

Assessment of Tip–Apex Distance as a Predictor of Implant Failure in Intertrochanteric Femur Fractures: A Prospective Observational Study**Intekhab Akram¹, Umesh Prasad², Marut Nandan Kumar³, Rakesh Chaudhary⁴**¹Senior Resident, Department of Orthopaedic, Patna Medical College & Hospital, Patna, Bihar²Senior Resident, Department of Orthopaedic, Patna Medical College & Hospital Patna, Bihar³Professor, Department of Orthopaedic, Patna Medical College & Hospital, Patna, Bihar⁴Professor & H.O.D., Department of Orthopaedic, Patna Medical College & Hospital, Patna, Bihar

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Abstract

Background: The intertrochanteric femur fracture is one of the most prevalent orthopedic injuries in the elderly and has a significant morbidity and health care utilization. A failure of the implant after surgical fixation is still a major concern, and Tip-Apex Distance (TAD) has been suggested as an important predictor of the success of surgical fixation.

Methods: A prospective observational study was carried out in the Department of Orthopaedics, Patna Medical College and Hospital (PMCH), Patna, Bihar, from April 2025 to December 2025. The total number of 50 patients with intertrochanteric femur fracture treated with Dynamic Hip Screw (DHS) or Proximal Femoral Nail (PFN). The postoperative TAD was assessed by the anteroposterior and lateral radiographs. The patients had a 6-month follow-up to evaluate implant-related outcomes. Data were analyzed statistically by SPSS version 26.0, and $p < 0.05$, the results were regarded as significant.

Results: Of the 50 patients, 36 (72%) had a TAD ≤ 25 mm and 14 (28%) had a TAD > 25 mm. Implant failure occurred in 8 patients (16%). The failure rate in patients with TAD > 25 mm was significantly higher than in patients with TAD ≤ 25 mm (42.9% vs. 5.6%, $p = 0.003$).

Conclusion: The length of the tip to the apex of the femur fracture is an important predictor of implant failure in intertrochanteric femur fractures. A TAD measuring 25 mm or less could reduce the risk of fixation failure and improve surgical outcomes.

Keywords: Intertrochanteric fracture, Tip–Apex Distance, Implant Failure, Dynamic Hip Screw, Proximal Femoral Nail.

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Introduction

Intertrochanteric femur fracture is one of the most frequent fractures encountered in orthopedic practice, especially in elderly people [1]. The fractures are located in the area between the greater and the lesser trochanters of the femur and often are associated with low-energy falls in an osteoporotic population. Intertrochanteric fractures are becoming a major public health problem, with the prevalence increasing in tandem with the world's aging population and its high life expectancy [2,3].

Such injuries are linked to high morbidity and mortality rates, length of hospital stay, loss of independence, and higher health care costs. The burden of hip fracture management is still growing in developing countries like India, even with the changing demographic transition and increasing prevalence of osteoporosis [4]. The main objectives

of treatment for intertrochanteric fractures are a stable fixation, enabling early mobilization and restoration of pre-injury functional status [5]. Surgical treatment is considered to be the standard of care, and devices used for fixation include DHS and PFN [6]. The purpose of such implants to offer biomechanical support and encourage fracture healing, while reducing the risks of complications with extended periods of immobilization [7]. Even though the design of the implants and surgical techniques has improved, fixation failure remains an important issue and can have a negative impact on patient outcomes.

The failure of an implant after being fixed in position, intertrochanteric fracture can present in several different ways first, by the chance of the lag screw cutting through the femur head and falling

out; second, by screw migration; third, by the collapse of the fracture site to the varus direction; fourth, by non-union; and fifth, by mechanical failure of the implant [8]. These complications may require revision surgery, extend recovery time and lead to additional health budget issues. Thus, it is crucial to be able to determine factors predicting implant failure, in order to optimize surgical results and minimize complications after surgery.

TAD is one of the most known radiographical parameters related to the success of fixation [9]. Introduced by Baumgaertner and colleagues, TAD is the sum of the distance from the tip of the lag screw to the apex of the femoral head on the AP and lateral radiographs following magnification correction [10]. There are numerous studies [11] that have shown an association of a smaller TAD with a decreased risk of screw cut-out and a value less than 25 mm is generally considered ideal implant positioning. Therefore, TAD has emerged as a crucial intraoperative and postoperative tool for evaluating the quality of fixation and stability of the implant.

There are a few studies that have assessed the association of TAD and implant failure, but the information from eastern India, like Bihar, is still rare. Moreover, patients' characteristics, fracture patterns and surgical procedure vary, which requires a region-specific evaluation. Hence, the present prospective observational study at PMCH, Patna, was designed to evaluate the role of TAD as a predictor of the failure of implants in intertrochanteric femur fracture. The results could help in better surgical planning, fixation techniques and outcomes in these patients.

Objectives

- To determine the association between postoperative TAD and implant failure.
- To calculate the average TAD in the study group.
- To determine incidence of implant failure.
- To compare the presence of implants failure rates between TAD ≤ 25 mm and TAD > 25 mm.
- To identify factors are associated with fixation failure.

Materials and Methods

Study Design: This study was designed a prospective observational study to evaluate the role of TAD can predict implant failure after surgery in patients with intertrochanteric femur fracture. Data on clinical, radiological and surgical findings were collected systematically and all the included patients were followed prospectively.

Study Setting: The study was conducted in the Department of Orthopaedics, PMCH, Patna, Bihar,

a tertiary care teaching hospital having manage a large volume of orthopedic trauma cases of Patna and other districts of Bihar.

Study Duration: The study was carried out for nine months from April 2025 to December 2025.

Sample Size and Sampling Method: A total of 50 patients treated with surgery for intertrochanteric femur fracture who were included in the study. All patients with the required characteristics presented during the study period were included until the required sample size was reached, using a consecutive sampling technique.

Study Population: Patients who were age 18 years or older with a radiologically confirmed intertrochanteric femur fracture that were surgically fixed with a DHS or PFN constituted the study population.

Inclusion Criteria

- Patients over 18 years old.
- Intertrochanteric femur fractures confirmed by X-ray.
- Surgical treatment patients (DHS or PFN fixation).
- Patients willing to participate and provide written informed consent.

Exclusion Criteria

- Pathological fractures.
- Patients with multiple significant injuries (polytrauma).
- Inadequate postoperative radiographs to measure TAD.
- Patients that are lost for follow-up during the study period.

Data Collection: A predesigned data collection form was used to collect detailed demographic, clinical and surgical data. Demographic variables such as age and sex.

Mechanism of injury, side involved and fracture classification were clinical variables. The surgical factors included were the type of implant, the quality of the fracture reduction and the postoperative TAD measurements.

Measurement of Tip–Apex Distance: Hip radiographs were obtained in an Anteroposterior (AP) and lateral view for all patients pre and postoperatively. After correction for magnification, the distance between the tip of the lag screw and the apex of the femoral head was measured on both views of the radiograph. The TAD was calculated using the formula:

$$\text{TAD} = \text{AP} \backslash \text{Distance} + \text{Lateral} \backslash \text{Distance}$$

Patients were grouped into different TADs and then examined for the fixation outcomes.

Outcome Measures: The primary outcome was implanting failure, which included screw cut-out, implant breakage, varus collapse and revision surgery. Secondary outcomes were radiological fracture union and functional recovery at follow-up.

Follow-Up: Patients were clinically and radiologically followed up in the immediate postoperative period and 6 weeks, 3 months and 6 months postoperatively. Fracture healing and implant position along with proof of fixation failure were evaluated for each follow-up visit.

Ethical Considerations: Proper approval was taken from the Institutional Ethics Committee of PMCH. All participants provided written informed consent prior to their inclusion in the study. Confidentiality and data privacy of patients were respected throughout the study.

Statistical Analysis: Data were analyzed using SPSS version 26.0 and entered into a Microsoft

Excel. Continuous variables are shown as mean with $\pm$ standard deviation and the categorical variables are shown as frequency and percentage. The independent t-test and Chi-square test were used to evaluate the association of TAD and implant failure as appropriate. Logistic regression analysis was carried out, as appropriate, to determine which factors were independently associated with implant failure. The p-value < 0.05 was defined as being statistically significant.

Results

A total of 50 patients with intertrochanteric femur fracture, who underwent surgical fixation, in the study. Table 1 shows the demographic characteristics of the study population. The majority of patients belonged to the age group of 61–80 years (56.0%), followed by 41–60 years (28.0%). The mean age of the study participants was 67.4 ± 11.2 years. 60.0% of the study population consisted of males and 40.0% of the study population consisted of females.

Table 1: Demographic Characteristics of Study Participants (N = 50)

Variable	Frequency (%)
Age Group (Years)	
18–40	4 (8.0)
41–60	14 (28.0)
61–80	28 (56.0)
>80	4 (8.0)
Gender	
Male	30 (60.0)
Female	20 (40.0)

Fracture characteristics are shown in Table 2. The most frequent fracture types were A2 (50.0%), A1 (30.0%) and A3 (20.0%) according to the AO classification system. 54.0% had a fracture on the right side, and 46.0% on the left side.

Table 2: Fracture Characteristics

Variable	Frequency (%)
AO Classification	
A1	15 (30.0)
A2	25 (50.0)
A3	10 (20.0)
Side Involved	
Right	27 (54.0)
Left	23 (46.0)

Table 3 shows the distributions of the postoperative TAD values. Most patients (72.0%) had a TAD of ≤ 25 mm, while 28.0% had a TAD greater than 25 mm.

Table 3: Distribution of Tip–Apex Distance

TAD Category	n (%)
≤ 25 mm	36 (72.0)
> 25 mm	14 (28.0)

During the follow-up period, 8 patients (16.0%) showed implant failure, while 42 patients (84.0%) had successful implant fixations without complications in Table 4.

Table 4: Implant Failure Incidence

Outcome	Frequency (%)
Failure	8 (16.0)
No Failure	42 (84.0)

The association between TAD and implant failure is summarized in Table 5. Patients with TAD >25 mm had a higher failure rate for implants (42.9%) than patients with TAD ≤25 mm (5.6%). This relationship was statistically significant (chi-square test, $p = 0.003$), and was found to be associated with a greater risk of implant failure.

Table 5: Association between TAD and Implant Failure

TAD Category	Failure n (%)	No Failure n (%)	p-value
≤25 mm (n=36)	2 (5.6)	34 (94.4)	
>25 mm (n=14)	6 (42.9)	8 (57.1)	0.003*

The results indicate that to minimize the risk of implant failure after surgical fixation of intertrochanteric femur fracture, maintaining the TAD of 25 mm or less may be recommended.

Discussion

The present prospective observational study aimed to assess the role of TAD as a predictor of implant failure in intertrochanteric femur fracture patients treated at PMCH. 50 patients were included and followed up for six months after surgery. The results showed that there was a significant correlation between the increase in TAD and the failure of implants, which confirmed that TAD is a useful radiographic factor in orthopedic surgery.

In the present study, most of the patients 72% had a TAD of no more than 25 mm, while 28% patients had a TAD more than 25 mm. There was a significant correlation between the higher TAD and implant failure ($p = 0.003$), showing that implant failure tends to be more common among patients with increased TAD, and thus improper screw placement can lead to mechanical problems.

The study by [12] that introduced the concept of TAD and showed that a TAD of more than 25 mm was strongly associated with screw cut-out.

Additionally, [13] found that screw positioning was significantly correlated with fixation failure in intertrochanteric fractures. [14] Observed the need for the ideal orientation of the screw inside the femoral head and reiterated the role of TAD in predicting implant success. Another review, performed by [15] found that TAD is still one of the most reliable predictors of screw cut-out and failure of fixation. In addition, the same results have been reported in recent studies from India, indicating that patients with TAD below the recommended range of 25 mm have had lower failure rates. These findings have important implications for clinical applications. Ensuring proper placement of the lag screw in the femoral head is an important goal in fracture fixation. The use of intra-operative fluoroscopic guidance is critical to a successful TAD and correct implant

placement. Following recommended TAD values could lower the risk of screw cut-out, implant migration, varus collapse and revision surgery which will enhance patient outcomes and reduce healthcare costs.

The advantages of the present study it is prospective in design and the clinical data collected was real life data from a tertiary care teaching hospital. However, certain limitations should be acknowledged. The study was carried out in a single institute and the number of patients taken in the study was small and only 50 patients. Furthermore, the study duration was limited, six months, so that it is possible that not all late complications of fracture fixation occurred. Larger multi-center studies with greater follow-up periods are needed to confirm these results.

Conclusion

The present study shows that TAD is an important factor in determining implant failure in patients with intertrochanteric femur fractures. Patients who had a TAD of more than 25 mm had a significantly increased risk of fixation failure in comparison with those patients who had a TAD of 25 mm or less. These findings justify the recommendation for the surgeon should achieve a TAD of ≤25 mm for fixation procedures. In orthopedic surgery, the regular evaluation of TAD can help optimize the surgical procedure and minimize the risk of complication after implanting.

Recommendations

In the above findings, the study suggest that surgeons should try to adhere to the TAD of less than 25 mm in the fixation of intertrochanteric femur fractures in order to reduce the chance of implant failure. As a quality tool in implant placement, routine evaluation and documentation of TAD on postoperative radiographs should be used. Optimal screw positioning is recommended with the use of meticulous surgical techniques and intraoperative fluoroscopy. Moreover, larger multicentric studies with more numbers of patients

and longer follow-up periods will be needed to confirm these results and create reliable guidelines.

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