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ORIGINAL ARTICLE**Role of Tip Apex Distance Accuracy in Reducing the Incidence of Lag Screw Cut-Out in the Treatment of Proximal Femur Fractures**Ibrahim Mohamed Attia Hammad¹, Ahmed Hashem Amin², Mohamed Abdel Fattah Sebaei², Osam Mohamed Metwally²

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**ABSTRACT:**

Background: Due to the population's longevity and high life expectancy, the frequency of proximal femoral fractures doubles with age. As a result, managing such fractures places a financial and logistical burden on the social and health care systems. This study aims for using Tip Apex Distance (TAD) as a tool for decreasing the incidence of lag screw cut-out in managing proximal femur fractures using cephalo-medullary nailing and dynamic hip screws.

Subject & Methods: This interventional clinical trial included 18 patients 18 with proximal femur fractures managed either by cephalo-medullary nailing or dynamic hip in the Orthopedic department, at Zagazig University Hospitals. Clinical as well as radiological assessments were applied pre- and post-operative.

Results: Gamma nails were used among 10 cases (55.6%) and Dynamic hip screw (DHS) was used among 8 cases (44.4%) of the studied group. Most of the cases (72.2%) didn't have any complications, three cases (16.7%) had cut out and two cases (11.1%) had superficial infections. The mean operative Tip Apex Distance among cases was (19.1± 3.13) ranging from (13.6 to 26.7) mm. Two-thirds of cases (66.6%) had excellent quality reduction, three cases (16.7%) had good quality and three cases (16.7%) had poor quality. TAD increased significantly at 6 months postoperative among patients with poor than good than excellent reduction quality. TAD increased significantly at 6 months postoperative among patients with cut-outs than without cut-outs.

Conclusion: Tip apex distance accuracy plays a crucial function in reducing the incidence of lag screw cut-out in managing proximal femur fractures.

Key Words: Tip apex distance, lag screw cut-out, proximal femur fractures.

INTRODUCTION

With advancing age, the prevalence of proximal femoral fractures duplicates as a result of the longevity and high life expectancy of the population. This leads to the occurrence of financial as well as logistic burdens on the social and healthcare systems in managing such fractures [1].

The incidence in the young-aged population suffering from proximal femur fractures is getting higher and it is believed that it is due to 2 major

causes. Either high-velocity traumas or predisposing pathological bone conditions associated with minimal trauma (e.g., simple fall, movement) [2].

Due to the instability of proximal femur fractures, surgical treatment is the mainstay in their management. The techniques can be widely divided into intramedullary nailing (e.g., gamma nail) or extramedullary nailing (e.g., dynamic hip screw) [3]. With the increasing number of patients and implants, the number of complications will subsequently grow.

One of these is lag screw extrusion, often known as a "cut-out," which occurs when the neck-shaft angle collapses towards the varus. So prophylactic measures must be undertaken to decrease the number of such complications and here comes the role of tip apex distance [4].

The measurement of the lag screw in relation to the femur neck and head is considered the way of assessment of TAD. Its measurement should not exceed 25 mm and it is measured by adding the distance of the lag screw tip in relation to the apex of the head of the femur on both the lateral and anteroposterior (AP) x-ray views. Better results are reached when the lag screw is in a midline axis in relation to the head and neck of the femur in the lateral view, while being slightly lower on the AP view in relation to the central axis [5,6].

Conditions that may influence the stability of the lag screw will be assessed and discussed with special consideration towards TAD as a prophylactic measure in decreasing lag screw cut-out risk by minimizing peripheral screw insertion and achieving an ideal cut-off measurement of less than 25mm on both lateral and AP X-ray views combined. Given the encouraging results of that study [7].

The aim of the work was to use tip apex distance as a tool for decreasing the incidence of lag screw cut-out in managing proximal femur fractures using cephalo-medullary nailing and dynamic hip screws.

SUBJECTS AND METHODS

This interventional clinical trial including 18 with proximal femur fractures treated with cephalo-medullary nailing or dynamic hip screw was conducted in the Orthopedic Department, Faculty of Medicine, Zagazig University. Clinical as well as radiological assessments were applied pre- and post-operative. The ethics of the current research as put by the Institutional Research Board (IRB) were followed up thoroughly with IRB number (#1011/19-10-2022) The Declaration of Helsinki, issued by the World Medical Association to ensure the protection of people participating in medical research, was strictly followed during this study.

Inclusion Criteria

Cases with proximal femur fracture happening among adults (after physeal closure).

Exclusion Criteria

Cases with the following: open fractures (Gustilo type III), infection, pediatric age (before physeal closure) as well as patients who were unfit for anesthesia were excluded from the study.

All subjects underwent the following:

Clinical evaluation

Full history including Patient complaint, present, past, and family history. Clinical examination including General and local examination with examination of the pelvis, knee, spine, as well as calcaneus is very crucial for associated injury. A plain X-ray was done in anteroposterior and lateral views.

Laboratory investigations included: complete blood count, coagulation profile, Hb A1C, urine analysis, liver and Kidney function tests, and Hepatitis C, and B virus antibodies.

Third-generation cephalosporin 1000 mg was administered to all patients as a single prophylactic dose 30 minutes before incision, every 12 hours, and for three days following surgery.

Anesthetic technique :

Either spinal anesthesia general anesthesia, and endotracheal intubation are done depending on the patient's condition. The intraoperative bleeding was reduced using monitored hypotensive anesthesia, and a Foley catheter was inserted before the skin incision to prevent bladder distension.

Surgical Technique :

All patients were placed on a traction table in the supine position. Traction, mild abduction, and internal rotation were used for closed reduction while the uninjured limb was flexed and externally rotated under image intensification supervision (c arm). When there was adequate bone buttressing in the medial and anterior cortices, the reduction was successful. Open reduction was done when close reduction failed. Traction was used along the length of the limb to help minimize the fracture. When sterilizing and draping, we made sure the greater trochanter and the area 5–6 cm proximal to it were exposed.

Fixation was carried out by Dynamic hip screw or Cephalomedullary nailing (gamma nail). We used lag screws with lengths ranging from 80 to 105 mm. Plates with four to six holes or lag screws with a nail and distal locking screws were used.

In the use of a gamma nail, an incision is made 3 centimeters proximal to the apex of the trochanter after the larger trochanter has been located by palpation. Next, the fascia lata is cut further, and the abductor muscles are split open about 3 cm above the greater trochanter so that the bone can be exposed with a finger. The trochanteric apex was located, and an appropriate incision site was selected. This was followed by inserting the owl at the tip of the greater trochanter to make an opening for the guide wire. After the guide wire was inserted, reaming followed at a typical rate of 3 ascending grades. Later, the

exchange of the guide wire was done with the insertion of the gamma nail.

After the gamma nail and lag screw have been inserted, an AP and lateral image intensifier view is taken to confirm the insertion site. Once the insertion was satisfactory on both views, distal locking screws were inserted and a set screw was applied over the head of the gamma nail.

In the setting of DHS, a similar positioning of the patient takes place. The incision was extended around 4 cm below the greater trochanter tip to allow visualization of the shaft of the femur, lag screw insertion, and plate insertion. Another anti-rotation screw might apply at a level that was more proximal to the lag screw.

According to Baumgartner and Solberg [8], Postoperative AP and lateral radiographs were analyzed to determine the degree of displacement and neck-shaft alignment to categorize the level of reduction as good, acceptable, or poor. On the AP radiograph, a good reduction had a neck-shaft alignment that was normal or slightly valgus, less than 20 degrees of lateral angulation, and less than 4 millimeters of movement in either direction. The reductions that were deemed acceptable met either the alignment or displacement criteria. Both criteria were not met by poor reductions. The type and angle of the implant were noted.

Mattress sutures or simple sutures were used to close the skin after the subcutaneous layer and the vastus lateralis and iliotibial tract had been closed with continuously locked sutures.

Tip Apex Distance was calculated by adding the millimeter-based measurements from the anteroposterior and lateral radiographs, respectively, of the distance from the lag screw tip to the apex of the femoral head.

The correction is found by multiplying the measured distance by the factor determined by dividing the known diameter of the screw's projected shaft by that diameter on the radiograph. Radiographs will be used to assess screw removal, nonunion, and union.

Follow-up: The first follow-up at our clinic was after 2 weeks to remove the surgical sutures. After 6–8 weeks or until full union was seen on an x-ray, protected weight bearing with crutches was advised. Data was gathered through immediate imaging postoperatively, clinical, and radiological follow-up at 2 weeks, 3, and 6 months in an outpatient clinic. Radiologically, the anteroposterior and lateral angles, union callus, bone bridge, malunion, varus deformity, shortening measured by tape, and metal

complications such as osteolysis, metal failure, cut through, and infection are evaluated; clinically, range of motion and pain were rated.

STATISTICAL ANALYSIS

The statistical work was performed in SPSS 28. (IBM Co., Armonk, NY, USA). The ANOVA (F) test and the post hoc test were used to assess the quantitative data reported as mean and SD (Tukey). The Chi-square test was used to examine categorical data, which were then displayed as frequencies and percentages.

RESULTS

The mean age of cases was (64.9 ± 7.1) ranging from 54 to 78 years and half of them (50.0%) were less than or equal to 64 years and half of them (50.0%) were above 64 years, two-thirds of the studied group (66.7%) were females, and one-third (33.3%) were males, fall was the most common mode of injury (72.2%) followed by RTA (27.8%), gamma nail was used among 10 cases (55.6%) of the studied group and DHS was used among 8 cases (44.4%) of the studied group (Table 1).

Most of the studied group (72.2%) didn't have any complications, two cases (11.1%) had a superficial infection requiring 2 weeks of parental antibiotics treatment and three cases (16.7%) had lag screw cut out (Table 2).

The operative tip apex distance in the studied group was (19.1 ± 3.13) ranging from (13.6 to 26.7) mm, there is an increase in mean TAD from operation to 6 months postoperative but without any statistically significant difference ($p\text{-value} > 0.05$) with a mean difference of -3 mm with 95% CI (-6.49 – 0.495) ranging from a decrease by 1.6mm to an increase by 27.5mm (Table 3).

About 66.6% of cases had excellent quality reduction, three cases (16.7%) had good quality and three cases (16.7%) had poor quality (Table 4).

The tip apex distance increased significantly at 6 months postoperative among patients with poor than good than excellent reduction quality while regarding TAD at operation, non-statistically significant differences were found (Table 5).

When comparing patients with and without cut-outs, a statistically significant difference was found; all patients without cut-outs had excellent reduction quality (Table 6).

The tip apex distance increased significantly at 6 months postoperative among patients with cut-outs than without cut-outs while regarding TAD at operation, non-statistically significant differences were found (Table 7).

Female patient, 70 years old, presented with unstable subtrochanteric fracture after a simple fall. Fixation

was made by a long Gamma nail and further augmented with tension band wires (Figure 1).

Table 1: characteristics and clinical data of the studied patients.

Demographic data	The studied group	
	No= (18)	%
Age (years) Mean ± SD	64.9±7.1	
Median(Range)	64.5 (54-78)	
Age (years) ≤ 64 years	9	50.0%
>64 years	9	50.0%
Sex		
Male	6	33.3%
Female	12	66.7%
The mode of injury		
Fall	13	72.2%
Road traffic accident	5	27.8%
Type of fixation		
Gamma nail	10	55.6%
DHS	8	44.4%

DHS: Dynamic hip screw

Table (2): Postoperative complications among the studied group.

Complications	The studied group	
	No= (18)	%
No	13	72.2%
Cut out	3	16.7%
Superficial Infection	2	11.1%

Table (3): Comparing Tip Apex Distance at operation and post-operative among the studied group.

TAD	At operative Mean ± SD Median (Range)(no=18)	6 months postoperative Mean ± SD Median (Range)(no=16)	Paired t-test	p-value
TAD (mm)	19.1±3.13 18.95 (13.6-26.7)	22.1±8.05 20.8 (12-45)	1.92	0.055
Difference	-3.0 ± 7.03 (-1.6 – 27.5)			
95% CI	(-6.49 – 0.495)			

TAD: Tip Apex Distance

Table (4): The quality of reduction postoperative among the studied group.

The quality of the reduction	The studied group	
	No= (18)	%
Poor	3	16.7%
Good	3	16.7%
Excellent	12	66.6%

Table (5): Relation between the quality of reduction and TAD among the studied group.

The quality of the reduction	TAD at operation	TAD post-operative
Poor	21.17 ± 4.88	37.3 ± 7.1
Good	20.67 ± 1.59	21.5 ± 1.16
Excellent	18.15 ± 2.75	18.39 ± 3.51
P-value	0.214	<0.001**

** Statistically significantly different.

Table (6): Relation between cut-out and quality of the reduction among the studied group.

The quality of the reduction	Cut-out No=3 (%)	No cut-out No=15 (%)	χ ² - Test	p-value
Poor	3 (100.0%)	0 (0.0%)	18.2	0.001**
Good	0 (0.0%)	3 (20.0%)		
Excellent	0 (0.0%)	12 (80.0%)		

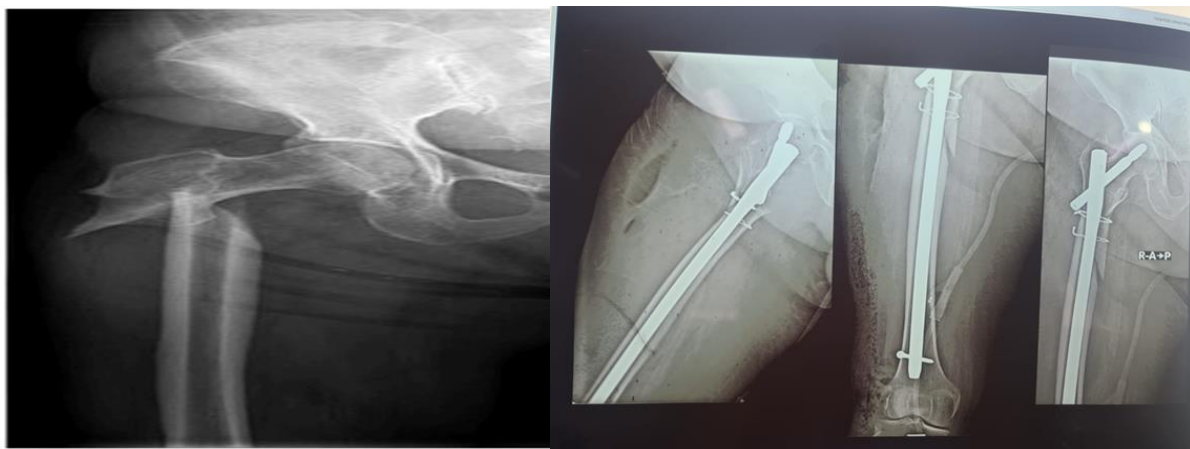
** Statistically significantly different.

Table (7): Relation between TAD and cut-out among the studied group.

Tip Apex Distance	No cut-out No=15 (%)	Cut-out No=3 (%)	T-test	p-value
TAD at operation Mean ± SD	18.65 ± 2.72	21.17 ± 4.88	1.3	0.214
TAD 6 months post-operative Mean ± SD	19.02 ± 3.4	37.3 ± 7.1	7.2	<0.001**

** Statistically significantly different.

Figure 1. Female patient, 70 years old, presented with unstable subtrochanteric fracture after a simple fall. Fixation was made by a long Gamma nail and further augmented with tension band wires



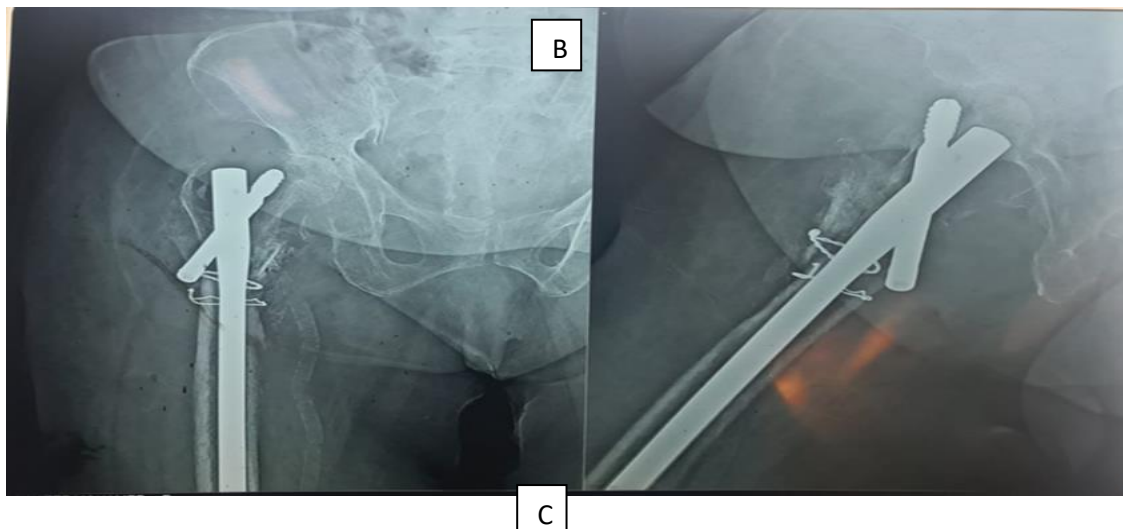


Figure 1. Female patient, 70 years old, presented with unstable subtrochanteric fracture after a simple fall. Fixation was made by a long Gamma nail and further augmented with tension band wires

DISCUSSION

The most anticipated complication of cephalomedullary nailing of proximal femur fracture is known as "cut-out," and it has a significant negative impact on elderly patients' functional recovery and life expectancy [9]. The term "cut-out" refers to the neck-shaft angle collapsing into a varus position, which causes the screw to protrude from the femoral head. The causes of the cut-out are thought to be multifactorial, and the incidence ranges from 1.8 to 16.5% [10]. In all failed surgically-managed intertrochanteric fractures, screw head cut out is responsible for the majority (84%) of cases [11]. In 1995, Baumgaertner et al. established the concept of tip-apex-distance (TAD) as the distance between the lag screw tip and the apex of the femur as seen in anteroposterior and lateral radiographs. For TAD, they found that 25 mm was the ideal cut-off [8].

According to our results, the mean age of cases was (64.9±7.1) ranging from 54 to 78 years, and half of them (50.0%) were less than or equal to 64 years and half of them (50.0%) were above 64 years. That was close to Khanna and Tiwari, [12] who reported that the mean age of cases was 61.63 years (45-96 years). Additionally, John et al., [13] reported the mean age of the cases was 69.56 years (range 30–96 years). In our study, two-thirds of the studied group (66.7%) were females, and one-third (33.3%) were males. This agreed with Caruso et al., [7] who reported that 35% of the cases were males and 65% were females. In our study, fall was the most common mode of injury (72.2%) followed by road traffic accidents (27.8%). Wang et al., [14] reported among the

studied group, there were thirteen males and thirty-nine females, with a median age of 75.1 and a range of 63-91. All fractures resulted from something very low energy, such as a fall from standing height. However, Khanna and Tiwari, [12] reported that due to the proximity of the institute to the highway, automobile accidents accounted for the majority of fatalities.

In our study, Gamma nail was used among 10 cases (55.6%) of the studied group and DHS was used among 8 cases (44.4%) of the cases. Sakr and Abourisha, [15] reported that Seventy-one patients were treated with DHS, while the remaining 35 patients underwent a Proximal Femur Nail fixation. Regarding our results, most of the studied group (72.2%) didn't have any complications, three cases (16.7%) had cut out and two cases (11.1%) had superficial infections which were treated by parental antibiotics for 2 weeks. Also, Sakr and Abourisha, [15] reported that there were no postoperative complications for 94.3% of patients (99 out of 100 cases). A total of 3% of patients experienced difficulties; 3 patients required amputation, 1 patient developed non-union and needed a THR conversion, 1 patient required removal, and 1 patient experienced multiple greater trochanter complications. Pehlivanoğlu et al. [16] reported that with no statistically significant difference (p=0.83), The rate of complications after surgery was 9.5% in the PFN group and 8.3% in the DHS group. In group proximal femoral nail, two individuals developed pulmonary emboli, while three developed issues at the wound's surface. In group DHS, Three patients experienced

complications from their superficial wounds, and two had pulmonary embolisms. In the group proximal femoral nail, 73.6% (42 cases) died, while 67.6% of those in the DHS group did (44 cases) ($p=0.469$).

According to our results, the mean tip apex distance in the cases was (19.1 ± 3.13) ranging from (13.6 to 26.7) mm. In accordance with our results, Caruso et al. [7] revealed that the median TAD was 26.42 mm overall, and 38.72 mm in the cut-out group, suggesting that TAD may be the strongest predictor of cut-out risk following intramedullary repair of proximal femur fractures (Q1 to Q3 30.59-46.23), and 22.16 mm in the group without a cut-out. Tip apex distance was measured in patients with intertrochanteric fractures of the femur treated with proximal femoral nailing; Khanna and Tiwari [12] observed a mean TAD of 22.93 mm. In the same line, Venugopal and Sandesh, [17] reported a similar average Tip-Apex Distance of 23.5mm ranging (19 mm - 28 mm).

Regarding our results, 66.6% had excellent quality reduction, three cases (16.7%) had good quality and three cases (16.7%) had poor quality. The quality of reduction depended on the type of fracture with the poorest was among the fractures with affection of posteromedial cortex of the proximal femur. Venugopal and Sandesh, [17] reported that Results were excellent for 14 patients (average TAD 23.1 mm) and good for 43 individuals (average TAD 23.6 mm). Two had moderate results (average TAD 25.2 mm), while one had a poor result (average mean TAD 27.9 mm).

In our study, there was a statistically significant increased TAD at 6 months postoperative among patients with poor than good than excellent reduction quality while regarding TAD at operation, non-statistically significant differences were found. In accordance with our results, Sevinc et al. [18] studied the difference in functional outcomes between patients who had A1 and A2 type intertrochanteric femur fractures treated with dynamic hip screws and proximal femoral nails with anti-rotation and reported that Patients who experienced implant failure had a mean tip-apex distance of 27.6 mm, independent of implant type, compared to patients who did not experience implant failure, who had a distance of 21.6 mm ($p=0.001$).

Regarding our results, Patients who underwent reductions with cut-outs had better results than those who did not, all patients with no cut-outs had excellent reduction quality. That was in agreement with Caruso et al. [7] who reported that There was a

nearly statistically significant link between the quality of reduction, distal locking, and nail selection and the risk of cut-out.

According to our results, there was a statistically significant increase in TAD at 6 months postoperative among patients with cut-outs than without cut-outs while regarding TAD at operation, non-statistically significant differences were found. Also, Khairy et al. [19] reported that Median TAD postoperatively with lag screw cut-through was significantly higher than median TAD postoperatively without lag screw cut-through ($p<0.001$).

Our study had several limitations. Our follow-up time was not long enough, and the study was a single-center study so we cannot do generalization to the data. To generalize the results, we suggest doing longer-term, multi-center research.

CONCLUSION

In conclusion, Tip apex distance accuracy plays a crucial function in reducing the incidence of lag screw cut-outs in managing proximal femur fractures.

No potential conflict of interest was reported by the authors.

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