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Assessment of Tip-Apex Distance in Dynamic Hip Screw Fixation of Intertrochanteric Fractures: Implications for Surgical Outcomes and Complications

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Abstract
Intertrochanteric fractures pose significant challenges in orthopedic practice, particularly among the elderly, due to high morbidity and mortality rates. Dynamic Hip Screw (DHS) fixation is a standard surgical approach aimed at achieving stable fracture fixation, with Tip-Apex Distance (TAD) serving as a critical parameter in assessing surgical success and complication risk. This retrospective cohort study analysed intertrochanteric fractures treated with DHS at Darbhanga Medical College from January 2023-May 2024 place of study. 20 Patients with complete medical records and radiographs were included. TAD measurements were calculated from postoperative and 6-month follow-up radiographs to evaluate their association with surgical outcomes. The study found that a TAD exceeding 25 mm postoperatively correlated significantly with higher rates of lag screw cut-through and poorer reduction outcomes. Fractures with cut-through exhibited consistently higher median TAD values compared to those without, underscoring the impact on fracture stability and patient recovery. Surgical precision in achieving an optimal TAD below 25 mm is crucial to minimize complications and enhance outcomes in DHS-treated intertrochanteric fractures. These findings emphasize the importance of meticulous technique and ongoing radiographic monitoring to optimize fracture fixation and patient care.

INTRODUCTION

Intertrochanteric fractures are a common type of hip fracture, particularly among the elderly population. These fractures occur between the greater and lesser trochanter of the femur and are associated with high morbidity and mortality rates[1]. Effective and stable fixation is critical to promoting early mobilization and reducing complications. The Dynamic Hip Screw (DHS) is a widely used surgical method for stabilizing intertrochanteric fractures, leveraging a sliding screw-plate construct to allow controlled compression and dynamic stabilization of the fracture site[2].

A crucial parameter in the successful fixation of intertrochanteric fractures using DHS is the Tip-Apex Distance (TAD). TAD, defined as the sum of the distances from the tip of the lag screw to the apex of the femoral head on both anteroposterior (AP) and lateral radiographs, serves as a predictive measure for the risk of fixation failure. A smaller TAD is believed to correlate with a reduced risk of screw cut-out and other fixation-related complications, thereby enhancing the stability and healing of the fracture[3,4].

The theory of Tip Apex Distance was introduced by Baumgaertner *et al.* in 1995 and later in 1997 as they confirmed the importance of good surgical technique in the treatment of trochanteric fractures using the TAD as a clinically useful way to describe the position of the screw[5].

The Tip Apex Distance is the sum of the distance from the tip of the screw to the apex of the femoral head on AP and lateral views. The Tip Apex Distance (TAD) should be <25 mm to prevent DHS cut-out or failure, which most often happens if the screw is placed too anterior or too superior[6].

Despite the clinical significance of TAD, there remains a need for further research to elucidate its precise role and establish standardized guidelines for its optimal measurement and application in surgical practice. This study aims to evaluate the value of TAD in the fixation of intertrochanteric fractures by DHS, examining its correlation with surgical outcomes, including fracture healing, complication rates and overall patient recovery.

Through this investigation, we hope to contribute to the body of knowledge on intertrochanteric fracture management and offer insights that may inform surgical techniques and improve patient prognosis.

MATERIALS AND METHODS

This study was a retrospective cohort analysis conducted at a tertiary care hospital. It reviewed cases of intertrochanteric fractures treated with Dynamic Hip Screw (DHS) fixation over 15 months, from January 2023-May 2024 at Darbhanga Medical College and Hospital.

Patients aged 50 years and above diagnosed with intertrochanteric fractures confirmed by radiographic imaging and treated with DHS fixation were included in the study. Additionally, patients were required to have complete medical records and radiographs for pre-operative, post-operative and follow-up assessments. Exclusion criteria comprised patients with pathological fractures, multiple fractures or polytrauma, previous hip surgery on the affected side, and incomplete medical records.

All patients underwent comprehensive radiological and clinical evaluations, including X-rays in anteroposterior, lateral views and anteroposterior pelvis with traction and internal rotation of the lower limb. Alongside routine preoperative investigations, additional specialized tests were requested by the anesthesiologist to ensure a thorough anesthetic assessment. Two units of blood were prepared for each patient, with utilization dependent on individual needs. Patients received a single dose of 1000 mg third-generation cephalosporin as antibiotic prophylaxis, administered 30 minutes before the incision, followed by doses every 12 hours for three days postoperatively.

In the surgical technique, patients were positioned supine on a traction table and closed reduction was performed under image intensification using traction, slight abduction and internal rotation. The quality of the reduction was evaluated according to Baumgaertner *et al.,* with satisfactory reduction defined by smooth anterior and medial cortical bony buttressing. A lateral approach to the proximal femur was employed in all cases and fixation was achieved using a DHS and plate. Lag screw lengths ranged from 80 mm to 105 mm, with 4-6-hole plates used. Neither anti-medialization plates nor anti-rotational screws were utilized and no bone grafts or cement were applied. The wound was closed in layers: the vastus lateralis muscle and iliotibial tract were sutured with continuous locked sutures and the subcutaneous layer and skin were closed with mattress and simple sutures. For the measurement of Tip-Apex Distance (TAD), a line drawing was used to illustrate the measurement technique. The true diameter of the screw (D true) was adjusted for magnification. The diameters of the lag screw on lateral (D lat) and anteroposterior (D ap) radiographs, as well as the distances from the screw tip to the center of the femoral head on anteroposterior (X ap) and lateral (X lat) radiographs, were defined. TAD was calculated as the sum of the distances from the lag screw tip to the apex of the femoral head on both anteroposterior and lateral radiographs, with corrections for magnification. The apex of the femoral head was identified as the intersection point between the subchondral bone and a line parallel to and

centered on the femoral neck. Radiographic magnification was determined by dividing the observed diameter of the projected screw shaft by its known diameter, with corrections applied by multiplying the measured distance by this factor. Radiographs were used to assess endpoints such as union, nonunion, and screw cut-out.

Technique for calculating the Tip Apex Distance. TAD is the sum of the distance in mm from the apex of the femoral head to the tip of the lag screw with correction for magnification in AP and lateral views. Derived from Baumgartner[5].

Descriptive statistics were used to summarize the demographic and clinical characteristics of the patients. Continuous variables were expressed as median with interquartile range, while categorical variables were presented as frequencies and percentages. Chi-square, Mann Whitney U test and Wilcox on rank test were applied for statistical analysis. A $p<0.05$ was considered statistically significant.

The study was approved by the Institutional Review Board (IRB) of the hospital. Informed consent was waived due to the retrospective nature of the study. Patient confidentiality was maintained by anonymizing the data and ensuring that no identifiable information was included in the analysis or reporting.

RESULTS AND DISCUSSIONS

The present study presents the measurements of Tip-Apex Distance (TAD) in patients undergoing fixation of intertrochanteric fractures with Dynamic Hip Screw (DHS). TAD is a crucial parameter in the placement of DHS implants, reflecting the positioning of the lag screw within the femoral head and neck. The incidence of screw cut-off in the present study was 25%.

In our study majority of patients with intertrochanteric fractures were above 50 years of age with mean age of 55.6±6.3 years.

In our study, five cases had a TAD (Tip-Apex Distance) exceeding 25 mm postoperatively. After 6 months of radiological follow-up, 2 cases reported the lag screw cut through the femoral head. The mean time to screw cut-out was 3.6 months

The table summarizes the quality of reduction observed in intertrochanteric fractures categorized by the presence of cut-through phenomenon during dynamic hip screw (DHS) fixation. The study classified reductions into three categories: Good, Acceptable, and Poor. Among cases where cut-through occurred (Yes, n=5), only 20% achieved a Good reduction, while 60% resulted in a Poor reduction. In contrast, cases without cut-through (No, n=15) showed significantly better outcomes with 73.3% achieving a Good reduction and only 6.7% resulting in a Poor reduction (p=0.028*). Acceptable reductions were similar between both groups, with 20% in the cut-through group and 20% in the non-cut-through group. These findings underscore the impact of cut-through phenomenon on the quality of reduction in intertrochanteric fractures treated with DHS fixation, emphasizing the importance of meticulous surgical technique to minimize complications and optimize patient outcomes.

The table presents the median values and interquartile ranges (IQR) of Tip-Apex Distance (TAD) observed in intertrochanteric fractures stratified by the presence of cut-through phenomenon at two time points: postoperative and at 6 months follow-up. Postoperatively, fractures with cut-through (Median TAD: 2.82, IQR: 2.73-3.03) had significantly higher TAD

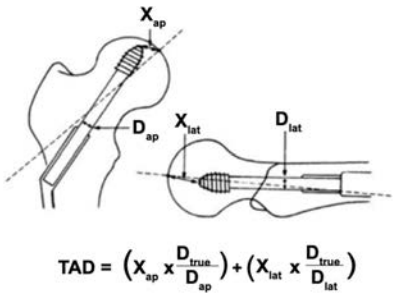

Fig. 1: Technique for Calculating the Tip Apex Distance

Fig. 2: Pre-op X-ray

Fig. 3: Post-op X-ray

Fig. 4: Post-op X-ray at 6th Month follow-up

Table 1: Quality of Reduction in Intertrochanteric Fractures by Cut-Through Phenomenon

Quality of Reduction	Cut-Through		p-value
	Yes (n=5)	No (n=15)	
Good	1 (20%)	11 (73.3%)	0.028*
Acceptable	1 (20%)	3 (20%)	
Poor	3 (60%)	1 (6.7%)	

Chi-square test applied

Table 2: Tip-Apex Distance (TAD) in Intertrochanteric Fractures with and without Cut-Through Phenomenon

TAD	Cut through (Median)		p-value
	Yes	No	
postoperative	2.82 (2.73-3.03)	1.96 (1.84-1.97)	0.0012*
At 6 months	3.62 (3.3-3.9)	2.1 (2-2.14)	<0.001*

Mann-Whitney U test applied

Table 3: Tip-Apex Distance (TAD) Measurements in Intertrochanteric Fractures

TAD	Median (Q1-Q3)	p-value
postoperative	1.97 (1.8-2.5)	0.0011*
At 6 months	2.12 (2.0-2.7)	

Wilcoxon test applied

compared to fractures without cut-through (Median TAD: 1.96, IQR: 1.84-1.97) with a p-value of 0.0012*. Similarly, at 6 months, fractures with cut-through exhibited a higher median TAD (3.62, IQR: 3.3-3.9) compared to those without cut-through (Median TAD: 2.1, IQR: 2-2.14), with a highly significant p-value of <0.001*. These findings indicate that the presence of cut-through phenomenon during dynamic hip screw (DHS) fixation correlates with increased TAD measurements, suggesting potential implications for fracture stability and clinical outcomes over time. The results underscore the importance of surgical precision in minimizing TAD and optimizing fracture fixation to enhance patient recovery and reduce complications.

This table summarizes the median values and interquartile ranges (Q1-Q3) of Tip-Apex Distance (TAD) in intertrochanteric fractures at two different time points: postoperative and at 6 months follow-up. Postoperatively, the median TAD was 1.97 (Q1-Q3: 1.8-2.5), indicating a range within which half of the observed TAD values fall. This measurement was significantly associated with the postoperative period, as evidenced by a p-value of 0.0011*. At 6 months, the median TAD increased to 2.12 (Q1-Q3: 2.0-2.7), suggesting a slight upward trend in TAD measurements over time, although the p-value for this comparison was not provided.

These findings highlight the dynamic nature of TAD measurements in intertrochanteric fractures, potentially influenced by factors such as bone healing, implant stability and patient mobility. The significant difference observed postoperatively underscores the importance of initial surgical precision in achieving optimal TAD, which is crucial for fracture stability and patient outcomes. Further longitudinal studies are warranted to explore the implications of TAD changes over time and their clinical relevance in the management of intertrochanteric fractures.

Case: A 59 years old female, presented with a left femur injury after falling on the ground.

She sustained an intertrochanteric fracture in her left femur, which was treated with Open Reduction Internal Fixation (ORIF) using Dynamic Hip Screw (DHS). The quality of reduction achieved was deemed acceptable.

Radiological findings revealed an immediate postoperative TAD measurement of 2.88 cm, which increased to 3.7 cm on X-ray after 6 months. Shahida Khatoon experienced a cut-through of the lag screw from the femoral head postoperatively, alongside defective union. Her management plan includes continued monitoring and supportive care, with a prognosis centred on rehabilitation to enhance mobility and strength.

Proximal femoral fractures are common among the elderly, placing a significant burden on both the individuals affected and society. Their frequency is increasing with the aging population. In our study, the majority of patients with intertrochanteric fractures were above 50 years of age, with a mean age of 55.6 ± 6.3 years.

This finding aligns with the research by Khanna *et al.,* where the mean age was reported to be 61.63±11.603 years. Intertrochanteric fractures are indeed more prevalent in individuals over 60 years of age[7].

The incidence of screw cut-out varies widely, from 2.0% as reported by Chua[8] to as high as 12.6%. In our study, we found a higher incidence of screw cut-outs at 25%. The mean time to screw cut-out was 3.6 months (ranging from 1-6 months) postoperatively, which is similar to the findings of Geller[9] Similarly, The mean time to screw cut-out was 3.8 months in chua *et al.* study finding[8].

In contrast, the study by Khairy reported an even higher rate of implant failure and cut-through at 27.8%[10].

In the study by M. R. Baumgaertner et al., out of the nineteen identified failures, sixteen were attributed to the device cutting out of the femoral head[5].

Shahu *et al.* found that good reduction was achieved in 28 cases of type 1 fractures, while all fractures with poor reduction were type 2 fractures. All type 1 fractures united at a mean of 12 months. Overall, 14 patients experienced lag screw cut-out, all of which were type 2 fractures. As per their conclusion The number of cut-outs had a direct correlation to the severity of fractures and the TAD[11].

In our study, cases with cut-through (n=5) had a 20% rate of good reduction and 60% poor reduction, contrasting with non-cut-through cases (n=15) where 73.3% achieved good reduction and only 6.7% had poor reduction (p=0.028*). These findings highlight the impact of cut-through on reduction quality in DHS-treated intertrochanteric fractures, emphasizing the need for precise surgical techniques to minimize complications. Additionally, two cases with TAD >25 mm postoperatively developed lag screw cut-through after six months, attributed to factors like good bone quality, intact lateral wall, young age, thin body and delayed weight-bearing.

Similar to our findings, in the study by M. R. Baumgaertner *et al.,* none of the 120 screws with a tip-apex distance of twenty-five millimeters or less cut out. There was a very strong statistical relationship between an increasing tip-apex distance and the rate of cut-out, regardless of all other variables related to the fracture[5].

Agni *et al.* also showed that there are predictive factors for lag screw cut-out, with the TAD being the most important determining factor. Other factors include the degree of comminution of the fracture site and the quality of reduction. Our study corroborates these findings[12].

In our study, the median TAD was 1.97 (Q1-Q3: 1.8-2.5) postoperatively, showing a significant association with the postoperative period (p=0.0011*). At 6 months, the median TAD increased to 2.12 (Q1-Q3: 2.0-2.7). Postoperatively, fractures with cut-through had a significantly higher median TAD (2.82, IQR: 2.73-3.03) compared to fractures without cut-through (1.96, IQR: 1.84-1.97) (p=0.0012*). At 6 months, fractures with cut-through had a median TAD of 3.62 (IQR: 3.3-3.9), significantly higher than those without cut-through (2.1, IQR: 2-2.14) (p<0.001*). These results highlight that increased TAD is associated with the cut-through phenomenon in DHS fixation, emphasizing the need for precise surgical technique to optimize fracture stability and clinical outcomes.

This finding was consistent with several studies[9,13-15]. The highest TAD was reported by Zirngibil[15] (24.8), while the lowest mean value was observed in the study by Guven *et al*. (17.14)[13].

Similar to our findings, Khairy *et al.* reported a postoperative median TAD of 2.05 and a median TAD of 2.23 at 6 months. They concluded that a TAD of less than 25 mm is safe, while a TAD exceeding 25 mm may lead to implant penetration, non-union, cut-through, and other complications. Therefore, TAD is a reliable and valuable factor in DHS procedures[10].

In the study by Khanna *et al.,* the postoperative X-ray showed a tip apex distance (TAD) of 22.93±3.88 mm. When comparing two groups-one with TAD <25 mm and the other with TAD >25 mm-the results indicated that both functional and radiological outcomes were better in the group with TAD <25 mm[7].

In the study by M.R. Baumgaertner *et al.,* the average tip-apex distance (TAD) was 24 millimeters (range, 9-63 millimeters) for fractures that were successfully treated compared to 38 millimeters (range, 28-48 millimeters) for fractures where the screw cut out (p = 0.0001)[5].

In Garth *et al.'s* study, 91 fractures occurred in 90 patients, including one patient with bilateral hip fractures. The mean tip-apex distance (TAD) was 19.06 mm±0.77 mm (±95% CI). Inter-observer variability assessment revealed a standard deviation of 1.99 mm among three observers, which is approximately 10% of the mean TAD. Twelve out of 91 sliding hip screw devices (13.1%) had a TAD greater than 25 mm, indicating a higher likelihood of implant extrusion[6].

CONCLUSION

In conclusion, our study underscores the critical role of Tip-Apex Distance (TAD) in Dynamic Hip Screw (DHS) fixation for intertrochanteric fractures. A TAD exceeding 25 mm postoperatively correlated significantly with an increased risk of lag screw cut-through and poorer fracture reduction outcomes. Surgical precision in achieving and maintaining optimal TAD is paramount to minimizing complications and optimizing patient recovery. These findings emphasize the ongoing importance of monitoring TAD dynamics over time to enhance fracture stability and improve clinical outcomes in patients undergoing DHS fixation for intertrochanteric fractures.

Recommendation: Based on our findings, we recommend meticulous attention to achieving and maintaining a Tip-Apex Distance (TAD) of <25 mm during Dynamic Hip Screw (DHS) fixation for intertrochanteric fractures to reduce the risk of cut-through and enhance fracture stability. Surgeons should prioritize intraoperative techniques that optimize TAD, such as precise screw positioning and adequate reduction. Regular postoperative monitoring of TAD, particularly during the early months, is crucial to identify and address any deviations that may impact long-term outcomes. Continued research into TAD dynamics and its clinical implications will further refine surgical protocols and improve patient care.

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