

The value of the tip-apex distance (TAD) in predicting failure of fixation of Intertrochanteric fractures of femur

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Abstract

Introduction: The intertrochanteric fracture is a common injury, and can be caused by high energy or low energy trauma; although the later is always the main source seen in elderly people. The favored treatment trend nowadays is closed reduction and fixation with Dynamic Hip Screw (DHS, sliding hip screw with a fixed angle i.e., 135°). With this treatment regimen, a high union rate and a low complication rate have been reported.

Study Design: Prospective cross sectional study.

Setting and Duration: Department of Orthopaedic Surgery, Dr. Ziauddin Hospital Karachi from January 2012 to January 2014.

Methodology: This study was conducted on 80 admitted patients with intertrochanteric fracture of femur, age ranging from 22 – 95 years. All patients were treated with internal fixation using 135° DHS after achieving closed anatomical reduction. Post-operative follow-up was undertaken in outpatient department for a period of minimum six months. The union of fracture or failure of fixation was assessed on the basis of follow-up radiographs. Tip-Apex Distance (TAD) was calculated on pre and post-operative radiographs. The data base was developed on SPSS on the basis of filled in proforma. The frequency of mechanical failure of fixation was presented by counts along with its percentage and 95% confidence interval. The degree of association of TAD was tested by logistic regression analysis. Other confounding factors such as age, gender, quality of bone and mechanism of injury were tested for their association with failure of fixation by chi-square test.

Results: There were 45 (56.3%) males and 35 (45.7%) female patients with a mean age of 62.4 ± 19.4 (22 – 90) and 65.1 (40 – 95) respectively. Male to female ratio was 1: 0.78.

Among 80 patients, tip apex distance (TAD) < 25 mm was found in 50 patients out of whom implant failure occurred in one (2%) patient, followed by 22 patients had TAD of 25-49 mm out of whom, implant failure occurred in 8 (36.4%) patients. TAD of >49 mm was found in 8 patients and implant failure occurred in only one (12.5%) patient in this category of TAD. Data have shown significant association of implant failure with TAD of 25-49 mm ($p < 0.001$)

Conclusion: The tip-apex distance of greater than 25mm is associated with increased rate of implant failure. Also increasing age of the patients and severe osteoporosis (Singh's Index grade 1 to 3) are also associated with a significantly increased risk of implant failure.)

Key Words: Intertrochanteric fracture, Dynamic Hip Screw, tip-apex distance, Implant failure.

Introduction:

Intertrochanteric fractures are most frequent fractures of the proximal femur and occur predominantly in geriatric patients.¹ These are al-

ways extracapsular and vascularity of femoral head is rarely compromised. Internal fixation of these fractures has advanced greatly in recent decades and DHS (Dynamic Hip Screw) is the

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implant of choice with or without trochanteric stabilizing plate (TSP).⁴ The Proximal femoral nail (PFN), Dynamic Condylar Screw (DCS) and Condylar plate may be valid alternative options in selected cases.⁵ One-piece rigid nail plates like Jewett nail plate have been used in past.⁶ The predisposing factors for implant failure include unstable fractures, severe osteoporosis, poor fragment reduction or inadequate placement of lag screw.⁷ The commonest cause of failure of fixation of intertrochanteric fractures treated with DHS is cutting out of the screw from the femoral head.^{7,8} The quality of bone for purchase within the head and neck varies from one quadrant to another. The optimal position of a compression screw should be central or slightly inferior and posterior.⁹ The bone of poorest quality is in the anterosuperior aspect of the head and neck.¹⁰

Kyle et al¹¹ and Cleveland et al¹² divided femoral head into superior, central and inferior thirds on the anteroposterior view and into anterior, central and posterior thirds on the lateral view, giving a total of nine separate zones. This system of nine zones did not account specifically for the depth of penetration of the screw but they recommended central placement.

In addition the depth of lag screw insertion measured is also highly predictive of implant failure by cutout.³

A simple measurement has been developed to describe the position of the screw in femoral head termed as the tip-apex distance (TAD).¹³ Baumgaertner et al³ described the tip apex distance (TAD) as the sum of the distances from the apex of the femoral head to the tip of the lag screw on both anteroposterior and lateral roentgenograms, correcting for magnification.¹⁴ The apex of femoral head is defined as point of intersection between the sub-chondral line and line passing in the centre of the neck. Baumgaertner technique for calculation of TAD is as under:

$$TAD = \left(X_{ap} \times \frac{D_{true}}{D_{ap}} \right) + \left(X_{lat} \times \frac{D_{true}}{D_{lat}} \right)$$

D_{true} :	Actual diameter of the shaft of lag screw used (8 mm in the study in all cases)
D_{ap} or D_{lat} :	The diameter of the shaft of the lag screw on the immediate post-operative AP and lateral views
X_{ap} or X_{lat} :	Tip to apex distance, recorded from immediate postoperative AP and lateral views
TAD:	tip-apex distance

The present study aims to determine the frequency of mechanical failure of fixation of intertrochanteric fractures using DHS, to determine degree of association of tip-apex distance with rate of implant failure using DHS and to describe clinico-demographic features (age, sex, side of fracture, quality of bone as described by Singh's index etc.) of these cases.

Methodology:

This research work was conducted at the department of Orthopaedic surgery, Dr. Ziauddin Hospital Karachi from January 2012 to January 2014. This is a prospective cross sectional study done on 80 admitted patients with intertrochanteric fracture of femur, age ranging from 22 – 95 years. All patients were treated with internal fixation using 135° DHS after achieving closed anatomical reduction. Post-operative follow-up was undertaken in outpatient department for a period of minimum six months. The union of fracture or failure of fixation was assessed on the basis of follow-up radiographs. Tip-Apex Distance (TAD) was calculated on pre and post-operative radiographs. The data base was developed on SPSS on the basis of filled in proforma. The frequency of mechanical failure of fixation was presented by counts along with its percentage and 95% confidence interval. The degree of association of TAD was tested by logistic regression analysis. Other confounding factors such as age, gender, quality of bone and mechanism of injury were tested for their association with failure of fixation by chi-square test. Purposive

Sampling technique was used. The inclusion criteria included age more than 25 years (after complete closure of epiphysis), close fracture and the ability to walk unassisted prior to the injury. The exclusion criteria were presentation after two weeks of initial trauma, multiple fractures, reverse oblique fractures (Evans type-II)¹⁷, previous fracture or dislocation of hip, anatomic anomaly (e.g Coxa Vera, Developmental Dysplasia of Hip etc.), pathological fracture and osteomyelitis or soft-tissue infection at the fracture site.

All patients with intertrochanteric fracture of the hip were admitted at Accident & Emergency and Orthopaedics clinic, a full history and physical examination were performed. Patients that fulfilled the inclusion criteria were recruited after taking the informed consent. Pre-operative roentgenograms of affected hip were taken.

Fracture patterns were categorized according to Evans classification.¹⁷ All relevant features including patient's bio-data, clinical and radiological findings during hospital stay and follow up visits were recorded on proforma. Patients were treated with close reduction and internal fixation with 135° DHS. Immediate post-operative radiographs of both AP and lateral views of operated hip taken by image intensifier were used for measurement of tip-apex distance. Post-operative follow up was undertaken in out patient department for a minimum period of 3 months or until union of fracture or failure of fixation. The union of fracture or failure of fixation was assessed on the basis of follow-up radiographs.

The data was entered and analyzed by SPSS ver-

sion 12.0. Ratio (Male: Female) was computed to present gender distribution. Patient's age was presented by Mean \pm SD. For categorical variables like patient's history, comorbidities, type of fracture, side of fracture, Grades of osteoporosis according to Singh's index, types of anesthesia, Tip apex distance (TAD), operative complications and nature of implant failure were presented by frequencies and percentages. Chi-square test was applied to determine the degree of association of Tip apex distance (TAD) with rate of implant failure. P-value ≤ 0.05 was considered statistically significant result.

Results:

This study was conducted on 80 patients of intertrochanteric fractures. Mean \pm SD age was 63.5 \pm 17.1 years (Range = 22 – 95 years), age of 56 (70%) cases was 40 – 79 years, 16 (20%) cases had age > 79 years while 8 (10%) cases had age < 40 years. (Figure-1)

Among these 80 patients there were 45 (56.3%) males and 35 (43.7%) females with sex ratio Male: Female = 1.3: 1.

Out of 80 patients, 70 (87.5%) patients had history of fall in different modes while 10 (12.5%) came with history of RTA (Figure 2).

Hypertension (HTN) was the commonest comorbidities found in 7 (8.75%) cases followed by Ischemic Heart Disease (IHD) in 4 (5%) cases, Diabetes Mellitus (DM) was found in 3 (3.75%) cases, HTN & IHD found in 2 (2.5 %) cases, HTN & DM, while Chronic obstructive pulmonary disease (COPD) and Chronic Renal Failure (CRF) were found in (2.5 %) cases. (Table-1)

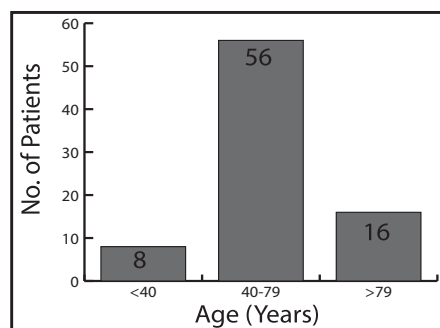


Figure 1: Age Distribution (n=80)

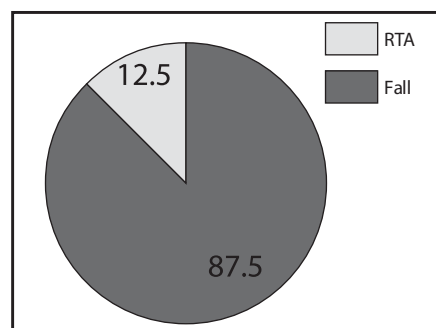


Figure 2: Mechanism of injury (n = 80)

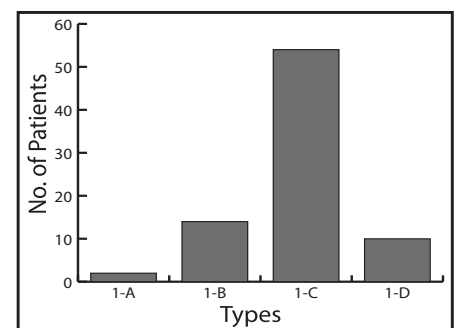


Figure 3: Types of fracture (n = 80)

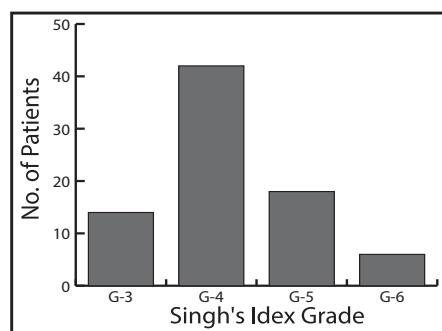


Figure 4: Grades of osteoporosis according to Singh's index of osteoporosis (n = 80)

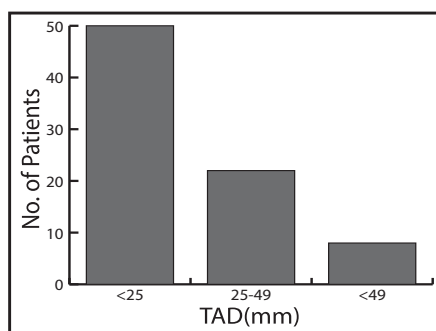


Figure 5: Tip apex distance (TAD) as seen on immediate postoperative radiographs (n = 80)

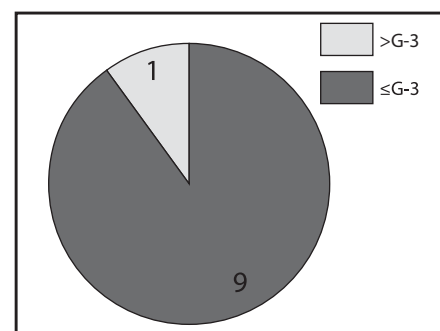


Figure 6: Distribution of implant failure according to Singh's index of osteoporosis (n = 10)

According to Evans classification there were 54 (67.5%) type I-C, 14 (17.5%) type I-B, 10 (12.5%) type I-D and 2 (2.5%) type I-A. (Figure-3)

There were 46 (57.5%) right sided fractures and 34 (42.5%) left sided fractures.

According to Singh Index Grade, there were 42 (52.5%) cases of grade-4, 18 (22.5%) cases of grade-5, 14 (17.5%) cases of grade-3 and 6 (7.5%) cases of grade-6. (Figure-4)

According to type of anaesthesia, spinal anaesthesia was given in 43 (57.5%) cases while general anaesthesia was given in 37 (46.3%) cases.

Mean \pm SD TAD was 31.4 ± 13.1 mm

(range 8 to 66 mm). There were 50 (62.5%) patients having TAD < 25 mm, 22 (27.5%) patients having TAD 25 – 49 mm and 8 (10%) cases having TAD > 49mm. (Figure-5)

Implant failure was found in 10 (12.5%) cases and Wound Infection in 1 (1.25%) case.

Among 80 patients, tip apex distance (TAD) < 25 was found in 50 patients out of whom implant failure occurred in one (2%) patient, followed by 22 patients had TAD of 25-49 mm out of whom, implant failure occurred in 8 (36.4%) patients. TAD of >49 mm was found in 8 patients and implant failure occurred in only one (12.5%) patient in this category of TAD. Data have shown significant association of implant failure with TAD of 25-49 mm ($p < 0.001$) as detailed in Table-2.

Out of ten cases of implant failure, 6 (60%) were females and 4 (40%) males.

Out of ten implant failure 9 (90%) cases were observed in \leq grade-3 and 1 (10%) case observed in > grade-3 as shown in figure-6.

According to nature of implant failure, lag screw cut out from femoral head was seen in all 10 (100%) cases, loosening of lag screw within femoral head was observed in 3 (30%) cases and varus displacement was seen in 1 case (10%).

Discussion:

In this study there were 45 males (56.3%) and 35 (45.7%) female patients with a mean age of 62.4 ± 19.4 (22 – 90) and 65.1 (40 – 95) respectively. Male to female ratio was 1: 0.78. In most

Table 1: Distribution of comorbidities (n = 80)

Comorbidities	Frequency	Percent
HTN	7	8.75
IHD	4	5
DM	3	3.75
HTN & IHD	2	2.5
HTN & DM	2	2.5
COPD	2	2.5
CRF	2	2.5

Key: HTN = Hypertension, DM = Diabetes Mellitus, IHD = Ischemic Heart Disease, COPD = Chronic Obstructive Pulmonary Disease, CRF = chronic renal failure

Table 2: Association of tip apex distance (TAD) with rate of implant failure (n = 80)

Tip Apex Distance (TAD)	Implant outcome		
	Successful	Failure	Total
< 25	49 (98%)	1 (2%)	50
25 – 49	14 (63.6%)	8 (36.4%)*	22
> 49	7 (87.5%)	1 (12.5%)	8

Chi-square=16.5, p-value< 0.001*Shows significant association of implant failure with TAD of 25-49 mm.

of the studies the incidence of intertrochanteric fractures in females was high ranging from 1.5 to 12 times more than males.³ Our study showed male predominance. All patients whose mechanism of injury was RTA were males. Some male patients gave history of fall on their way to mosque for morning prayer due to both bad light in early morning and low visual acuity of these patients.

It was also evident that with increasing age, the risk of intertrochanteric fractures also progressively increased. This observation was also noted by Bandion et al.¹⁸ According to their study incidence of intertrochanteric fractures were more in females with increasing age. Females were usually 5 years older than males.³ In our study average difference in males and females was 2.7 years, as the average age of people is increased, more and more people live beyond 70 years, and at this age almost all have a bone mineral density lower than the fracture threshold.¹⁹ Due to these factors age also effect on screw cut out and act as a positive variable in predicting implant failure, whereas, sex of the patients had no significant effect on the rate of cut out. Although it is also well known that size of most bones are on average greater in men than in women.²⁰ But above the age of 60 bone loss in males and females are equal therefore it is not the sex of the patient which effect the rate of implant failure but the grade of osteoporosis which is significant. By comparing different studies it was seen that proportions of implant failure were significantly high in "Singh index" grade less than 3. In our study nine out of ten cases of implant failure had Singh index grade less than 3 and only one case greater than 3.^{21,22}

It was also noted that mean age in our study at the time of fracture was less probably because of less life expectancy in this region as mentioned by Dhal et al.²³ In Europe, according to different studies the mean age is of 70 – 80 years or more.³ But De Lucas et al.²⁴ showed 59.5 years of mean age. On the other hand, in India Kamble et al.²⁵ showed range of 50 – 94 years. Dhal et al.²² noted the mean age 62 years in their patients. In our study the average age of patients in whom the

screw cut out took place was 63.5 ± 17.1 years (Rang = 22 – 95 years). In our study there were 46 (57.5%) right sided fractures and 34 (42.5%) left sided fractures. In other series 53% by Brayn²⁶ 56% by Clark and Ribbans²⁷ and 54% by Lewng et al.²⁸ were noticed on left side. Pun et al.²⁹ found more (53%) hip fractures on right side.

Implant failure in intertrochanteric fractures treated by DHS is frequently related to the position of the lag screw in femoral head. Cleveland et al.³⁰ describe the location of implant into 9-zones. With this method, the femoral head is divided into superior, central and posterior thirds on the AP view and into anterior, central and posterior thirds on lateral view, thus making total of 9-zones in which screw can be located.

The ideal location for placement of screw in the femoral head has been the subject of controversy. According to mechanics, central placement of lag screw within the femoral head is the best because the centre of rotation of hip and the resultant force of hip is applied on the femoral head therefore the tip of implant must be as close as possible to the centre of femoral head. Anterosuperior zone is related to high incidence of cut out.³

The depth of screw insertion is also important. In order to gain good purchase, it is essential to insert the screw well into the femoral head. According to Snaib et al.³¹ 6 – 7 mm of sub articular distance is safe. Whereas Davis et al.³² found more complication when subarticular distance was less than 10mm in Kunsher Y-nail group but for DHS this distance did not appear to be critical.

Baumgaertner et al.³ found tip-apex distance (TAD) of more than 25mm was related to high incidence of implant failure.

In our study Mean \pm SD TAD was 31.4 ± 13.1 mm (range 8 to 66 mm) there were 62.5% patients having TAD < 25 mm, 27.5% patients having TAD 25 – 49 mm and 10% cases having TAD > 49mm

In our study the implant failure was observed in 10 (12.5%) cases. Among 80 patients, tip apex distance (TAD) < 25 was found in 50 patients out of whom implant failure occurred in one (2%) patient, followed by 22 patients had TAD of 25-49 mm out of whom, implant failure occurred in 8 (36.4%) patients. TAD of >49 mm was found in 8 patients and implant failure occurred in only one (12.5%) patient in this category of TAD. Data have shown significant association of implant failure with TAD of 25-49 mm ($p < 0.001$). The rate of about 5 – 10% has been reported for implant failure in different studies.³³ In some studies the rate of implant failure of sliding hip screw has been reported to as high as 10 – 23% and as low as zero.³⁴

By comparing the nature of implant failure in different studies it is evident that cutting out is more common complication than varus displacement, implant bending, uncoupling of implant and loosening from the shaft. In our study there were 3 cases of loosening of implant and one case of varus displacement along with cut out of lag screw. Studies have shown that restricted weight bearing after hip surgery has no biomechanical justification.¹³ The patients were allowed up in a chair the day after surgery. When active straight leg raising became possible, partial weight-bearing with crutches or a walker was allowed. Progressive weight-bearing was based on roentgenographic evidence of callus formation. The majority of patients returned to their pre-morbid level of basic function within 4 – 6 weeks of surgery.

Conclusion:

The findings of study demonstrate that:

- TAD is an important factor in the outcome of treatment of intertrochanteric fracture using DHS implant.
- Rate of implant failure is 12.5%.
- The tip-apex distance of greater than 25-49 mm is associated with increased rate of implant failure.
- The incidence of male to female and left to right side hip fracture was more in our study.
- Also increasing age of the patients was also associated with a significantly increased risk

of implant failure.

- Singh index less than grade 3 is associated with more implant failure.
- The average age of male at the time of fracture was less as compared to female in this study.

We would recommended that the TAD should be less than 25mm to avoid implant failure in intertrochanteric fracture using DHS and to achieve stable fixation, hence we can say that TAD of less 25mm is safe and more than 25mm may result in penetration of implant, non-union and other complications.

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