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CT Evaluation of Rotational Malalignment after Intertrochanteric Fracture Fixation

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ABSTRACT

Background: Intertrochanteric fractures account for 60% of all proximal fractures of femur and most of these fractures occur in patients over 65 years of age and mostly affect females. They are fixed mostly either by proximal femoral nails (PFN) or dynamic hip screw (DHS) post reduction under C- arm images.
Objective: To evaluation by CT the quality of reduction in the horizontal plane.
Patients and methods: Prospective study including 20 patients operated for intertrochanteric fracture femur between April 2019 and December 2019. Thirteen fractures were treated using DHS plate and screw fixation and 7 with PFN. All these patients underwent postoperative CT of the pelvis and knee on the same day of the operation during their hospitalization with measurement of anteversion of the operated and healthy necks of femur compared with a tangent posterior condyles of femur.
Results: There was malalignment greater than 15° on the operated side compared to the unoperated side at 30% of patients.
Conclusion: The rate of rotational malreductions of operated trochanteric fractures is very high; 30%, with a majority of external over rotation occurred during reduction maneuvers. The criteria normally used for reduction of trochanteric fractures are insufficient to prevent rotational malalignment. The increase in the number of C-arm images seems to be an advantageous to avoid these reduction errors during pre- and intraoperative maneuvers.
Keywords: CT, Intertrochanteric Fracture Fixation, Rotational Malalignment.

INTRODUCTION

The majority of intertrochanteric fractures in occurs in patients over 65 years old and are mostly affecting woman. They are associated with an increasing incidence due to population aging and associated bone fragility and osteoporosis. Trochanteric fractures represent 60 percent of all proximal femoral fractures [(1)].

Intra-medullary nailing and dynamic hip screw are the two most widely-used kinds of open reduction and internal fixations (ORIFs). Often DHS is performed by surgeons because to its frequency and reputation for ease [(2)]. In treatment of osteoporotic intertrochanteric fractures, dynamic hip screw (DHS) has been regarded the gold standard. Nailing has, however, become popular among surgeons, especially for certain types of unstable fractures with improved cephalomedullary nailing techniques [(3)].

The quality of postoperative reductions of these fractures is determined for the most part at the time of the pre- and intraoperative reduction maneuvers. Although the quality of reduction is simple to evaluate in the frontal plane and has been reported in the literature. The frontal images do not hold true for rotational malalignment. The objective of this prospective study was the CT evaluation of the quality of hip reduction in the horizontal plane [(4)]. After procedure, the same day of the operation, a CT was done with measurement of anteversion in neck of both femurs. Anteversion of neck femur average was measured using **Jeanmart *et al.*** technique to determine the angle between the tangent through the both posterior condyles of the femur and the axis of the neck of femur [(4)]. When the femur s inspected along its long axis from top to bottom, the angle created by a line anteriorly protruding from the femoral neck in comparison to the femoral shaft is known as femoral anteversion angle (FAVA). Assessment entails measurement of the femoral neck angle with modifications made for rotation of the femoral condyles [(5)].

The purpose of this research was to assess the rotational malalignment after trochanteric fractures reductions and osteosynthesis.

PATIENTS AND METHODS

A prospective study including 20 patients, 7 males and 13 females was conducted between April 2019 and December 2019 in the Orthopedic Department of Sohag University Hospital. Follow-up visits were scheduled at 1, 3, 6 and 12 months following the operation.

Exclusion criteria:

1. Poly traumatized patient.
2. Patient with bilateral trochanteric fracture.
3. Patient with subtrochanteric extension (type A3).
4. Patients with congenital anomalies.
5. Patients had surgery on the contralateral femur.
6. Patients with neoplasm.
7. Patients with osteomyelitis.

Preoperative assessment:

History taking, evaluation of the general condition, associated other injures, clinical examination of the fracture site, neurovascular assessment, the radiological

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examination by x-rays and preoperative routine lab were done. These fractures were classified using the AO classification.

Surgical technique:

All the patients were operated upon under spinal anesthesia in supine position on the orthopedic traction table with C-arm images. Preoperative reduction was traction and neutral rotation of the lower limb. After reduction, the image intensifier was used to check the anteroposterior and lateral views. The implants either DHS or a proximal femoral nail were placed under the image intensifier. The choice of osteosynthesis material of DHS or PFN was according the surgeon's preferences and experience.

Postoperative assessment:

Neurovascular assessment, postoperative treatment administrated (antibiotic, analgesic, anti-inflammatory and anticoagulant) and postoperative x-rays were done.

Rotational evaluation by CT postoperatively:

Rotation malalignment was determined by a method reported by **Jeanmart *et al.*** [6] who estimated the angle between the tangential line to the posterior contours of the femoral condyles and the line drawn through the femoral neck axis. The angle difference between the fractured and unoperated side determines rotational malalignment (Figure 1).

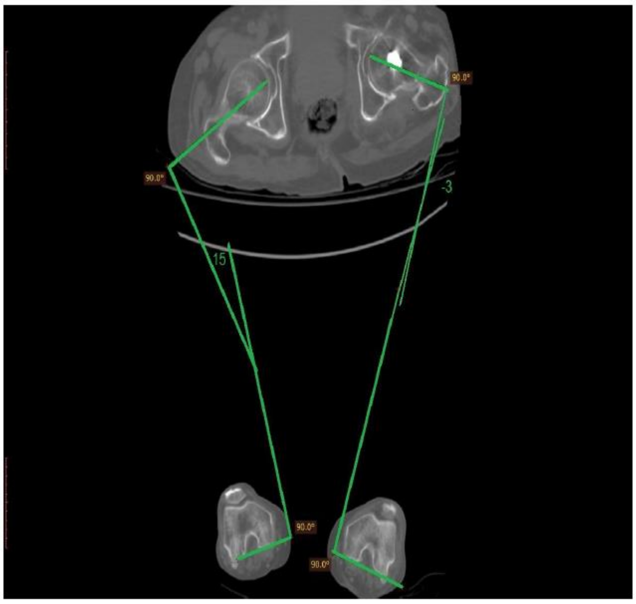


Fig. (1): CT measurement of healthy and operated side.

The D value, which corresponds to the difference between the anteversion of the operated side and the anteversion of the unoperated side, was determined for each patient. The absolute value of D corresponded to rotational malalignment. We defined three patient categories on the basis of this value:

Group A (No. =4): Patients with satisfactory reduction ($0° < D \leq 5°$)

Group B (No. =10): Included patients with insufficient reduction ($5° < D \leq 15°$)

Group C (No. =6): Clear malunion ($D > 15°$) occurred in the cases. The mean anteversion was calculated for the healthy and operated upon femurs.

The assessment criterion was if the malalignment on the operated side exceeded 15° or not compared to the healthy side after the operation. Patients with a torsion angle difference > 15° were regarded as having a true rotatory malalignment that might cause hip and knee discomfort and impede demanding activities such as climbing stairs, jogging and sports.

Functional evaluation:

After surgery in outpatient clinics follow up visits were arranged at 1, 3, 6 and 12 months. In relation to the Western Ontario and the McMaster University Osteoarthritis Index (WOMAC) knee score and the WOMAC hip score, patient groups with or without CT identified actual rotational malalignment were compared. The surveys indicated that knee discomfort when ascending stairs was the main concern for patients. Thus the patients were asked a closed question on whether knee discomfort during escalation was experienced (e.g. "Yes' or "No").

Ethical consent:

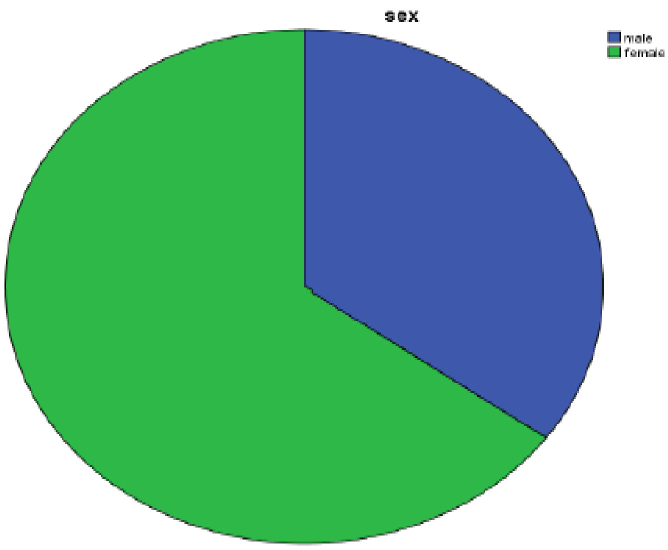
An approval of the study was obtained from Sohag University Academic and Ethical Committee. Every patient signed an informed written consent for acceptance of the operation. This work was carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

The collected data were coded, processed and analyzed using the SPSS (Statistical Package for the Social Sciences) version 22 for Windows® (IBM SPSS Inc, Chicago, IL, USA). Data were tested for normal distribution using the Shapiro Wilk test. Qualitative data were represented as frequencies and relative percentages. Chi square test (χ^2) was used to calculate difference between qualitative variables. Quantitative data were expressed as mean ± SD (Standard deviation). Independent samples t-test was used to compare between two independent groups of normally distributed variables (parametric data). P value < 0.05 was considered significant.

RESULTS

Most of patients in the present study were females. There was a female preponderance (Figure 2).



Green for Females and blue for Males

Figure (2): Gender distributions of the studied populations.

Distribution of method of treatment among studied population is shown in table 1.

Table (1): Distributions of method of treatment among studied population DHS or nail

Type of fixation	Summary statistics
DHS	**13 (65%)**
Nail	**7 (35%)**

The mean anteversion value of healthy and operated sides is shown in table 2.

Table (2): The mean anteversion value of healthy and operated sides

Variables	Summary statistics
Anteversion of healthy side	12° ±SD 7.15° (range 0°—23°)
Anteversion of operated side	9° ±SD 19.9° (range −37°—38°)

Table 3 shows Effect of the type of implant on the rotational malalignment.

Table (3): Effect of the type of implant on the rotational malalignment

Variables	Number of cases	Mean rotational malalignment	P value
Rotational malalignment with DHS fixation	13	Mean 14.52° ± SD 14.05° (range2°— 45°)	0.968
Rotational malalignment with intramedullary fixation	7	Mean 14.57° ± SD 13.35° (range 4°—36°)	

As regard the type of fracture, there was a significant difference in the mean of rotational malalignment as shown in table 4.

Table (4): Effect of the type of fracture on the rotational malalignment

Type of the fracture	Number of cases	Mean ±SD	P value
31A1	9	7.56±7.07	0.03
31A2	11	20.36±14.92	

Table 5 shows that majority of case had external malalignment.

Table (5): Distribution of over-rotation

Variables	Number of cases
Internal overrotation	8 (40%)
External overrotation	12 (60%)

Four of the patients were in group A whose reduction was satisfactory. Group B consisted of 10 patients with a mean (8° ± 2.1°) rotational malalignment (range 6°-11°). 6 patients were in group C with mean rotational malalignment of 32.8° ±9.94 ° (range 18° - 45°).

Table (6): Distributions of differentials D

Differential D	Number of cases	Percentage
Group A (0°<D≤5°)	4	20%
Group B (5° <D≤15°)	10	50%
Group C (D > 15°)	6	30%

In patients with rotational malalignment >15°, WOMAC knee and WOMAC hip scores were significantly reduced compared to those with rotational malalignment <15° (Table 7).

Table (7): Rotational malalignment versus function

	WOMAC knee	WOMAC hip
Rotational malalignment<15° (N=14)	93.85 ± 0.26	99.83 ± 0.45
Rotational malalignment>15° (N=6)	92.70 ± 0.70	98.59 ± 1.37
p value	<0.0001	0.006

Climbing staircases were tolerated considerably better than those with rotational malalignment in patients without rotational malalignment (Table 8).

Table (8): Climbing stairs tolerance (anterior knee pain)

	Anterior knee pain, can tolerate (%)	**Anterior knee pain, cannot tolerate (%)**	**P value**
Rotational malalignment<15°	13 (92.9%)	1 (7.1%)	0.005
Rotational malalignment>15°	2 (33.3%)	4 (66.6%)	

DISCUSSION

After reduction to the orthopedic surgery table under radiological supervision, trochanteric fractures were stabilized either by a PFN or by a plate and screw (DHS). The analysis of femur rotation malalignment is widely described. The clinical procedure, the most straightforward, compares the external rotation and the internal rotation between the two hip (operated and healthy). The literature also describes the radiographic ultrasonic measuring procedures. But, because of their complexity, they are no longer utilized [7].

Currently, the reference method used to the rotational malalignment measurement is CT. **Jeanmart *et al.*** have described that [6] the difference between the two measurements determines rotation malalignment. This is considered abnormal by **Jaarsma and Pavkis** [8] if it exceeds 15°. We utilized the criteria provided by **Jeanmart *et al.*** [6] in this analysis and also kept the threshold value of 15°. In their study, **Ramanoudjame *et al.*** [4] observed a postoperative torsional malalignment of up to 40% and no variation was seen in various osteosynthesis. This is 20% to 30% in the literature once femoral diaphysis has been nailed [8].

Winquist *et al.* [9] observed that external malrotation was more often following proximal shaft fractures repaired by unlocked nailing, possibly due to the proximal fragment pull by iliopsoas.

In our series, we observed 30 % rotational malalignment greater than 15°. 60 % of this cases with external malalignment, which was indicating inadequate reduction of the fracture. It appears required to improve the quality of the reduction. It is advised that the foot be placed on the internal rotation in order to center the patella after installing the patient on the orthopedic operating table [10].

We noted that there was no distinction between various osteosynthesis when we compared between different kinds of osteosynthesis on rotational malalignment.

Annappa *et al.* [11] showed that the p-value was statistically significant when comparing two-part fractures (31A1) with comminuted fractures (31A2 and 31A3). In our study, the type of fracture had significance role on the rotational malalignment. More unstable fractures have more risk of rotation malunion.

Following internal fixation of the intertrochanteric fractures femur; **Kim *et al.*** [12] have observed a 25.7 percent postoperative torsal deformity caused by unstable fractures and prolonged operating time. They suggested that the unstable fractures produced malalignment when reduced by the internal rotation of the distal fragment.

In the study, we discovered that in patients with rotational malalignment, WOMAC knee and WOMAC hip scores were substantially lower than in those without. Hip discomfort with poorer WOMAC hip scores was also present in patients with rotational malalignment. Rotational malunions impede activities, in particular those requiring tough activities such as escalation, running and athletics [13].

This problem needs to be adequately reduced intraoperatively and prevented. This challenge should be solved by methods that can correctly evaluate the anteversion intraoperatively. Clinical and radiological rotational alignment assessment techniques during surgery have been described. The rotation of the hip is compared with the rotation of the other side in the hip rotation test. In case of torsional deformity, the cortices of the proximal and distal fragments seem to be different in thickness, as 'diameter difference sign' [14].

The size of the lesser trochanter of the fractured side is compared to the normal side in 'lesser trochanter shape sign.' In the posterior anterior C-arm images can be utilized to assess rotation with the lesser trochanter visible intraoperatively. It shows in internal rotation a small area of the lesser trochanter and a bigger area on the external rotation of the proximal fragment of the femur [15].

This insight helps to achieve the neutral position of the proximal part of the fracture during operation. The reproduction of the profile of the lesser troch of the healthy femur enhances the good reduction. This may readily be done in fractures of the femoral shaft, but in many cases of the intertrochanteric fracture femur, a lesser trochanter fracture occurs, which hinders this method. This technique can be utilized in stable fractures, but in unstable fractures, such in subtrochanteric extension, four-part fractures, big posteromedial fragments, and reverse oblique-type fractures.

Tornetta *et al.* [10] used two C-arm images, first for dead lateral of the neck femur, and the second C-arm for the post-condyles alignment. The difference in the inclination of the C-arm position can determine the angle of anteversion. Postoperative only 5° (0 to 8) of malalignment was observed by CT test.

In the intertrochanteric fractures femur, the shaft of femur is sagged posteriorly in lateral view, this makes the method difficult. Addition, the anteversion of the normal femur is not measured by this approach.

CONCLUSION

The rotational malunity rate of surgical trochanteric fractures is high: 30%; most external overrotation occurs during maneuvers of reduction. The patient's mean rotational malalignment was 14.6°. The osteosynthesis material was not disassembled early.

The functional ramification of these reduction flaws were negligible. However, for a younger population this deformity would not have been necessary tolerable. In order to prevent rotational malalignment, the standard criteria employed for reducing intertrochanteric fractures are inadequate. The increase of fluoroscopic images (especially measuring the healthy femur anteversion) appears to be a beneficial way of preventing these reduction mistakes during pre- and intraoperative procedures.

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