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ORIGINAL ARTICLE

EVALUATION OF CLINICAL AND RADIOLOGICAL OUTCOME OF INTERTROCHANTERIC FRACTURES OF FEMUR TREATED WITH PROXIMAL FEMORAL NAIL, A PROSPECTIVE STUDY

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ABSTRACT: BACKGROUND & OBJECTIVES: Intertrochanteric fractures of femur is one of the most common fractures of the hip especially in elderly, accounting for 10 to 34% of all hip fractures. By 2040, the incidence is estimated to be doubled. Surgical stabilization of these fractures remains a challenge. Dissatisfaction with extra medullary devices especially in unstable fractures, led to the evolution of intramedullary devices. So the Proximal femoral nail was designed which gives an advantage of intramedullary device. This study analyses the radiological and functional outcome of treatment of intertrochanteric fractures with Proximal Femoral Nail. **METHODS:** This study is a prospective, time bound, hospital based study conducted in KEMPEGOWDA INSTITUTE OF MEDICAL SCIENCES AND RESEARCH CENTER, Bangalore, between November 2012 to May 2014. The study included 40 cases of intertrochanteric fractures that were operated with the proximal femoral nail. The fractures were classified according to AO/ASIF classification and were followed up at regular intervals. Clinical and radiological parameters including Tip-apex distance, position of tip of Lag screw in femoral head as well as lateral slide of lag screw were noted. Final functional outcome was assessed using Kyle's criteria. **RESULTS:** Good reduction was achieved in 90% of the cases. 65% had ideal placement of lag screw in femoral head (Inferior on AP view and central on LATERAL view). Intra-operative difficulties were encountered in 20% of the cases. Mean TAD_{AP} was 11.92 mm, TAD_{LAT} was 11.50mm and mean TAD_{TOTAL} was found to be 23.42mm. All but one fracture united on an average in 17.74 weeks. Overall mean average slide was 3 mm and it was more in unstable fracture. We had three cases (7.5%) of mechanical failure, one case (2.5%) of Z effect without screw cut through.80% patients returned to pre-injury levels of activity with 87.50% patients had good to excellent outcome as per Kyle's criteria. **CONCLUSION:** Proximal Femoral Nail provides good fixation for unstable intertrochanteric fractures, if proper preoperative planning, good reduction and surgical technique are followed, leading to high rate of bone union and minimal soft tissue damage. Proper reduction and placement of the screws are absolutely essential for successful fixation. Optimal position of lag screw is inferior on AP view and central on Lateral view. Tip apex distance should be kept to minimum, especially its AP component. The lag screw should be inserted deeply into the femoral head, close to sub chondral bone. Anti-rotation screw should be 10-15mm shorter than the lag screw.

KEYWORDS: Intertrochanteric fracture, proximal femoral nail, Kyle's criteria, Tip apex distance.

INTRODUCTION: Intertrochanteric fractures of femur is one of the most common fractures of the hip especially in elderly, accounting for 10 to 34% of all hip fractures.[1] By 2040, the incidence is estimated to be doubled. Surgical stabilization of these fractures remains a challenge. Dissatisfaction with extra medullary devices especially in unstable fractures, led to the evolution of intramedullary

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devices.[2,3] So the Proximal femoral nail was designed which gives an advantage of intramedullary device. Intramedullary devices offer certain distinct advantages.[4]

A. An intramedullary fixation device provides more efficient load transfer than does a Sliding hip screw, because of its location.
B. A shorter lever arm of the intramedullary device can decrease tensile strain on the implant so decreasing the risk of implant failure.
C. Because an intramedullary fixation device incorporates a sliding hip screw, the advantage of controlled fracture impaction is maintained.
D. The intramedullary location limits the amount of sliding and therefore limb shortening and deformity that can occur.
E. Insertion of intramedullary hip screw requires shorter operative time and less soft tissue dissection than a sliding hip screw, so decreasing the overall morbidity.

The proximal femoral nail, a recent AO-ASIF intramedullary device, has two screws. The advantages of two screws are.[5]

- More stable fixation.
- Prevention of rotation of proximal fragment.

It also has a specially shaped tip together with a smaller distal shaft diameter resulting in less stress concentration at the tip.

This study is an attempt to evaluate the effectiveness and safety of the proximal femoral nailing in intertrochanteric fractures of femur in our set up.

METHODOLOGY: between November 2012 and January 2014, 25 males and 15 females, aged 30-90 years (mean 68.35) presenting to our hospital with trochanteric fractures of femur underwent PFN fixation and were followed up for >12 months. Reduction was achieved by closed manipulation and traction under anaesthesia. Fixation used an intra-medullary nail (10-12 mm in diameter), a lag screw (8.0mm diameter) and a derotation screw (Hip pin- 6.4 mm in diameter). The lag screw was inserted near the sub chondral femoral head. The intramedullary nail was interlocked distally with one or 2 screws.

Post-operative radiographs were taken for evaluation. 2nd post op day, active quadriceps drill, free hip and knee movements were started on bed and the patient was made to sit.

Non weight bearing mobilization with walker was started as the wound reaction and patient acceptance improves around one week. Partial weight bearing walking was started at about 6 weeks post operatively. Full weight bearing walking was allowed after assessing for radiological and clinical union.

Radiological Evaluation: Radiological measurements of the post-surgery fixation device were performed using post-operative radiographic images. All measurements were scaled by a factor of the true lag screw width divided by the radiographic lag screw width measurement. We defined the neck-head transition points as the points where the head neck contour changes from the head convex, to neck concave contour. The head –neck interface was defined as the connection of these two points (L1). The neck center line was defined as a line perpendicular to L1, which crosses L1 in its center (L2).The head apex was defined as the point which the neck centre line crosses the femur head cortical bone (Figure 1).

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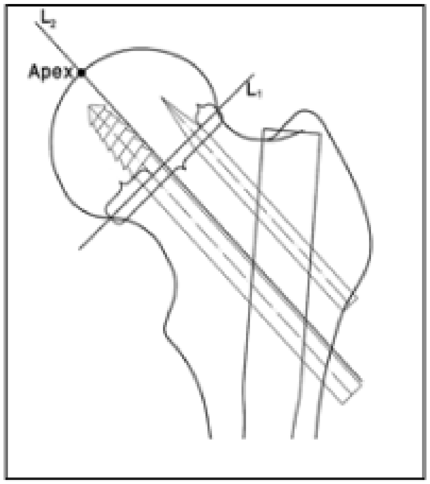

Fig . 1: Defining Apex

Fig. 2: The femoral head is divided into 9 sectors by drawing 2 parallel lines on the:
(a) Anteroposterior radiograph to divide superior and inferior parts and 2 parallel lines on the
(b) Lateral radiograph to divide anterior and posterior parts.

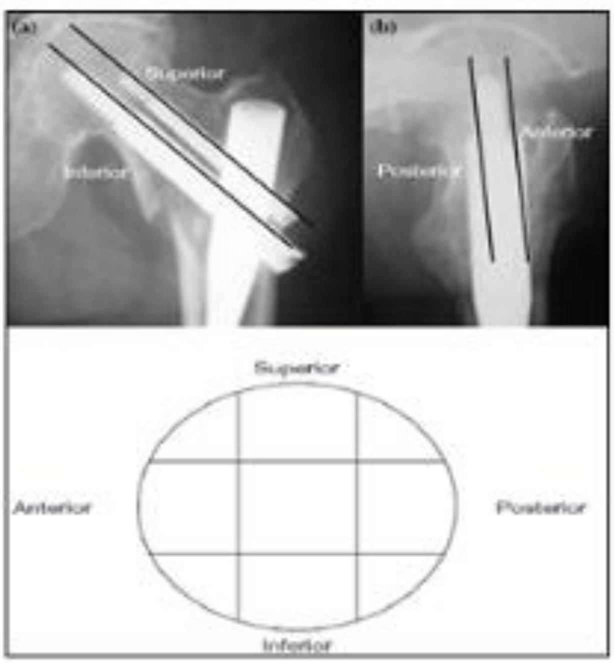

Fig. 2a, 2b

Quality of reduction: Quality of reduction was assessed using Baumgaertner criteria.[6]

Calculation of tip apex Distance: Tip apex distance was used to describe the position of the screw in femoral head. It was calculated by the method described by Baumgaertner ET al.[7]

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The tip apex distance is defined as the sum of the distance, in millimeters from the tip of the lag screw to the apex of the femoral head, as measured on the antero posterior radiograph and that distance measured on a lateral radiograph, after correction has been made for magnification.

For the purpose of this study, the immediate post-operative radiographs were used to measure the tip-apex distance (TAD). TAD was measured for only the lag screw as hip pin would be obscured by the lag screw in lateral view. The amount of radiographic magnification was determined precisely by dividing the diameter of the projected shaft of the screw as seen on the radiograph by its known diameter (8.0mm) and correction was achieved by multiplying the measurement of the distance by this factor. $TAD = TAD_{AP}+TAD_{LAT}$

Position of the Tip of Lag Screw in Femoral Head.[8]: To measure the influence of lag screw placement on migration, the femoral head was divided into 9 sectors by drawing 2 parallel lines on the antero posterior (AP) radiograph to divide superior and inferior parts and 2 parallel lines on the lateral radiograph to divide anterior and posterior parts. The position of the lag screw tip within the femoral head was then measured and charted upon the nine sectors of head marked (Figure 2). This method was devised by Parker et al.[9]

Measurement of lateral slide of the Lag Screw: The lateral slide of the lag screw after fracture consolidation was measured by comparing the immediate postoperative and final AP radiographs.[8] (Figure 3).

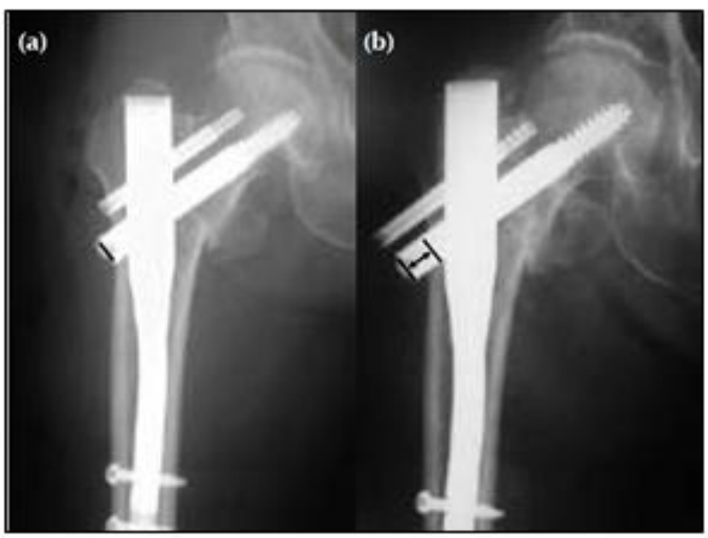

Fig. 3: Measurement of lateral slide of lag screw. (a) immediate post-op (b) final x ray

Final Functional assessment was done using kyle's criteria.[10] and level of independence was in activities of daily living was assessed using Barthel's index[11].

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RESULTS AND DISCUSSION:

Variables	value	
Age	**Mean 68.35 years(range 30-90 years)**	
Sex	Male	62.5%(n=25)
	female	37.5%(n=15)
Side affected	Left	45%(n =18)
	Right	55%(n=22)
Mode of injury	Trivial fall	97.5%(n=39)
	Road traffic accident	2.5%(n=1)
Pre injury walking ability	With support	12.5%(n=5)
	Without support	87.5 %(n=35)
Associated co-morbidities	Hypertension	42.5%(n=17)
	Diabetes mellitus	32.5%(n=13)
	Ischaemic heart disease	17.5%(n=7)
	Chronic renal failure	12.5%(n=5)
	others	15%(n=6)
Duration of hospital stay	**Mean 13.25 days**	**Range(6-23 days)**
Type of fracture	A1	17.5%(n=7)
	A2	80%(n=32)
	A3	2.5%(n=1)
Pre anaesthesia ASA grading	ASA 1 +ASA 2	42.5%(n=17)
	ASA 3 + ASA 4	57.5%(n=23)

Table 1: Demographic Details

Intra-Operative Details:

MEAN DURATION OF SURGERY(min)	**86 minutes(Range: 50-150 minutes)**
MEAN LENGTH OF INCISION(cm)	4.8 cm(Range: 4-8 cm)
MEAN BLOOD LOSS(ml)	171 ml(Range: 100-300 ml)
REDUCTION METHOD	Closed reduction in 39 patients 1 patient underwent joystick manoeuvre
NAIL ANGLE USED	135 ° nail – 77.5 %(n=31) 130 °nail - 22.5%(n=9)
NAIL DIAMETER USED	Size 10 mm - 22.5%(n=9) Size 11 mm - 50%(n=20) Size 12 mm - 27.5%(n=11)
SIZE OF 8.0mm(LAG) SCREW	Mean: 94.25 mm(80-110mm)
SIZE OF 6.4mm(ANTIROTATION) SCREW	Mean: 80mm(65-95mm)
DIFFERENCE BETWEEN LAG SCREW AND ANTIROTATION SCREW	Mean: 14.25mm(5-25mm) 10-15 mm shorter antirotation screw were used in 85 %(n=34) cases.
QUALITY OF REDUCTION	GOOD: 90%(n=36) ACCCEPTABLE:10%(n=4) POOR: NONE

Table 2: Intra-Operative Details

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Intra Operative Complications:

	Present series (n=40)	Fogagnolo[12] (n=46)	Tyllianakis[13] (n=45)	Schipper[14] (n=211)
Difficulty putting derotation screw	3(7.5%)	0	3(6.66%)	4(1.8%)
Fracture shaft of femur	1(2.5%)	0	1(2.22%)	0
Greater trochanter fracture	3(7.5%)	4(8.6%)	1(2.22%)	0
Guide wire breakage	1(2.5%)	2(4.3%)	0	0
Difficulty inserting nail	0	2(4.3%)	1(2.22%)	0
Conversion to open reduction	0	1(2.2%)	3(6.66%)	17(8.1%)
Difficult distal locking	0	5(10.8%)	5(11.11%)	3(1.4%)

Table 3: intra-operative complications

In our series, intraoperative difficulties were encountered in 20% (n=8) cases. We encountered 3 cases (7.5%) in which we had difficulty putting 6.4mm anti-rotation screw. Other complications encountered intra-operatively were fracture of the greater trochanter in 3 cases (7.5 %), guide wire breakage and fracture of shaft of the femur in one case each (2.5 % each). Domingo ET[15] reported 12% cases with operative difficulties. Most of the intra-operative difficulties arise directly as a result of faulty instrumentation set, improper reduction and improper entry point of the nail. Faulty instrumentation is a major source of difficulty in distal locking.

Problems in putting proximal screws: There can be problems while reaming over guide wire for hip screw, as guide wire may bend slightly as it reaches sub chondral bone. Now if one starts reaming over this, guide wire may break. We had one such guide wire breakage and we could not remove the broken guide wire tip. Also in 2 cases we were able to detect bending of guide wire but we could remove the guide wire before it actually broke.

To prevent guide wire breakage, we reamed up to the bend in the guide wire, then pulled the guide wire and then proceeded with reaming under C-arm guidance. The guide wire was reinserted after the removal of reamer for screw insertion. One should always pass the lag screw in the inferior part of neck in AP projection and centre in the lateral plane. If lag screw is in the centre then sometimes derotation screw goes too superiorly and even out of superior cortex of neck of femur.

Communition of greater trochanter: Communition of greater trochanter leads to technical difficulty in passing nail and nail entry point may get lateralized, and tip of trochanter can get splayed. However in the final follow- up, almost all patients have good abductor strength and do not have any significant disability related to that.

Fracture shaft of femur occurs at the tip of the nail due to inadequate reaming, too much force application during nail insertion or mismatch of femoral bow with that of nail. We had one such case, in which the nail was removed and long cephalomedullary nail was inserted.

Position of lag screw in femoral head: In our study, 65% (n=26) cases had ideal placement of lag screw viz inferior – central in femoral head. 27.5% (n=11) had placement in central-central quadrant in femoral head. This was recorded as per the method devised by Parker.[9]

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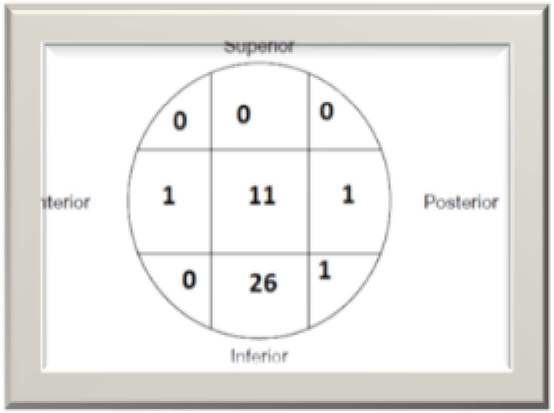

Fig . 4: Recording Femoral Lag Screw Placement in Femoral Head

Morihara.[8] (2007), in his study found the optimal position—inferior on AP view and central on lateral view, was achieved in 78/87(90%) patients. Kyuzky et al.[16] in their biomechanical study on position of lag screw in femoral concluded that the placement of lag screw inferiorly in the AP plane maximizes biomechanical stiffness, whereas placement of the lag screw centrally in the lateral plane maximizes load to failure.

Placement of hip screw is critical to the final result as placement of hip screw in superior part of neck can lead to cut out or varus collapse. In view of this, we believe, most important technical aspect of this surgery is maintaining the proper neck shaft angle and placing the lag screw in inferior portion of the head. Both are interlinked as screw placement angle is prefixed and hence unless good neck shaft angle is achieved, it is impossible to put the hip screw correctly.

Post-operative tip apex Distance:

Study	Sample	Mean TAD_{total}	Mean TAD_{AP}	TAD_{LAT}
Present study	40	23.4 mm	11.9 mm	11.5 mm
Amir herman et al[17]	227	20.7 mm	9.9 mm	10.0 mm
Fogagnolo et al[12]	46	27.2 mm	-	-
Metin uzen et al[18]	35	24.2 mm	-	-

Table 4: Comparison of tip-apex distance (TAD)

In our study, the mean TAD was 23.4mm. The concept of tip apex distance was introduced by Baumgartner.[7] and he recommended that TAD should be less than 25 mm. However, his recommendation was for single screw constructs unlike PFN which has two screws in the femoral head. Some authors.[12,18] have co-related large tip apex distance in PFN with that of screw cut out while others like Herman.[17] have questioned the validity of TAD for PFN.

However, all authors agree that the tip of the lag screw should be placed as close to the sub chondral bone as possible. The length of the anti-rotation screw is also important in this aspect. The PFN is fixed with 2 screws; the larger (lag) screw is designed to carry most of the load, and the smaller screw (The hip pin/anti rotation screw) is to provide rotational stability. If the hip pin is longer than the lag screw, vertical forces would increase on the hip pin and start to induce cutout, a

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knife effect or Z-effect. This might force the hip pin to migrate into the joint and the lag screw to slide laterally. Therefore the derotation screw is recommended to be at least 10 to 15 mm shorter than the lag screw.[8]

COMPLICATIONS:

COMPLICATION	Frequency
ISOLATED LATERAL THIGH DISCOMFORT	7.5%(n=3)
DEEP INFECTION, Z EFFECT, SCREW CUT THROUGH, LOSS OF REDUCTION*	2.5%(n=1)
SCREW BACK OUT,LOSS OF REDUCTION**	2.5%(n=1)
SCREW BREAKAGE,SCREW BACK OUIT, LOSS OF REDUCTION***	2.5%(n=1)
SUPERFICIAL INFECTION#	2.5%(n=1)
Z EFFECT, LATERAL THIGH DISCOMFORT,WITHOUT SCREW CUT THROUGH##	2.5%(n=1)

Table 5: Complications encountered

*(Case 40) - (Figure10) - This case presented with complication at 4 weeks follow up. He complained of severe hip pain and a small discharging sinus form proximal portion of the wound. Fracture pattern was AO 31A2.3 and post op tip apex distance in AP, LATERAL and TOTAL were 13mm, 16mm and 29 mm respectively. Quality of reduction was assessed as “good” and the tip to the lag screw in femoral head was CENTRAL on both the views. The tip of the anti-rotation screw was almost at the level in the femoral head. His x ray showed severe “z effect” with anti-rotation screw migrating medially and penetrating into the joint along with lag screw backing out(cut out) laterally and tenting the skin. The reduction too was lost. His implant was removed and conservative management with skeletal traction was adopted. Infection subsided with IV antibiotics and the fracture united at 22 weeks.

**(Case 39) - (Figure 11) This case with AO 31A2.1 fracture presented with near complete lateral backing out(cut out) of both the screws with loss of reduction and varus collapse of the fracture. Tip apex distance on immediate post op radiographs TAD_{AP} 13mm, TAD_{LAT} 12mm, TAD_{TOTAL} 25mm and the quality of reduction was assessed as “good”. Position of the tip of lag screw was CENTRAL on both AP and Lateral views. The tip of the anti-rotation screw was distal to the tip of lag screw.

Possible reasons for failure in this patient could be inappropriate length of the screws. The implant was removed and re-fixation was done with PFN. Re-do PFN also suffered similar screw back out after 10 weeks along with secondary varus collapse of the fracture. The patient did not consent for another surgery and is presently wheelchair bound with the fracture un-united at 24 weeks follow up.

***(Case 38) - (Figure 8,9) This case with the fracture pattern of 31A1.2 came with loss of reduction and varus collapse of the fracture along with proximal anti rotation screw breakage and lateral back-out of the lag screw.

There was no back-out of the anti-rotation screw. His immediate post op X ray reveals TAD_{AP} 18.2 mm, TAD_{LAT} 20.6 mm and TAD_{TOTAL} 38.8mm and good reduction according to

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Baumgartner's criteria. While the position of lag screw in the femoral head was found out to be central on AP view and central on lateral view, the anti-rotation screw tip was distal to the tip of lag screw. The follow up X ray with failure showed that the lag screw had lost its purchase in the head and had cut out with its tip lying in the neck. The anti-rotation screw was broken but the tip of the anti-rotation screw was in its place as in immediate post op radiograph.

In this case probably the large tip apex distance of 38.8 mm combined with inappropriate length of anti-rotation screw caused excessive stress on the anti-rotation screw, leading to failure. Implant removal and re-fixation with PFN was done and the fracture united by 14 weeks of repeat surgery. Although there was little back-out of the lag screw even in the re-do PFN, the fracture united and the patient had good functions and no complaints of pain.

This patient developed superficial infection of the operative wound in the immediate post-operative period. Wound debridement and secondary suturing was done. The wound healed and the patient was discharged on 20th day.

- This patient had mild "Z effect" with solid union in 12 weeks. TAD_{AP}, TAD_{LAT} and TAD_{TOTAL} were found to be 10mm, 12.2mm and 22.2 mm respectively. Quality of reduction was "good" and the tip of the lag screw was inferior in AP and central in LATERAL view. The functional outcome was assessed as "fair" according to Kyle's criteria.

	Present series	**Fogagnolo[12]**	**Boldin[19]**	**Werner[20]**	**Al yassari[21]**
Sample size	40	46	55	70	70
Intra-op difficulties	20%	23.4%	18.7%	25.7%	10.5%
Cut out(no. of patients)	3	5	2	6	4
Implant failure (no. of patients)	1	2	-	2	0
Fracture below the tip (no. of patients)	1	1	-	1	1
Z effect without loss of reduction (no. of patients)	1	0	3	0	0
Re-operation rate	7.5%	19.10%	18%	19%	7.1%

Table 6: Comparison of complications with various studies

Incidence of technical failure due to screw cut out varies in literature. Cut-out of the implant was reported in one subject among a series of 46 fractures by Tyllianakis et al.[13], in one out of 191 subjects by Simmermacher et al.[22], in four out of 295 subjects by Domingo et al.[15], in four out of 76 subjects by Alyassari.[21] in two out of 55 subjects by Boldin et al.[19] 11 out of 211 subjects by Schipper et al.[14] The screw cut out has been analyzed separately in this section.

In literature, frequency of requirement for secondary operation in intertrochanteric fractures treated with PFN varies. Domingo et al.[15], 3.3%, Banan et al.[23] 6.5%, Simmermacher et al.[22] 7%, Al-yassari et al.[21] 7.1%, Boldin et al.[19] 18%, Schipper et al.[14] 18.4%, Fogagnolo.[12] 20%, Tyllianakis.[13]

28.8% reported a secondary operation rate. In our study two patients were re-operated for screw cut out and one for superficial infection.

Z-effect is a specific complication of PFN. The Z-effect phenomenon is referred as a characteristic sliding of the proximal screws to opposite directions during the postoperative weight-bearing period; normally a vertical force passing from the center of the femoral head tends to move the affected hip into varus as soon as the patient is mobilized. This leads to normal sliding of both proximal screws achieving the expected compression at the fracture site. In some cases this sliding occurs only to one of the proximal screws while the other remains in its initial position leading to penetration of the femoral head Reverse Z-effect means lateral migration of anti-rotation (hip) pin.[15] Tylianakis et al.[13]detected Z-effect in five subjects and reverse Z-effect in one subject (Out of 45), Boldin et a.l[19] detected Z-effect in three subjects (Out of 55).

Time to Union: In our study, the mean fracture union time was 17.74 weeks. One fracture remained un-united even at 24 weeks (Failure of re-do PFN). If we take out the cases with mechanical complications where re-intervention was required, 37 out of 40 fractures united, with average time taken for union as 17.2 weeks.

Lateral slide of lag Screw: (Figure 6,7) The overall mean lateral slide of lag screw, in our study, excluding the cases with screw cut out was 3.03 mm(Range 0-11mm). The mean lateral slide in A1 fractures was 2.33mm (Range 0-4mm) while in type A2 fractures it was 3.28mm (Range 0-11mm). The lateral slide was more in A2 type of fractures (Unstable). This lateral slide of the lag screw is purely because of the impaction of the fracture. As the fracture unites, the proximal fragment gets impacted onto the distal fragment and nail construct. This impaction of the proximal fragment leads to lateral slide of both the proximal screws and is an indirect measure of collapse of the fracture. Restriction of the sliding mechanism in the femoral neck screw-nail assembly may initiate cut-out or penetration of the joint.

Shortening: In our study, average shortening was 4mm. 22.5% of the patients (n=9) had a shortening of one or more centimeter.

Barthel's Index.[11]: The mean pre-op barthel score was 98 while mean final Barthel score was 91.5. Mean change in barthel score was 6.5(6.5 %). 80%(n=32) of our patients recovered to pre-injury levels of activities with change in Barthel's score of equal to or less than 5. Significant change in Barthel score occurred in 20% (n=8) cases.

Functional Assessment: 87.50% (n=35) cases had good to excellent functional outcome as per Kyle's criteria.[10] in our study. (23 patients had excellent and 12 had good outcome, while one patient had poor outcome, and 4 had fair outcome.)Gadegon.[24] and pavelka.[25] in their studies reported 90 % and 92% good to excellent functional outcome.

Mechanical Failure: We encountered 3 patients with screw cut out. One of which was associated with infection, and two without infection. The mean TAD calculations were considerably higher in the group with screw cut out than in the group with no screw cut out

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COMPARISON OF TIP APEX DISTANCE IN CASES WITH SCREW CUT OUT VS THOSE WITHOUT CUT OUT

Present series		
	No cut out of screws (n=37)	**Mechanical failure (n=3)**
Mean TAD_{AP}	11.69 mm	14.73 mm
Mean TAD_{LAT}	11.12 mm	16.2 mm
Mean TAD_{TOT}	22.81 mm	30.93 mm

Table 7: comparison of TAD in cases with mechanical complications vs. those without

In all three cut out cases, the tip of the anti-rotation screw was distal to the tip of the lag screw. The PFN is fixed with 2 screws; the larger (lag) screw is designed to carry most of the load, and the smaller screw (The hip pin) is to provide rotational stability. If the hip pin is longer than the lag screw, vertical forces would increase on the hip pin and start to induce cutout, a knife effect or Z-effect. This might force the hip pin to migrate into the joint and the lag screw to slide laterally.[19]

Morihara ET al.[8] in 2007, reported no cut-out of lag screws, not even Z-effect after operating 87 patients with intertrochanteric fractures with a proximal femoral nail. They concluded that when the anti-rotation screw was 10 to 15 mm shorter than the compression screw, it prevented overloading of the anti-rotation screw and cut-out in all cases.

In all three cases, position of the tip of lag screw in femoral head was central in AP and central in Lateral projection. In an AP projection it is recommended that the tip of lag screw be inferiorly to prevent any cut out. This has been proved by biomechanical studies.

Kyuzky et al.[16] in their biomechanical study on position of lag screw in femoral concluded that the placement of lag screw inferiorly in the AP plane maximizes biomechanical stiffness, whereas placement of the lag screw centrally in the lateral plane maximizes load to failure.

In view of this, we believe, most important technical aspect of this surgery is maintaining the proper neck shaft angle and placing the lag screw in inferior portion of the femoral head. Both are interlinked as screw placement angle is prefixed and hence unless good neck shaft angle is achieved, it is impossible to put the hip screw correctly.

So a combination of high TIP – APEX DISTANCE, incorrect placement of the lag screw in femoral head in AP plane as well as inappropriate length of the screws led to failure of the fixation in our cases.

We recommend minimizing the Tip Apex distance (Especially in AP plane) by placing the tip of the lag screw deep in the femoral head below the sub chondral bone (5 mm short of it). This also ensures adequate purchase in the proximal fragment and also prevents placement of longer anti-rotation screw. Equally important is the careful placement of lag screw in inferior portion of femoral head. This can be ensured by appropriate anatomical reduction of the fracture, maintaining the proper neck shaft angle and by not accepting even a slight varus reduction (Valgus reduction may be accepted, and in fact is recommended in unstable fractures as more impaction and varus occurs in unstable fractures during union).

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CONCLUSION: Proximal Femoral Nail provides good fixation for unstable intertrochanteric fractures, if proper preoperative planning, good reduction and surgical technique are followed, leading to high rate of bone union and minimal soft tissue damage. Proper reduction and placement of the screws are absolutely essential for successful fixation. Optimal position of lag screw is inferior on AP view and central on Lateral view. Tip apex distance should be kept to minimum, especially its AP component. The lag screw should be inserted deeply into the femoral head, close to sub chondral bone. Anti-rotation screw should be 10-15mm shorter than the lag screw.

Our recommendations for an ideal Fixation:

1. Accurate reduction of the fracture is very essential for proper fixation with proximal femoral nail. If closed reduction is not achieved, one may need to go for open reduction.
2. The entry point determination is the most crucial step in this procedure, which is the tip of trochanter.
3. The optimal position of compression screw - inferior on AP view and central on lateral view.
4. Tip apex distance should be kept to a minimum, especially in Anter oposterior plane.
5. The compression screw should be inserted deeply into the femoral head close to the sub chondral bone minimizing the tip apex distance.
6. The short PFN is fixed with 2 screws; the larger compression screw is designed to carry most of the load, and the smaller anti rotation screw is to provide rotational stability. The anti-rotation screw should always be 10 to 15 mm shorter than the compression screw, to prevent overloading of the anti-rotation screw and Z effect. Tip of the anti-rotation screw in the femoral head should never be at the same depth or deeper than lag screw tip.
7. Unstable fractures should be initially reduced to a slightly valgus position during short PFN surgery, because the neck-shaft angle would decrease during the first 6 postoperative weeks. One should never accept varus reduction.

Because of the short period of this study, less number of subjects and other limitations, a longer and randomized controlled study in Asian population is required.

Illustrations: Figure 6, 7- Illustration of lateral slide of lag screw.

Fig. 6: Immediate post op

Fig. 7: After 6 weeks

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Fig. 8: Implant failure (Left)

Fig. 9: Follow up of re-fixation (Right)

Fig. 10: z effect

Fig. 11: Implant failure with varus collapse

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