International Journal of Research in Orthopaedics
Shah N et al. Int J Res Orthop. 2024 Nov;10(6):1214-1218
http://www.ijoro.org

Original Research Article

DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20243113

Beyond 25 millimetres makes the difference: a prospective study on tip apex distance in dynamic hip screw treatment of intertrochanteric fractures

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Received: 01 October 2024
Accepted: 19 October 2024

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ABSTRACT

Background: The tip apex distance (TAD) is a key indicator of screw cut-out risk in dynamic hip screw (DHS) treatment for intertrochanteric fractures. This study sought to assess the prognostic significance of TAD in intertrochanteric fractures managed with DHS.
Methods: This prospective observational study encompassed 50 patients with intertrochanteric fractures who had DHS fixing treatment. TAD was measured on postoperative radiographs. Patients were followed clinically and radiologically for a minimum of 3 months. The primary outcome was screw cut-out.
Results: The mean TAD was 25.5 mm, with a range of 10 to 47 mm. Four screw cut-outs were seen, all in patients with TAD exceeding 35 mm. The mean TAD was 24.18 mm for successfully treated fractures, in contrast to 40.89 mm for those who experienced cut-out. No cut-outs were seen with TAD <25 mm. The inferior-central region of the femoral head was the predominant site for screw placement, occurring in 30% of cases.
Conclusions: TAD is a dependable predictor of screw cut-out risk in DHS fixation of intertrochanteric fractures. Maintaining a TAD <25 mm and screw position in the inferior-central zone of the femoral head may help minimize cut-out risk. Surgeons should aim for proper screw placement and consider TAD when treating these fractures.

Keywords: Intertrochanteric fractures, Dynamic hip screw, Tip apex distance, Screw cut-out

INTRODUCTION

Intertrochanteric fractures provide a considerable problem in orthopaedic surgery, especially in the geriatric demographic.[1,2] These fractures, located between the greater and lesser trochanters of the proximal femur, constitute roughly 45% of all hip fractures and are linked to significant morbidity and death.[1,3] The occurrence of these fractures has been progressively rising due to the ageing global population and the widespread prevalence of osteoporosis within this group.[1-4]

The dynamic hip screw (DHS) has historically been regarded as the gold standard for managing intertrochanteric fractures because of its capacity to permit controlled compression and impaction at the fracture site, so promoting healing; nevertheless, it is now being supplanted by proximal femoral nails.[3,4] However, despite its widespread use, DHS fixation is not without complications.[4] Failure rates of up to 16-23% have been reported, with screw cut-out being the most common mode of failure.[4,5]

In 1995, Baumgaertner et al proposed the notion of tip apex distance (TAD), a metric that quantifies the cumulative distances from the tip of the lag screw to the apex of the femoral head on both anteroposterior and lateral radiographs, adjusted for magnification.[6] This

metric has since become a crucial tool in assessing the risk of screw cut-out and ensuring optimal screw placement within the femoral head. [6,7] Numerous studies have demonstrated that a TAD greater than 25 mm is significantly associated with an increased risk of fixation failure.[6,7] The biomechanical rationale behind this observation lies in the distribution of trabecular bone within the femoral head.[8] Screws placed in the inferior-central zone, where trabecular bone is denser, have shown better outcomes compared to those placed in superior or anterior positions.[8,9]

Despite the established importance of TAD in predicting fixation failure, there remains a need for further investigation into its predictive value in different patient populations and fracture patterns. Additionally, the influence of other factors such as patient demographics, fracture reduction quality, and bone quality on relationship between TAD and fixation failure warrants further exploration. The primary aim of this study is to understand the predictive value of TAD in intertrochanteric fractures treated with DHS in our local Indian population. Specifically, we seek to assess the relationship between TAD and screw cut-out in patients managed with DHS fixation for intertrochanteric fractures.

Addressing these objectives will contribute to the existing knowledge on optimal DHS placement and may refine guidelines for surgical techniques in the treatment of intertrochanteric fractures. This study's findings may have significant implications for improving patient outcomes and reducing the economic burden associated with fixation failures in this common and challenging fracture type.

METHODS

Study design and setting

This observational cohort analysis carried out at a tertiary care centre from October 2019 to March 2021. Approval from the institutional ethical board was secured before commencing study.

Participants

Patients aged 18 years and above who presented with intertrochanteric fractures and were treated with DHS fixation were eligible for inclusion. Exclusion criteria encompassed patients treated with other modalities (e.g., proximal femoral nails), those not willing to get enrolled in study, and cases with incomplete follow-up data. All participants included in study after written informed consent.

Variables and data sources

The primary outcome variable was fixation failure, defined as screw cut-out through the superior aspect of the femoral head. Secondary outcomes included fracture union and functional outcomes assessed using the Harris hip score. The primary predictor variable was the TAD, measured using Baumgaertner's method. Other variables of interest included patient demographics, fracture characteristics (Evans classification), and quality of fracture reduction.

Data were collected from medical records, radiographs, and direct patient assessments. Preoperative radiographs (anteroposterior, traction internal rotation view and lateral views) were used to assess fracture patterns and classify fractures according to the AO/OTA system. Postoperative radiographs were utilized to evaluate fracture reduction quality and calculate TAD. All radiographic measurements were performed by two independent observers using a standardized digital measurement tool to ensure consistency and minimize bias.[10]

Bias

To mitigate potential sources of bias, the following measures were implemented - standardization of surgical technique: all procedures were performed by a team of four experienced orthopaedic surgeons following a standardized protocol; blinded outcome assessment: radiographic evaluations were conducted by independent observers unaware of the clinical outcomes; and prospective data collection: all data were collected prospectively to minimize recall bias.

Study size

We included 50 patients with intertrochanteric femur fractures reported to our tertiary care centre during the mentioned time and managed with dynamic hip screw.

Quantitative variables

TAD values were categorized into seven groups for analysis from 10 mm to >45 mm. Fracture reduction quality was classified as good, acceptable, or poor using standardized radiographic criteria. Age was analyzed both as a continuous variable and categorized into groups to assess potential non-linear effects.

Statistical methods

Descriptive statistics summarised demographic data and fracture characteristics. Continuous variables were expressed as means with standard deviations or medians with interquartile ranges, contingent upon their distribution. Categorical variables were reported using frequencies and percentages.

The association between TAD and fixation failure was analyzed using logistic regression, with TAD as the primary predictor variable. Multivariable models were constructed to adjust for potential confounders, including age, sex, fracture type, and reduction quality. The strength of association was reported as odds ratios with 95% confidence intervals. To examine the influence of fracture reduction quality on the relationship between TAD and

fixation failure, we performed stratified analyses and tested for interaction effects. Subgroup analyses were conducted to assess the consistency of findings across different age groups and fracture types.

All statistical analyses were performed using Microsoft excel and PSPP version GNU 2.0.1. A two-sided p value <0.05 was considered statistically significant.

RESULTS

The study included 50 intertrochanteric fractures patients treated with dynamic hip screw (DHS) fixation. The average age of patients was 71 years, with a range of 55 to 95 years. The majority of patients (38%) were in the 76-85-year age group. There was a slight female predominance, with 29 females (58%) and 21 males (42%). The right side was affected in 54% of cases and the left in 46% (Table 1).

Table 1: Patient demographics and fracture characteristics.

Variables	Number of patients (n=50)	Percentage (%)
Age group (years)		
55-65	10	20
66-75	13	26
76-85	19	38
86-95	3	6
<55	5	10
Gender		
Male	21	42
Female	29	58
Fracture stability		
Stable	21	42
Unstable	29	58

Regarding fracture classification, 58% were unstable fractures and 42% were stable fractures according to Evans' classification. The quality of fracture reduction was assessed as good in 52% of cases and acceptable in 48%, with no poor reductions.

The key parameter evaluated was the TAD. The average TAD for all 50 fractures was 25.5 mm, with a range of 10-47 mm. The majority of screws (36%) had a TAD between 20-24.9 mm. Four cases of screw cut-out occurred, all in patients with TAD values greater than 35 mm (specifically 36.4, 38.72, 41.44, and 47 mm). The average TAD for successfully treated fractures was 24.18 mm, compared to 40.89 mm for those that experienced cut-out (Table 2).

Regarding screw placement, the majority of screws (30%) were positioned in the inferior-central zone of the femoral head. No screws were placed in the inferior-anterior zones or superior-posterior. Of the four cut-outs, one occurred in the antero-superior zone, one in the infero-posterior zone, and two in the infero-central zone.

Table 2: Distribution of tip apex distance (TAD).

TAD range (mm)	Number of screws (n=50)	Percentage (%)
10-14.9	1	2
15-19.9	8	16
20-24.9	18	36
25-29.9	12	24
30-34.9	7	14
35-44.9	3	6
>45	1	2

The study found that increasing TAD was strongly associated with an increased risk of lag screw cut-out. All cut-outs occurred in patients with TAD values exceeding 35 mm. Additionally, three of the four cut-outs occurred in unstable fractures, and the average age of patients experiencing cut-out was 85 years, suggesting that advanced age and fracture instability may be contributing factors.

Table 3: Outcomes of fixation.

Outcomes	Number of patients (n=50)	Percentage (%)
Successful fixation	46	92
Screw cut-out	4	8
TAD >35 mm (cut-out)	4	8
TAD <25 mm (no cut-out)	46	92

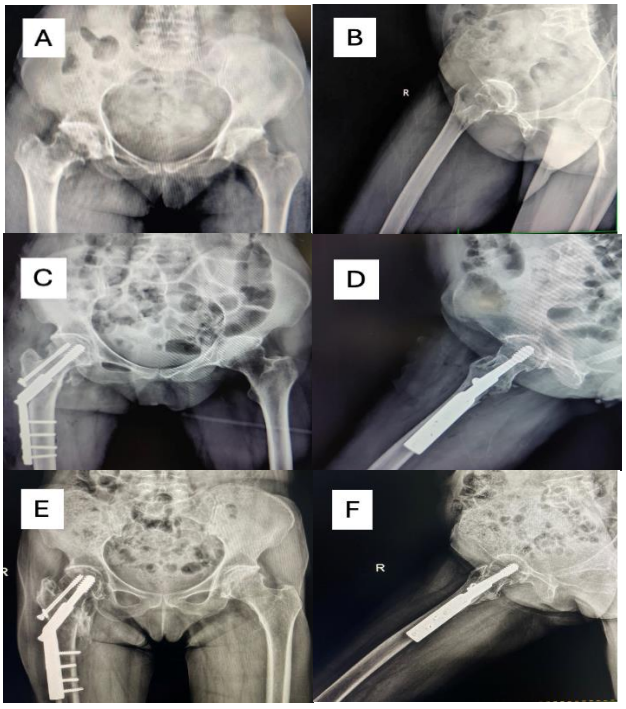

Figure 1: Case 1 (A and B) pre-operative radiographs; (C and D) immediate post-operative radiograph; (E and F) 1-year post-operative follow-up radiograph.

In conclusion, the study reinforces the importance of achieving a low TAD, ideally below 25 mm, to minimize the risk of fixation failure in DHS fixation of intertrochanteric fractures. The findings support the use of TAD as a reliable predictor of screw cut-out risk in these fractures.

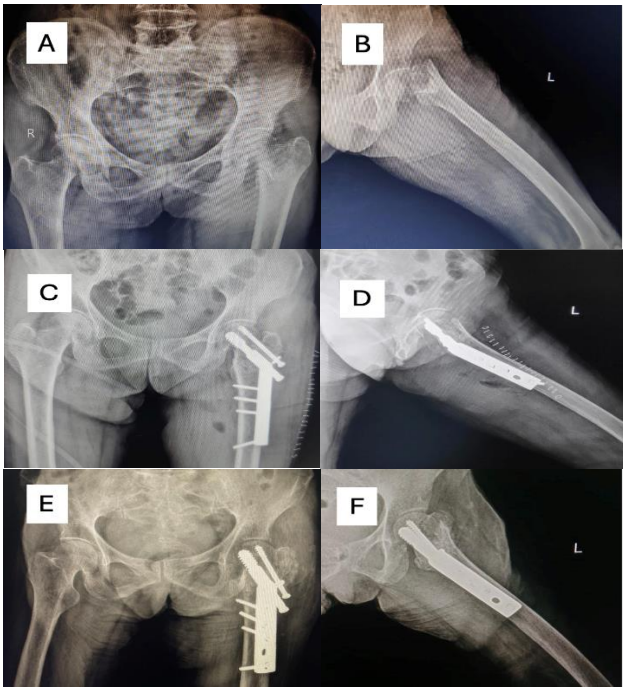

Figure 2: Case 2 (A and B) pre-operative radiographs; (C and D) immediate post-operative radiograph; (E and F) 1-year postoperative follow-up radiograph showing cutout).

DISCUSSION

Key results

Our aimed to evaluate the predictive value of TAD in intertrochanteric fractures treated with DHS. The average TAD for all 50 fractures was 25.5 mm (range 10-47 mm), with 36% of screws having a TAD in the optimal range of 20-24.9 mm. Four screw cut-outs occurred, all in patients with TAD values greater than 35 mm. The average TAD for successfully treated fractures was 24.18 mm, compared to 40.89 mm for those that experienced cut-out. The majority of screws (30%) were placed in the inferior-central zone of the femoral head. These results confirm the importance of maintaining a TAD below 25 mm to minimize the risk of screw cut-out, as initially proposed by Baumgaertner et al.[6]

Interpretation

Our results support the use of TAD as a reliable predictor of screw cut-out risk in intertrochanteric fractures treated with DHS. The findings are consistent with previous studies, particularly that of Baumgaertner et al, which established the 25 mm threshold for TAD.[6,11,12] The occurrence of all cut-outs in cases with TAD >35 mm further emphasizes the critical importance of proper screw placement.[6,7,11,12]

The preference for screw placement in the inferior-central zone aligns with biomechanical studies suggesting this area provides better support due to denser trabecular bone.[9,11] However, our study also saw cut-outs in this zone, indicating that TAD remains a crucial factor regardless of placement zone.

Table 3: Comparison with existing literature.

Study	Samp-le size	Average TAD (successful) (mm)	Average TAD (cut-out) (mm)	Cut-out rate (%)
Current study	50	24.18	40.89	8
Baumga-ertner et al[6]	198	24	38	4
Geller et al[7]	82	22.2	30.9	11

Generalisability

The study offers important insights into the relationship between TAD and screw cut-out risk; however, its generalisability is constrained by the single-center design and the relatively small sample size. The results are particularly relevant for elderly patients with intertrochanteric fractures who are treated with DHS in comparable healthcare environments. To establish broader generalisability, multicenter studies with larger sample sizes and extended follow-up periods are required.

Limitations

The primary limitations of this study include its small sample size of 50 patients and short follow-up period of 1 year, which may limit generalizability and fail to capture delayed complications. As a single-center study, it may not account for variations in surgical techniques or patient populations across institutions. These limitations could introduce bias and should be taken into account when interpreting the results.

CONCLUSION

This study confirms that tip apex distance is a reliable indicator for predicting screw cut-out in intertrochanteric fractures treated with DHS fixation. An ideal average TAD of 28 mm or less was associated with successful outcomes. Surgeons should strive to achieve a TAD under 25 mm whenever possible to minimize cut-out risk as the fracture heals. Proper screw placement in the inferior-central zone of the femoral head, along with close attention to TAD, can help optimize outcomes for patients with intertrochanteric fractures treated using this fixation

method. Further research with larger sample sizes may help elucidate the relative importance of other factors such as age, fracture pattern, and reduction quality in conjunction with TAD.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Shah N, Abhyankar AM, Ghag NS, Ghoti S, Gohil K, Dakhode S. Beyond 25 millimetres makes the difference: a prospective study on tip apex distance in dynamic hip screw treatment of intertrochanteric fractures. Int J Res Orthop 2024;10:1214-8.