. Also, the tip was in the midline for area 8; the sum was high because of the higher AP reading. The tip for area 9 (posteroinferior) was below the bisecting line in both AP and lateral. Hence, the reading was higher in both AP and lateral if TAD was used, so higher reading does not mean the tip of the screw is above the compressive tensile intersection. Keshor Putezhath et al. CalTAD is a better predictor of screw cut-outs in general<sup>(24)</sup>, and Gaetano Caruso et al. They also determined the most sensitive and specific cut-off values for TAD and CalTAD to be 34.8 mm and 35.2, respectively; they stated that the incidence of cut-out could be markedly reduced by avoiding any value above 34.8 for TAD and 35.2 for CalTAD<sup>(25)</sup>.

Regarding CalTAD in AP, the reading was ideal because the screw tip was inferior, and the intersection line was inferior and parallel to the femoral cortex. For the lateral view, the intersection line was central in the midline. Still, our screw tip was below that central line, so we had a higher lateral reading, and the sum for area 9 was higher, which was not necessarily mean that the tip was above the compressive tensile intersection. In this study, we compared centre-centre to infero-posterior, but we needed help finding literature comparing these two positions or finding a solution for CalTAD's higher reading. Thus, a new modification of CalTAD may be proposed that the intersection line needed to be in line with the femoral cortex in both AP and lateral not only in AP, but no single study supports this.

Regarding the NSA in the final follow-up, both groups had nearly identical results with no significant correlations. Also, the changes in the results from the postoperative day till the last follow-up were minimal and similar in both groups. The final NSA in group A was  $128.34\pm 5.358$  with an NSA loss of  $5.23\pm 2.247$  and was  $129.68\pm 262$  with an NSA loss of  $4.11\pm 1.536$  ( $p=0.816$ ) for group B. We could not find a comparable study to these outcomes.

A functional MHHS was added to support the study. The average MHHS between the follow-up periods was better in group B's posteroinferior screw position ( $p=0.002$ ). The mean for group A was  $82.09\pm 8.01$ , while for group B was  $87.13\pm 3.37$  at the final follow-up;

also same was applied for 3- and 6-month follow-ups. Unfortunately, we could not find a comparable study in the literature.

Regarding the complications, we found implant-related complications in 2 patients (one in each group). For group B, the cut-out occurred after six months of follow-up. The patient's postoperative NSA was 135, it became 127 at three months, and finally, it became 120 at six months. TAD and CalTAD were 29 and 25, respectively. CI was 8 (inferior-centre), correlated to BMI (30.3 kg/m<sup>2</sup>) with SI grade 2, so the patient was obese and osteoporotic. Progressive macular hypomelanosis (PMH) was only positive for patients with hypertension, and MHHP was good at three months.

Concerning the patient's screw cut-out in the centre-centre group, their BMI was 27 kg/m<sup>2</sup> with grade 2 SI; the screw tip was in area 4 CI (centre-anterior), she had diabetes, MHHS at 3 months was 55, was correlated with her preoperative MHHS (65). BMI and osteoporosis may have a role in this failure scenario, as her TAD and CalTAD were 26 and 32, respectively. These abnormal measures were included in failure-related causes as the tip position was not optimal. Another patient in group A had varus collapse at the final follow-up with a BMI of 34.7 kg/m<sup>2</sup>. She has DM and HT, with grade 2 SI, and her NSA was 130. TAD and CalTaD were 25 and 28, respectively, and the tip were in the centre-centre position (CI= 5).

After three months, NSA became 125 with MHHS 42; at six months, NSA was 125 with 1 cm femur neck shortening, her functional score was 46, and she refused re-operation. After one year, her NSA was 110 with a bad functional score, and she underwent arthroplasty. Because of our few rates of complications due to multiple exclusion criteria, and fewer patient numbers, we could not perform statistical analysis and compare it with other studies. Non-implant-related complications were excluded, which led to fewer complications, especially when unstable fractures were excluded.

This study's limitation includes its short duration (12 months); even though it is acceptable for follow-ups, it cannot predict the long-term function and implant durability. Because of the COVID-19 pandemic, we used MHHS instead of HHS. SI is subject to error and interobserver bias but is used instead of DEXA due to high cost, time consumption, unavailability in the emergency centre, and impractical in acute fracture

settings.

in conclusions, there was a better functional outcome in the posteroinferior neck screw position. In addition, a posteroinferior position had a comparable radiological effect to a centre-centre position. However, this study was conducted for the first time without recorded supporting data. Therefore, further prospective studies are needed to address more conclusive evidence regarding screw position or positions in different implant types of femoral ITF surgeries. Recommendations include enrolling larger populations (>100 patients), as ITF is one of the most familiar fracture types. Also, perform large multicenter randomized controlled trials to extend the follow-up time for long-term complication assessment. Moreover, use DEXA scan for bone quality assessment and more detailed HHS instead of MHHS for functional outcome assessment.

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