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Original Research Article

Comparative study to measure femoral malrotation in inter-trochanteric femur fracture done by conventional and fluoroscopic method

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ABSTRACT

Background: Rotational malalignment following intramedullary nailing in intertrochanteric femur fractures is an under recognized complication. The incidence is varied from 17 to 35% as per literature. In this study we used intraoperative fluoroscopic method to assess anteversion angle, incidence of malalignment and to check whether intraoperative fluoroscopy is useful to reduce incidence of rotational malalignment or not.

Materials and Methods: Twenty patients of intertrochanteric femur fracture who presented to hospital between 1st October 2019 to 30th September 2020 were divided in two groups of 10 patients each. Group 1 was operated with intraoperative fluoroscopic method and group 2 operated by conventional method of intramedullary nailing. Alignment measured as angle of anteversion by post-operative CT scan and comparison between two groups was done.

Results: The incidence of rotational malalignment was 15%. Three patients had significant difference of 15° in anteversion angle compared to opposite normal femur. All these three malalignments were seen in the fluoroscopic group 1 and had unstable fracture patterns.

Discussion: Unstable fracture patterns are at increased risk of rotational malalignment. In intra operative fluoroscopic method distal femur posterior condylar axis is taken in to consideration. Most of the elderly people have some degree of fixed flexion deformity of the knee due to arthritic changes. This requires more internal rotation to achieve straight posterior condylar axis. This may be the reason for internal rotation malalignment in the fluoroscopic method.

1. Introduction

Intertrochanteric femur fractures are commonly treated by orthopedic surgeons in their daily practice. Their numbers are increasing due to increase in the elderly population. The main goal of management is early safe and secure fracture fixation to enable early mobilization and eventually return to better quality of life.[1] The method of fixation that is currently evolving is the cephalomedullary nail system with percutaneous approach. This technique has its advantages; lesser operating time, less blood loss, improved anatomical alignment, early load bearing even in the unstable fracture pattern and fewer days in hospital.[2,3] The outcome of surgical fixation is more determined by surgical tactics and quality of intraoperative reduction than implant designs. Assessment of quality of reduction is easy in frontal and sagittal plane but challenging to assess rotational alignment in horizontal plane due to limitation of intra operative fluoroscopy. Possible complications during intramedullary nailing are; iatrogenic fracture of lateral wall, implant

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breakage, screw cut in or screw cut out and rotational malalignment. Rotational malalignment is one of the most underrecognized complication of intramedullary nailing and also the most challenging to detect radiographically and clinically. It is often missed or neglected.[4] Incidence of rotational malalignment vary from 17 to 35%.[5] Rotational malalignment or torsional deformity of the femur is defined as a difference of femoral anteversion between the injured and uninjured leg. Rotational malalignment can be measured by physical examination, radiography and CT scan. Measurements of anteversion angle by CT are considered gold standard.[6,7] Many studies are available for diaphyseal femur fractures regarding incidence of rotational malalignment and intra operative techniques to reduce the same but less literature available for intertrochanteric femur fractures. Stable fractures are generally reduced well with closed means under image/C-arm control. Comminution increases instability and reduces fracture apposition surfaces, which warrants additional means of reduction and maintenance of fracture reduction. These fractures occur due to uncontrolled external rotation. Anterior cortex breaks first in tension and followed by posterior cortex in compression causing its comminution. During open reduction assisted with fluoroscopy palpatory method for anterior cortical reduction is used to assess adequacy of reduction. Anterior cortical reduction methods in isolation can misguide the overall 360-degree reduction of intertrochanteric fractures. This assessment method is further compromised as comminution increases. In literature the problem of femoral torsion (rotational malalignment) pertaining to unstable femur diaphyseal fractures has been studied but there is no literature available, to our knowledge which guides to reduce intra operative malrotation in intertrochanteric femur fractures.

2. Materials and Methods

Study was carried out in the department of Orthopaedics at Indian Spinal Injuries Centre, Vasant Kunj, New Delhi from 01^{st} October 2019 to 30^{th} September 2020. The study was approved by the Research Review Committee and Institutional Ethical Committee. Inclusion criteria were age more than 50 years, unilateral intertrochanteric femur fracture, operated by closed or open reduction with intramedullary nailing. Exclusion criteria were bilateral femur fracture, previous lower limb surgery, congenital/developmental disorder of lower limb, open fracture, and contraindication to CT scan or absence of consent. The AO/ASIF classification was used for the fracture classification. 31A1 was classified as a stable fracture, and 31A2 and 3 as unstable fractures. Informed written consent was taken from the patient for post-operative CT scan. Patients' allocation in Group 1 (Fluoroscopic group) and Group 2 (Conventional group) was done by lottery method. All the surgical procedures were done in supine position on traction table. Reduction of fracture achieved by closed or mini open technique depending on fracture pattern. Intramedullary nail inserted after achieving reduction following conventional steps.

Assessment of anteversion in group 1: After inserting appropriate size nail with help of proximal zig, move C arm distally to view lateral image of ipsilateral knee to assess distal femur fragment rotation (Figure 1 a). C arm placed with beam parallel to the ground and perpendicular to femoral condyles. Rotation of femur was adjusted until both condyles showed perfect overlapping. This was interpreted as neutral position of distal femur in 0-degree rotation (Figure 1 b). This angle taken as angle of true lateral view of knee. After this C arm was moved to proximal femur in same position. The beam focused on greater trochanter (GT) to create image, including the proximal femur shaft with femoral neck and head. To determine adifference between true lateral and anteversion of proximal femur, the C arm inclined in steps of one degree until a clear lateral view of the femoral head-neck junction was projected (Figure 1 c). This angle at which true lateral view of proximal femur achieved noted down (Figure 1 d). Angle of anteversion is difference between true lateral view of proximal femur and true lateral view of knee (Figure 1 f). Fracture reduction in true lateral view again adjusted to reduce supplement reduction. This step further helps to correct anteversion angle and reduce rotation mismatch (as implied by Tornetta et al).[8]

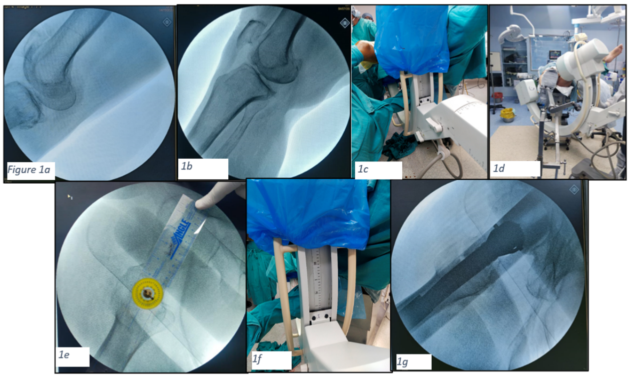

Figure 1: Lateral view of knee joint- both condyles are not overlapped, **b)**: True lateral view of knee joint; both condyles are overlapping each other, **c)**: After moving C arm to proximal femur C arm inclined step by step to achieve true lateral view of proximal femur, **d)**: C arm inclination of true lateral view on proximal femur, 1e: Our technique to assess true lateral view of proximal femur, **f)**: Angle at which we achieved true lateral image of proximal femur- 65° in this case- so, the angle of AV is 90-65=25°, **g)**: True lateral C arm view of proximal femur

Once reduction was reconfirmed in both AP and true Lateral views, lag screw placed in center-center of femur neck and head. Distal locking screw inserted under c arm guidance free-hand in dynamic screw hole.

Group 2 was operated by conventional method of proximal femur nailing. In this group reduction and its fixation are done on the merits of fracture. No further correction done as distal fragment (distal femur) was not taken in to account. Here after insertion of intra medullary nail, proximal femur screw was inserted in center of femur neck and head in both AP and Lateral views. True lateral view angle was noted by using lateral view of proximal femur under C arm. Distal locking done as usual method.

CT guided Anteversion of the femoral neck was measured using the method described by Jeanmart et al.,[9] determining for each femur the angle between the tangent passing through the line of the posterior condyles and the neck axis. For each patient the difference between anteversion of operated side and healthy side calculated which denoted as X angle. When value of X was negative, there was excess internal rotation of the distal fragment during reduction. The fixation was in external rotation if X was positive. Absolute value of X indicateds rotational malalignment. Based on this value, we defined three grades of patients: grade 1, when value of X was ≤ 5°; grade 2 when the value of X was 5° to ≤ 15°; grade 3, when angle of X was more than 15°. This was the standard used by Ramanoudjame et al.[10]

In Table 1 first 10 are patients of group 1 (cases which were operated by fluoroscopic method) and 11 to 20 are group 2 (controls) which were operated by conventional technique. Descriptive statistics were presented in mean±standard deviation (SD) for continuous variables and count with percentage for Categorical variables. T test of two independent samples and Fisher Exact test were used. The P-value less than 0.05 was considered as statistically significant. IBM SPSS 25.0 software was used for data analysis.

3. Results

20 patients with intertrochanteric femur fractures. Mean age was 77.35(SD 8.99) years, range 63-90 years. Group 1 (10 patients) operated as fluoroscopic method; Group 2 (10 patients) operated as conventional method. Mean age of group 1 is 75.5(SD 10.3) years, range 63-90 years. Mean age of group 2 was 79.2(SD 7.6) years, range 68-90 years. Mean anterversion (AV) of the opposite hip by post-operative CT scan technique is 13.5(7.88 SD) degrees with range 2.9-30.6 degrees. Mean anteversion of affected side was 16.77(8.18 SD) degrees with range 1-30.5 degrees.

In group 1 Fluoroscopic group mean AV of normal side was 14.1 degrees and affected side was 19.4 degrees. Three patients had external rotation deformity: one was grade 1 and two had grade 2 malalignment. Seven patients had internal rotation deformity of which one was grade 1, three grade 2 and three grade 3 malalignment. The three grade 3 angles were 18.2°, 17.3°, 16.9°. All three significant rotational malalignment were towards internal rotation. In group 2 (Conventional) mean AV of normal side was 12.9 degrees and affected side was 14.1 degrees. Four patients had external rotation deformity of which three grade 2, one grade malalignment. Six patients had internal rotation of which two grade 1, four grade 2 malalignment and no patient in grade (significant rotational malalignment) category. All grade 3 malalignment was found in the unstable fracture pattern which is towards internal rotation.

Mean C arm exposure in group 1 was 79.1 (SD 15.68) and for group 2 it was 71.1 (SD 8.72) milli Gray. This difference is non significant (P value 0.262). Time to surgery was measured in minutes starting from shifting of patient to traction table till starting of closure which is taken as end point. Average time of surgery for group 1 was 84.5 minutes (range 70-120), for group 2 was 74 minutes (range 60-100). The difference in time of surgery between two groups is non-significant (P value = 0.696).

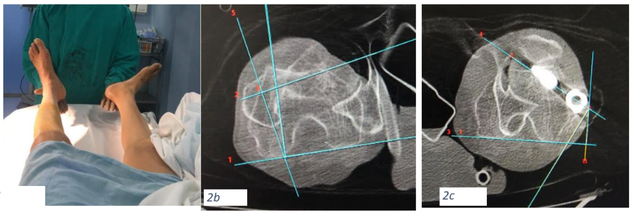

Figure 2: Group 1 Case 10- Operated left femur – **a)**: Right lower limb externally rotated, left lower limb in comparatively neutral position on Heel on palm test; **b)**: CT measured anteversion is 11.1° on normal side (right); **c)**: measured anteversion is 28° on operated side (left); 16.7 degree of Rotational malalignment towards Internal rotation

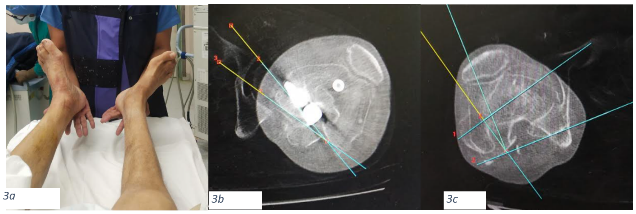

Figure 3: Group 2 case 7; **a)**: both lower limb in external rotation (Operated left limb lesser than normal side lower limb); **b)**: CT measured anteversion is 14.1° on operated side (left); **c)**: 13.4° on normal side (right), there so Rotational malalignment less than 1°

4. Discussion

Rotational malalignment is an underrecognized complication of intra medullary nailing. According to literature the incidence ranges from 17% to 35%. This suggests that every third nailing may be in malrotation.[5] CT scan guided assessment has the best accuracy to detect this abnormality.[7,11] The CT scan guided technique was described by Jeanmart et al. They measured the angle

Table 1: Demographic details

S. No.	Name	Age	Sex	Fracture type	Side	Duration	AVF	AVN	Difference of Angle of AV (X)
1.	IJ	63	F	Stable	L	80	30.5	12.3	**-18.2**
2.	NK	82	F	Unstable	R	100	1	3	2
3.	SD	90	F	Unstable	R	70	28.6	19.4	-9.2
4.	KP	88	F	Unstable	L	80	19.3	30.6	11.3
5.	KD	67	F	Stable	R	70	9.2	21.7	12.5
6.	BTD	84	F	Unstable	R	80	28	18	-10
7.	BFD	75	F	Stable	R	95	20.2	13.1	-7.1
8.	SV	77	F	Unstable	R	80	21.3	4	**-17.3**
9.	JG	64	M	Unstable	L	120	8.2	7.8	-0.4
10.	PK	65	F	Unstable	L	70	28	11.1	**-16.9**
11.	KC	83	M	Stable	L	60	19.8	11.4	-8.4
12.	SK	72	M	Unstable	L	70	13.9	17.9	4
13.	SUD	83	F	Stable	R	60	19.9	24.3	4.6
14.	SB	85	F	Stable	L	90	14.7	7.3	-7.4
15.	SM	90	F	Unstable	R	60	17.9	9.7	-8.2
16.	US	69	F	Unstable	R	70	4.9	2.9	-2
17.	RL	83	M	Unstable	L	100	14.1	13.4	-0.7
18.	KAM	68	M	Unstable	L	80	13.5	5.3	-8.2
19.	BD	75	F	Unstable	L	80	7.9	20.8	12.9
20.	ND	84	F	Stable	L	70	14.6	15.8	1.2

Table 2: Degree of rotational malalignment vs fracture pattern

Deformity (Malrotation)	Group 1 (n=10)		Group 2 (n=10)	
	Stable (n=2)	Unstable (n=8)	Stable (n=4)	Unstable (n=6)
Grade 1	0	2	2	3
Grade 2	2	3	2	3
Grade 3	0	3	0	0

between the axis of femoral neck and posterior femoral condylar line.[9] Difference between both lower limbs was considered as rotational malalignment. This technique is considered the gold standard for measurement of rotational malalignment.[7] Bråten et al defined rotational difference between 10° to 14° as "possible torsional deformities" and more than 15° as "true rotational deformity".[11] Jaarsma and Pavkis concluded that the value is clinically significant if difference exceeds more than 15 degrees.[7] In this study we used the same technique to measure rotation of the lower limbs and we considered more than 15 degrees of difference as significant rotational malalignment.

Overall incidence of significant rotational malalignment (Grade 3 >150) in this study was 15% (i.e., 3 out of 20 patients). All three patients were from group 1 (Fluoroscopic group). In all these patients' malalignment was towards internal rotation. There was no grade 3 rotational malalignment in patients of group 2. This difference was significant with p value of 0.034.

Most of the elderly patients have degenerative arthritis changes of the knee joint along with fixed flexion deformity. In group 1 during the assessment of anteversion angle intra operatively, we took the posterior condylar line of distal femur condyles in to consideration. This necessitates more internal rotation of distal femur fragment sometimes to achieve true lateral view of knee joint. This might be the reason for higher internal rotation deformity in group 1. Ramanoudjame M et al. in their study reported a 40% incidence of grade rotational malalignment more towards internal rotation.[10] Kim TY et al reported 25.7% incidence of rotational malalignment following intramedullary nailing for intertrochanteric femur fractures and concluded unstable fracture pattern as the major risk factor.[12] Annappa R et al. reported 24.3% incidence following intramedullary fixation of intertrochanteric femur fractures.[6] In this study the overall incidence of significant malrotation was lower compared to available literature but our sample size is smaller compared to other studies.

The Uunstable fracture pattern is more common in the elderly. than stable fractures in intertrochanteric femur region. In this study 6 had stable and 14 patients had unstable fracture patterns. All three patients who has grade 3 rotational malalignment were having an unstable fracture pattern. This difference is significant (P value <0.05). In elderly patients fractures occurs due to uncontrolled external rotation. The anterior cortex breaks first in tension and followed by posterior cortex in compression. The compressive forces causing its are most probably responsible for comminution of the posterior cortex. In stable fracture pattern due to pull of short external rotators and gluteus medius there is a gap anteriorly at fracture site but the posterior cortex is remains intact. Before surgery the fracture gap can be reduced by internal rotation of distal fragment and because the posterior cortex it acts as a hinge. This prevents an excess of internal rotation of the distal femur fragment. There is posteromedial comminution in unstable fractures and the restraining hinge against internal rotation is lost. This permits uncontrolled internal rotation of distal fragment. While palpating reduction by fingertip in mini open technique we can only check anterior cortical matching. Only palpating the anterior cortical reduction cannot reliably guide 3D reduction of the unstable fracture. This assessment is further limited as comminution increases. So, we possibly perform more internal rotation of distal femur fragment in view to achieve anterior cortical reduction. This could be a reason for more rotational malalignment in unstable fractures and that as well towards internal rotation. Kim TY et al. found similar results with more rotational malalignment in unstable fractures.[12] Ramanoudjame et al., Kim TY et al. and Annappa R et al. also found similar results. Internal rotation deformity is far more common than the intuitive expectation of external rotation.

In the present study we also assessed rotation of lower limb by 'heel on palm' test. Normally lower limb falls in to slight external rotation while performing this test. According to literature clinical examination has very low sensitivity and specificity to assess rotational malalignment and alone it cannot quantify the malrotation. Assessment of rotation by heel on palm test in this study cannot quantify degree of rotational malalignment but one can get an idea of gross rotational deformity and can take remedial action to correct the deformity.[7] Assessment of rotation by heel on palm test in this study cannot quantify degree of rotational malalignment but one can get an idea of gross rotational deformity and can take remedial action to correct the deformity.

In this study we measured angle of anteversion by post-operative CT scan technique and found mean anteversion angle of 15.13° with range of 1° to 30.6°. When we exclude the fractured side and take only normal side femur in to consideration, mean anteversion angle is 13.5° with range 2.9°-30.6°. According to literature there is high variation in physiological angle of anteversion. Hoaglund and Low reported a range of AV from -4 to +36 degrees.[13] Decker et al reported physiological variation in AV from -5° to 45° and 86% of patients had anteversion within a 0° to 30° range.[14] Based on this result, we presume that it is unreasonable to fix all intertrochanteric femur fractures with lag screw in 15° of anteversion. Further the center-center fixation of the lag device is ideal but may not always be achievable. This study includes a smaller number of patients and there is requirement of larger study to give better future direction. To the best of our knowledge this is the only study in literature where intra operative fluoroscopy method was used to correct the anteversion angle in intertrochanteric femur fracture. Overenthusiastic internal rotation should be avoided in unstable fracture patterns. Fluoroscopic method did not benefit inminimizing the rotational malalignment. Internal rotation done during the reduction maneuver while setting up the patient on the fracture table is possibly the main offender. This study cautions against over doing internal rotation in unstable fracture patterns.

5. Conclusions

There is high variation in physiological angle of anteversion. In this study the range was from 2.9° to 30.6° with mean value of 13.5°. Rotational malalignment is a largely hidden complication of intramedullary nailing of intertrochanteric femur fracture. The incidence was 15% in our study. Fluoroscopic method is an intra-operative method but has shown no value addition in reducing the incidence of rotational malalignment. Clinical assessment with heel on palm test post-operatively gives an idea about gross rotational malalignment. Unstable fracture patterns are more prone to rotational malalignment compared to stable fractures. Placement of the limb on the fracture table must avoid excessive internal rotation.

The major limitation of our study is the small sample size, Presence of osteophytes along the posterior aspect of distal femur condyles confound exact measurement of the posterior condylar axis. We did not assess the eventual clinical outcomes of the patients.

6. Source of Funding

None.

7. Conflict of Interest

None.

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