

## Original Research Article

# Functional and radiological outcomes of intertrochanteric fractures treated with proximal femoral nail

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### ABSTRACT

**Background:** Hip fracture is one of the most invalidating diseases affecting geriatric populations and in fall related fractures, they lead to most severe morbidity and mortality. Their surgical treatment allows stable fracture fixation which allows the early weight bearing. Many devices have been developed, yet mechanical failures still occur. The aim of this study was to assess the functional and radiological outcomes of intertrochanteric fractures treated with proximal femoral nail.

**Methods:** 46 patients with intertrochanteric fractures fixed with proximal femoral nail were assessed. Functional outcome was measured by Harris hip score (HHS) and lower extremity functional scale (LEFS) and radiological outcome was measured by tip apex distance (TAD), any changes in neck shaft angle, neck length and the offset as compared to uninjured hip.

**Results:** The tip apex distance on the postoperative X-ray was found to be  $22.02 \pm 2.499$  mm, change in the neck length as compared to the uninjured hip was found to be  $1.507 \pm 1.1808$  and change in the offset and neck shaft angle was  $1.470 \pm 1.0126$  and  $-1.602 \pm 1.5992$  respectively. The LEFS was found to be  $70.63 \pm 6.584$  whereas the HHS was found to be  $90.35 \pm 7.593$

**Conclusions:** With the increase in TAD the functional and radiological outcome worsens. It was also seen that the cutoff of 25 mm stands true in predicting the outcome of the patients with PFN in intertrochanteric fractures. Hence, the TAD should be routinely measured and if found more than 25 mm then proper precautions like delayed weight bearing may be advised.

**Keywords:** Proximal femoral nail, Intertrochanteric fractures, Hip fracture, Harris hip score, Lower extremity functional scale

### INTRODUCTION

Among the fall related fractures, hip fractures lead to the most severe health problems and reduced quality of life thus causing the greatest number of deaths.<sup>1</sup> High velocity injuries, generally seen in young adults with more comminution are more difficult to treat as the soft tissue destruction associated with them is more and hence, are associated with more complications as

compared to low velocity injuries in the elderly osteoporotic population.

The incidence of hip fracture rises dramatically with increasing age. Jacobsen et al estimated that, in the mid-1980s in the United States, the annual incidence in 65-year-old white women was 1.6 per 1,000 compared with 35.4 per 1,000 in 95-year-old white women.<sup>2</sup> The incidence of hip fracture is higher in women than in men.

Male: Female ratio being 1:3. Risk factors include neurological impairment, malnutrition, impaired vision, malignancy, and decreased physical activity. The Indian population appears particularly vulnerable to the problem of osteoporosis and hip fractures.<sup>3</sup> It has been projected that by the next century 50% of all hip fractures in the world will occur in Asia.<sup>4</sup>

A hip fracture is generally a fracture of the proximal femur. Such injuries may be divided into three categories, according to the anatomical area in which they occur. Femoral neck and intertrochanteric fractures account for over 90% of hip fractures, occurring in approximately equal proportions and sub trochanteric fractures account for the remaining 5-10%.<sup>5</sup>

The aim of the surgical treatment of these fractures is to achieve stable fracture fixation that will allow early weight bearing. Many different devices have been developed, yet mechanical failures still occur. The literature, as noted from the early 1800s, revealed that intertrochanteric hip fractures were treated conservatively with prolonged bed rest, prolonged traction in bed, or prolonged immobilization in a full-body (Spica) cast.

Though healing rates for previous nonsurgical methods may have been acceptable, they were accompanied by unacceptable morbidity and mortality rates because of frequent non-orthopaedic complications associated with prolonged immobilization or inactivity, hence, surgical intervention has replaced previous non-surgical methods. Several methods of internal fixation were advocated in the treatment of trochanteric fractures, like fixed angle blade-plate by Jewett, variable angle nail plate by McLaughlin, Schumplick Jantzen described sliding screw plate, modified by Massie and finally evolved into the present day Richard compression screw system as described by Multholland and Gunn.<sup>6,7</sup> Though internal fixation was logically the best way to restore stability and mobility, early attempts met with failure because of a high risk of infection as reported by Bartel and high mortality caused by surgical trauma on debilitated patients.<sup>8,9</sup>

To reduce the extensive surgical trauma, intramedullary devices were designed, which could be inserted by closed technique causing minimal surgical trauma to the patient. The primary goal in the treatment of an elderly patient with intertrochanteric fracture is to return the patient to his/her pre-fracture activity as early as possible.

The tip-to-apex distance has been described by Baumgaertner et al.<sup>10</sup> as a useful intraoperative indicator of deep and central placement of the lag screw in the femoral head, regardless of whether a nail or a plate is chosen to fix the fracture. The tip-apex distance is defined as the sum of the distance in millimetres from the tip of the lag screw to the apex of the femoral head, as measured on an antero-posterior and lateral radiograph after correction has been made for magnification. This is

perhaps the most important measurement of accurate hardware placement and predictive of success after the treatment of intertrochanteric fracture.<sup>11,12</sup>

The outcome in hip functional status can be very well assessed with the help of Harris hip scoring system and lower extremity functional scoring system.<sup>13-15</sup> We have used both these clinical scoring systems to determine the ideal screw placement in regards to the Tip apex distance. The clinical assessment is dependent on the radiological outcome of the proximal femoral nailing in intertrochanteric fractures.

The failure may occur in the way of cut out of the sliding hip screw or the decrease in the neck shaft angle which causes the varus collapse in the proximal femur. This decrease in the neck shaft angle of femur is often associated with the decrease in the functional outcome of the patient. This is also associated with the decrease in the neck length of the femur. There has not been much work done to assess the correlation between the TAD and the clinical outcome of the fractures. There are less instances of the backing out of the screws and hence, there has not been any conclusive data regarding the appropriate tip apex distance and the ideal fixation in cases of the intertrochanteric fractures treated by proximal femoral nails.

With the increasing popularity of proximal femoral nail in treating intertrochanteric fractures and superiority of its results over Dynamic Hip Screw (DHS) in case of unstable intertrochanteric fractures there is a need of a criteria to evaluate the proper placement of the screws in terms of tip apex distance and also to compare it with the functional outcome. In this study we intended to quantify the parameters for the ideal screw placement and its clinical outcome.

## METHODS

This study was a prospective study carried out in the department of orthopedics at Medanta – The medicity, Gurgaon, India over a period of 6 months from September 2016 to February 2017. A total of 46 patients coming with intertrochanteric fracture of femur who were treated with proximal femoral nail were informed about the study and after an informed consent their immediate postoperative X-rays were analyzed for tip apex distance (TAD) neck-shaft angle and following which the patients were assessed using the Harris hip score and the lower extremity functional scoring system along with any complications, like backing out of screws, cut out, and change in the neck length and the change in the neck shaft angle. All the observations and measurements were done by a single observer.

Inclusion criterion include: closed intertrochanteric fractures, patients with intertrochanteric fractures of less than 3 weeks and age above 25 including both sex groups. Exclusion criteria include: open fractures,

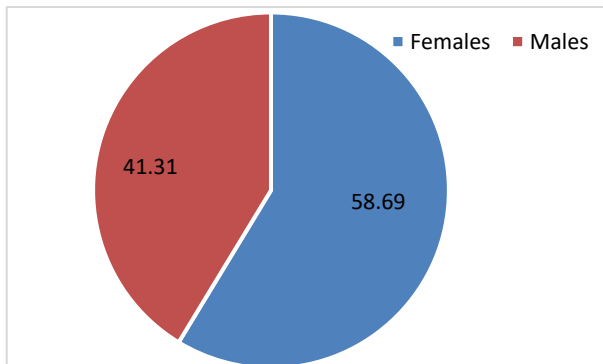
fractures of more than 3 weeks, age below 25 years and patient unfit for surgery and Patient already operated elsewhere.

**Statistical analysis**

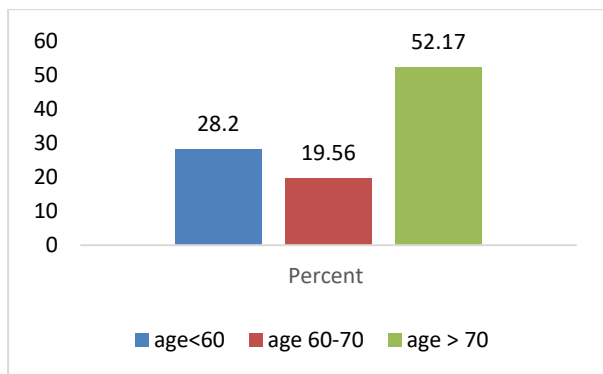
The analysis included profiling of patients on different demographic and clinical parameters. Descriptive analysis of quantitative data was expressed as means and standard deviation. Categorical/Ordinal data were expressed as percentage, median and range. Cross tables were generated, and chi square test was used for comparisons & associations. Independent Student t-test was used for comparison of individual quantitative parameters between groups and paired t-test for within the group, p<0.05 was considered statistically significant. SPSS software, version 24.0 was used for analysis.

**RESULTS**

In our study, we noted a female predominance with affected females being 58.69% of total affected patients (Figure 1). The female:male ratio was 1.42:1 overall. In our study, 28.2% of the total patients were less than 60 yrs of age, 19.56% between 60-70 yrs, 52.17% more than 70 yrs of age with youngest being 37 yrs of age and eldest being 85 with a mean age of 67.72 (years).



**Figure 1: Percentage age of females and males in our study.**



**Figure 2: Percentage age of patients in different age groups.**

In radiological outcome the tip apex distance (in mm) was minimum 18.00 and maximum was 29.00 with a mean of 22.02±2.499. The neck shaft angle change was from -5.1 to 3.2 with mean change of -1.602±1.5992. The neck length change was from -2.8 to 3.3 with mean change of 1.507±1.1808. The offset change was from -2.7 to 2.8 with mean change of -1.470±1.0126.

Functionally the HHS in our study was from 56.00 minimum to 98.00 maximum with mean being 90.35±7.593. The LEFS score ranged from minimum 42 .00 to 77.00 maximum with mean 70.63±6.584 (Table 1).

**Table 1: showing functional and radiological outcome of our study.**

	Minimum	Maximum	Mean
Tip apex distance	18.00	29.00	22.02±2.499
Neck shaft angle change	-5.1	3.2	-1.602±1.5992
Neck length change	-2.8	3.3	1.507±1.1808
Offset change	-2.7	2.8	-1.470±1.0126
HHS	56.00	98.00	90.35±7.593
LEFS	42.00	77.00	70.63± 6.584

**DISCUSSION**

The increasing trend of intertrochanteric hip fractures and subsequent treatment methodologies are also dynamically changing in pace with the incidence and changing expectations of the patients. Technological shifts, advancements in skill levels, increasing affordability has not only prompted the availability of newer methods but has also contributed towards improvement in existing treatment modalities with a focus on improvement of quality of life and early restoration of functional status without causing discomfort.

The placement of the screw in the femoral head has been recognized as an important variable in the outcome of the intertrochanteric fracture managed with proximal femoral nail. Previous studies comparing the outcomes between DHS and IM devices (PFN) have shown that IM devices are associated with decrease in operative time, intraoperative blood loss, limb shortening and shorter duration of hospital stay. Even biomechanically the IM devices have shown to be more advantageous in the outcome of the fracture such as low number of lag screw cut outs.

With the increase in the frequency of PFN the failures of PFN have also come into picture. These mainly include screw cut out. This cut out of the screw has been attributed to various factors including the bone quality of the femoral head, screw length and purchase of the screw. This has brought upon an urgent need to control the surgeon dependent factors, i.e. the screw placement and

the quality of reduction. The screw placement has 2 components: the quadrant of placement and depth of screw placement. The quadrant of the placement of the screws cannot be controlled in proximal femoral nail due to the presence of the antirotation screw. Hence, the factor which can be controlled remains the depth of screw insertion, vis-a-vis the tip apex distance. Hence, the calculation of the tip apex distance of the lag screw has not gained much popularity.

Therefore, with this background in mind in the present study we have calculated the tip apex distance and compared it with the radiological and functional outcome of the intertrochanteric fractures managed by PFN.

For evaluating the clinical outcome the Harris Hip Score, Lower Extremity Functional Scale were estimated. Both these scales have been widely used as the gold standard and have proved to be very reliable in a number of studies.<sup>15-18</sup> Both these scores were calculated by a single observer to avoid any interobserver variation and also to avoid any bias.

The present study shows that the majority of patients were females with 58.7% females whereas 41.3% were males. Most of the works have shown a higher prevalence of hip fractures in females as compared to males.<sup>19-21</sup> The higher risk in elderly females has been reported to be associated with higher risk of osteoporosis in postmenopausal women. In Indian context, this risk is even higher among female owing to nutritional deficiency and low calcium intake.<sup>22,23</sup>

The majority of cases were due to fall at home (54.3%) followed by road traffic accident (45.7%), this is mainly due to fracture is more in old age group population.

On the prospective analysis it is seen that the majority of fractures were of Type 2 fracture configuration (45.7%) followed by Type 3 fracture configurations (26.1%). Luis et al. in a study of 54 patients of intertrochanteric fractures found 77.78% of fractures to be unstable. In this study there were more than 50% of cases had unstable fractures which was attributed to the large percentage of either due to fall or due to RTA. All the fractures were treated as soon as possible

In all the calculations the magnification of the X-rays was taken into account and subtracted accordingly. The mean tip apex distance was calculated as 22.02 with a standard deviation of 2.499 in this study. This was comparable to various studies found in the literature.

There was a decrease in the neck shaft angle as compared to the uninjured hip of all the cases which may be attributed to partial varus collapse. The mean change in the neck shaft angle was found to be  $-1.602 \pm 1.5992$  whereas Pajarinen J et al. found neck shaft angle change to be  $-3.9 \pm 2.6$ .<sup>32</sup> There was an increase in the mean neck length and the offset calculated as compared to the

uninjured hip with both the hips in 15 degrees of internal rotation.

**Table 2: Comparison of mean TAD between the current and the previous studies.**

Study	Modality of fixation	Mean TAD
Guven et al <sup>24</sup>	DHS	17.14
Geller et al <sup>12</sup>	PFN	20
Andruszkow et al <sup>25</sup>	PFN	19.65
Lindsay et al <sup>26</sup>	DHS/PFN	23.4/ 24.1
Siwach et al <sup>27</sup>	DHS	20.24
Escolar et al <sup>28</sup>	PFN	23.8
Zirngibl et al <sup>29</sup>	PFN	24.8
Uzun et al <sup>30</sup>	PFN	24.2
Davies et al <sup>31</sup>	DHS/PFN/Gamma nail	19
Present study	PFN	22.02

The possible causes might include, increased vascularity due to the fracture causes increased osteogenesis leading to increase in the neck length, irregularity of the trochanter causing the length calculated to be longer than the actual length and increased callus formation in and around the trochanter might have led to the increase in the calculated length of the femoral neck length.

This finding also concludes that compression is not that important for the union of the intertrochanteric fractures. The values were found to be comparable to the study by Pajarinen et al.<sup>32</sup> where there is mention of change in neck length and the offset after 3 months postoperative period.

**Table 3: Comparison between the mean change in neck length and offset between the present and the reference study.**

Study	Change in neck length	Change in offset
Pajarinen J et al. <sup>32</sup>	$2.3 \pm 2.5$	$0.1 \pm 1.9$
Present Study	$1.507 \pm 1.1$	$1.470 \pm 1.01$

The functional outcome was measured by the HHS and the lower extremity functional scoring system. The mean Harris hip score was found to be  $90.35 \pm 7.593$ . This mean HHS was comparable to various studies found in the literature.

The mean Lower Extremity functional scoring system was found to be 70.63 (SD 6.584). In the present study it was seen that cases having a higher tip apex distance (25) were prone to have lesser neck length, offset and neck shaft angle as compared to the patients having lower tip

apex distance (25) and eventually these patients were prone to have screw cut outs unlike the other group of patients. As seen there was a significant difference between the screw cut out group and the non-screw cut out group. This is the criteria which have been widely

assessed in the literature as the criteria for successful and unsuccessful outcome of the proximal femoral nail in intertrochanteric fracture femur. These results were comparable with that found in the literature.

**Table 4: Comparison between the mean Harris hip score between the current and the references studies.**

Mode of treatment	Guven et al <sup>24</sup>	Siwach et al <sup>27</sup>	Akan et al <sup>33</sup>	Uzun et al <sup>30</sup>	Tandon et al <sup>34</sup>	Present study
DHS	88.71	92.87	-	-	-	-
PFN	-	-	73.58	82.1	86.6	90.35

**Table 5: Comparison between the mean average tip apex distance in screw cut out group between the current and the references studies.**

Mode of treatment	Guven et al <sup>24</sup>	Geller et al <sup>12</sup>	Kraus et al <sup>35</sup>	Escolar et al <sup>28</sup>	Zirngibl et al <sup>29</sup>	Bruijn et al <sup>36</sup>	Uzun et al <sup>30</sup>	Present study
DHS	36.67	-	-	-	-	25.9	-	-
PFN	-	38	41.3	32.2	24.7	-	24.2	29

On calculation of the correlation in between the tip apex distance with the clinical and radiological outcome in patients having complications it was seen that the patients having the screw cut out it was seen that there was a

negative correlation between the HHS and the neck length and the offset. This indicated that with the increase in the neck length and the offset there was a decrease in the functional outcome of the patients.

**Table 6: Comparing the outcome of the current study with the previous studies.**

Study	Mode of treatment	Study groups of 25mm>TAD>25mm	Outcome Criteria	Result
Guven et al <sup>24</sup>	DHS	Yes	Screw cut out	Screw cut out more in TAD>25 mm
Geller et al <sup>12</sup>	PFN	Yes	Screw cut out	Screw cut out more in TAD>25 mm
Andruszkow et al <sup>25</sup>	DHS/PFN	Yes	Screw cut out/ Neck Shaft angle (NSA)	Screw cut out more in TAD>25 mm.
Nikoloski et al <sup>37</sup>	PFN	3 groups: 1 <sup>st</sup> group TAD<20, 2 <sup>nd</sup> group TAD = 20-30, 3 <sup>rd</sup> group TAD>30	Screw cut out	Screw cut out more if TAD <20 and TAD >30.
Kraus et al <sup>35</sup>	PFN	TAD>30 and TAD<30	Screw cut out.	Screw cut out more in TAD>30 mm.
Davies et al <sup>31</sup>	PFN	Yes	Screw cut out.	Screw cut out more in TAD>25 mm.
Kelkar et al	PFN	Yes	Harris hip score (HHS)	Harris hip score increases with TAD<25 mm
Present study	PFN	Yes	Screw cut out/ HHS/LEFS/ Neck Length/ Offset/NSA	HHS/ LEFS/ NSA/ Neck Length and Offset all significantly higher in the group with TAD<25 mm and without any complications.

In the patients having uneventful healing of the fracture it was seen that the TAD had a strong negative correlation with the functional scores whereas there was a positive correlation between the neck shaft angle, neck length and

the offset. Hence, it was concluded that with the increase in the TAD, the HHS decreased which is in accordance to the search of literature. Also with the increase in the neck shaft angle, neck length and the offset, the functional



score improved which indicates that, the lesser the degree of collapse, varus deformation and medialization of the femur the better is the functional outcome of the study.

To check the significance of the value given for the tip apex distance i.e. 25 mm all the patients were divided into 2 groups of TAD>25 and TAD<25. There was a significant difference between the 2 groups in both radiological and the functional outcome. There was a significant decrease in the neck shaft angle, neck length and offset along with the decrease in the functional scoring. This was comparable to the previous studies done. As the functionality of the patient is also dependent on the age of the patient hence, a correlation was calculated between the radiological and functional outcome of the patient with the age of the patient. It was seen that there was very minimal negative correlation seen between the age of the patient and radiological criteria's whereas a significant negative correlation was seen in the between both the functional criteria's of assessment and the age which proved that with the increase in the age of the patient the functional capability of the patient decreases.

## CONCLUSION

This study done in Medanta the Medicity 46 (27 females) follow up patients with the mean age of 67.72±12.357 years with majority of the cases being due to fall with proximal femoral nail in intertrochanteric fractures showed that with the increase in the Tip apex distance the functional and radiological outcome worsens. It was also seen that the cut off of 25 mm stands true in predicting the outcome of the patients with PFN in IT. Hence, the TAD should be routinely measured and if found more than 25 mm then proper precautions like delayed weight bearing may be advised.

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