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### Optimal fracture site compression of trochanteric region fracture managed with proximal femoral nailing at the time of surgery: Analysis of clinico-radiological and functional outcome

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#### Abstract

**Objectives:** Proximal Femoral Nail (PFN) with dual cephalic screw configuration is now widely used for the management of trochanteric region fracture. Good fracture reduction and intraoperative achievement of optimal fracture site compression are very important surgical steps of proximal femoral nailing. There is very limited information available in the literature regarding trochanteric region fracture site compression while fixation by PFN with dual cephalic screws (lag and anti-rotation screws). We are practicing a technique of intraoperative compression of fracture site by alternate tightening of lag and anti-rotation screws of PFN. The aim of this study is to evaluate the clinico-radiological and functional outcome of trochanteric region fracture management by PFN with intraoperative adequate fracture site compression achieved by this method.

**Materials and Methods:** Total of 47 patients, who underwent PFN fixation for trochanteric region fractures during September 2017 to October 2019 with 12 months follow-up period, were included in this prospective study. Fractures were classified according to the AO/OTA system; the most common fracture type 31A2 (n = 28), followed by 31A1 (n = 18) and 31A3 (n = 1). At the time of PFN fixation, fracture site compression was performed by a combination of two surgical steps - 1) by giving firm manual pressure towards the medial direction with the help of PFN Jig after nail insertion into the medullary canal, maintaining this pressure till fixation of both lag and anti-rotation screws and 2) alternate tightening of the anti-rotation and lag screws till final sitting of both screws was achieved. Clinical and radiological parameters, including quality of reduction, tip-apex distance (TAD), the lateral slide of a lag screw, length of both cephalic screws as well as complications, were measured. Functional outcome was assessed using Harris Hip Score (HHS).

**Results:** Good reduction was achieved in 89.4% of cases. Mean TAD AP (anteroposterior) was 11.6 mm, mean TAD LAT (lateral) was 11.1 mm and mean TAD<sub>Total</sub> was 22.7 mm. Overall mean lateral slide was 3.2 mm and it was more in unstable 31A2 fracture. The HHS at 12 months postoperatively was excellent in 20 (42.6%), good in 16 (34.0%), fair in 5 (10.6%), and poor in 6 patients (12.8%).

**Conclusion:** Intraoperative fracture site compression achieved by alternate tightening of the anti-rotation and lag screws of PFN shows excellent to good results in the management of trochanteric region fractures and a low incidence of complications.

**Keywords:** trochanteric region fracture, proximal femoral nail, anti-rotation screw, lag screw

#### Introduction

Trochanteric region fractures are a very common orthopaedics problem, accounting for 33–50% of all hip fractures<sup>[1-3]</sup>. The majority of fractures occur in elderly patients<sup>[1]</sup>. Management of these fractures is often challenging as many of these fractures are associated with severe osteoporosis. The treatment of these fractures has evolved along with advances in the design of the implants used for osteosynthesis. There is a pragmatic shift towards using intramedullary implants for the treatment of such fractures as extramedullary implants have performed less satisfactory results in unstable fracture pattern<sup>[4-6]</sup>. PFN is one of the intramedullary implants, now extensively used. PFN has two cephalic screws. The proximal cephalic screw is known as the anti-rotation screw/hip pin and distal cephalic screw is known as lag screw/hip screw. Intraoperative fracture site compression is achieved by alternate tightening of the anti-rotation

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and lag screws till final sitting of both screws. Literatures showing results of PFN with intraoperative adequate fracture site compression achieved by this method are very limited. Therefore, to enhance the literature, this study was performed with an evaluation of the clinico-radiological and functional outcome of trochanteric region fracture managed by PFN with intraoperative adequate fracture site compression achieved by this method.

## Material and Methods

### Study Design

This prospective study was carried out in the Department of Orthopaedics, American International Institute of Medical Sciences, Udaipur, Rajasthan, India, from September 2017 to October 2019. A total of 47 patients, aged 27 to 89 years who underwent PFN fixation for trochanteric region fractures were included in this study after taking the approval of the protocol review committee and institutional ethics committee. After taking informed consent, detailed history regarding the nature of the fall, the associated medical comorbidities of the patient was documented. Patients who met the inclusion and exclusion criteria were included in this study.

### Inclusion Criteria

- Skeletally mature patient.
- Trochanteric region fracture.
- Fracture with less than 2 weeks duration.

### Exclusion Criteria

- Fractures extending well below the lesser trochanter.
- Polytrauma patients.
- Open fracture.
- Tumor patients with pathological fractures.
- Patients with previous ipsilateral hip or femur surgery possibly affecting functional outcomes.

All patients were evaluated preoperatively with the use of standard plain radiographs - anteroposterior radiographs of the pelvis including both hip joints, femur with knee joint and lateral radiographs of hip with the proximal 2/3<sup>rd</sup> of femur. The fracture was classified according to AO/OTA classification<sup>7</sup>.

### Methodology

The surgery was performed on a fracture table under spinal anesthesia. The patient was positioned supine on a traction table. The unaffected leg was abducted as possible so that fluoroscopic examinations were easily carried out. Fluoroscopy-guided closed reduction of all fractures was attempted. Only after failure of closed reduction, limited open reduction was done. Through the lateral approach, the entry point was made with an awl at the tip of the greater trochanter. Proximal reaming for PFN was done. The proximal diameter of PFN is 15 mm and the neck-shaft angle is of either 130° or 135°. Neck shaft angle of 130° was used in this study. Length of the nail used was 240 mm in most of the cases. If excessive bowing of the femur was present, then a nail length of 180 mm was used. After insertion of nail into medullary canal, an attempt was made to compress the fracture site by a combination of surgical steps - 1) by giving firm manual pressure towards medial direction with the help of PFN Jig, maintaining this pressure till fixation of both anti-rotation screw (6.4 mm diameter) and lag screw (8.0 mm diameter) and 2) alternate tightening of the anti-rotation and lag screws till final sitting of both screws is achieved. Position

two guide wires were checked under fluoroscopy. The distal guide wire was placed in the most inferior part of neck as seen on anteroposterior view and in the center of neck on lateral view. The PFN incorporates two parallel cephalic sliding screws. Anti-rotation screw was inserted first, followed by a lag screw. Distal locking was performed using a jig in static and dynamic mode for unstable and stable fracture patterns, respectively. Intraoperative and postoperative events were recorded. The intraoperative time was recorded from the time that close reduction was started to the time that the wound was sutured. Intravenous antibiotic, analgesic and DVT prophylaxis were given according to institutional protocol. Postoperative rehabilitation included passive and active-assisted lower limb exercises, and mobilization in a sitting position at day one. Toe-touch weight-bearing with walker support was started at day two and full weight-bearing was undertaken only after the radiological union. Patient was discharged from the hospital usually on the 7<sup>th</sup> or 8<sup>th</sup> postoperative day and reviewed at the end of 2<sup>nd</sup> weeks, 6<sup>th</sup> weeks, 12<sup>th</sup> weeks, 18<sup>th</sup> weeks, 6<sup>th</sup> months and for final follow-up at 12<sup>th</sup> months. At every follow-up, x-ray were taken and radiological parameters were assessed. Immediate post-operative radiographs were considered as a baseline for subsequent implant-related measurements. Quality of reduction, tip apex distance (TAD), position of tip of lag and anti-rotation screws in the head were assessed on the immediate post-operative radiograph. The quality of reduction was assessed as per Baumgartner's criteria<sup>[8]</sup>.

**Table 1:** Baumgartner's reduction quality criteria<sup>[8]</sup>

Criteria
1. Alignment -
a. Anteroposterior view: normal or slight valgus neck-shaft angle.
b. Lateral view: less than 20° of angulation.
2. Displacement -
Less than 4 mm displacement of any fragment on either view.
Reduction quality -
Good: both criteria met.
Acceptable: only one criterion met.
Poor: neither criterion met.

TAD was used as a method of evaluating the head screw position of the implants. TAD is the sum of the distance from the tip of the lag screw to the apex of the femoral head on an anteroposterior radiograph and this distance on a lateral radiograph, after controlling for magnification. TAD was calculated by the method described by Baumgartner *et al.*<sup>[8]</sup> with modification for cephalomedullary nail<sup>[9]</sup>. Apex was marked in both the views for calculation of TAD. The distance between the tip of screw and apex in that particular view was defined as TAD in that view. [TAD<sub>total</sub> = TAD<sub>AP</sub> + TAD<sub>lateral</sub>.] TAD was measured for the lag screw only as the anti-rotation screw gets obscured by the lag screw in lateral view. For the measurement of lateral slide of a lag screw, immediate post-op and final AP radiographs were compared as described by Morihara *et al.*<sup>[10]</sup>. Functional outcome was assessed using Harris Hip Score<sup>[11]</sup>.

### Statistical analysis

The recorded data was compiled and entered in a spreadsheet computer program (Microsoft Excel 2010) and then exported to the data editor page of SPSS version 19 (SPSS Inc., Chicago, Illinois, USA). Descriptive statistics included the computation of percentages and means.

**Results**

Demographic details of 47 patients are enlisted in Table 2. Males were 68.1%, while the rest were females. The mean age of participants was 71 years. The largest age group of patients was 61-80 years (42.6%). 9 patients who died or lost during 1 year follow-up, were not included in this study. The mode of injury was shown in table 3. The commonest mode of injury was slip and fall (55.3%). The majority of fractures were of 31A2 type (59.6%, Table 4). Closed reduction was achieved in 45 patients (95.7%), while 2 patients (4.3%) needed limited open reduction. The quality of reduction as per Baumgartner’s criteria [8] in immediate postoperative radiographs was good in 42 patients (89.4%), acceptable in 5 patients (10.6%) and no patient was classified as poor reduction. Intraoperative details are compiled in table 5. Intraoperative difficulty includes bending of a guide wire for a lag screw (inferior guide wire) near its tip while drilling in 5 cases (10.6%). The Bended guide wire was removed immediately and replaced with a new guide wire. Mean TAD<sub>AP</sub> was 11.6 mm, mean TAD<sub>LAT</sub> was 11.1 mm and mean TAD<sub>Total</sub> was 22.7mm. The mean number of blood transfusion units the patients required during the hospital stay was 1.2 units (range: 0–3 units). The overall mean lateral slide of compression screws was 3.2 mm (range 0 to 10 mm), after exclusion of case with screw failure. Unstable fracture patterns had more slides than stable ones. 31A1 fractures had a mean slide of 2.3 mm (range 0-4 mm), while 31A2 type had

3.5 mm (range 0-10 mm). The 31A3 type (1 case in this series) had a lateral slide of 3 mm. Complications and HHS are enlisted in table 6 and 7 respectively.

**Table 2:** Demographic profile of the study population

Variables	Number (n = 47)	Percentage (%)
<b>Gender</b>		
Male	32	68.1
Female	15	31.9
<b>Age</b>		
18-40 years	9	19.1
41-60 years	14	29.8
61-80 years	20	42.6
Above 80 years	4	8.5
Mean age	71 years (range 27-89 years)	
<b>Laterality</b>		
Right	26	55.3
Left	21	44.7

**Table 3:** Mode of injury

Nature of violence	Number (n = 47)	Percentage (%)
Motor Vehicle Accident (RTA)	19	40.4
Fall from height	2	4.3
Slip and fall	26	55.3

**Table 4:** Classification of trochanteric region fracture according to AO/OTA<sup>7</sup>.

Group	Number (n= 47)	Percentage
31A1- Simple pertrochanteric fracture.	18	38.3
31A2- Multifragmentary Pertrochanteric lateral wall incompetent (< 20.5 mm) fracture.	28	59.6
31A3- Intertrochanteric (reverse obliquity) fracture.	1	2.1

**Table 5:** Intraoperative details

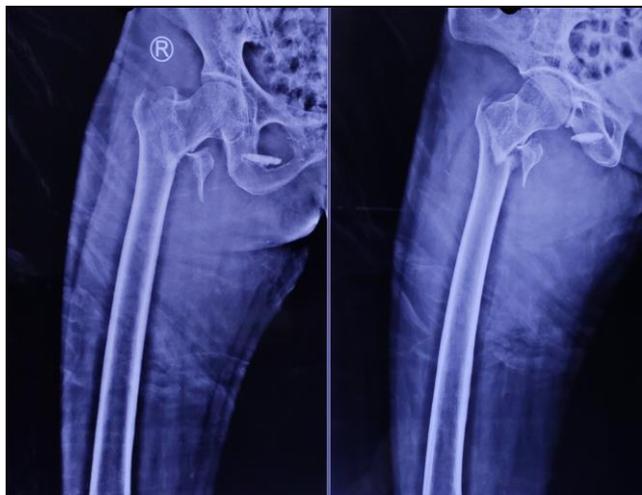
Variables	Value
a. Mean duration of surgery	65.3 minutes (range: 34–116 minutes)
b. Mean blood loss	160 ml (range: 100-350ml)
c. Nail diameter used	Size 10 mm – 38.3% (n=18) Size 11 mm – 48.9% (n= 23) Size 12 mm – 12.8% (n= 6)
d. Size of 8 mm (Lag) screw	Mean 95.10 mm (range: 80-105 mm)
e. Size of 6.4 mm (Anti-rotation) screw	Mean 78.10 mm (range: 70-90 mm)
f. Differences between lag screw and anti-rotation screw	Mean 14.95 mm (range: 10-25 mm), Anti-rotation screw was used 10-15 mm shorter than lag screw
g. Length of PFN	240 mm – 82.98% (n=39) 180 mm – 17.02% (n=8)

**Table 6:** Complications

Complication	n=47 (%)	Remarks
a. Z effect with loss of reduction	1(2.1%)	Occurred at 8 <sup>th</sup> week in 31A2 type fracture. Managed by exchange nailing with long PFN.
b. Periprosthetic fracture	1(2.1%)	Occurred after fracture consolidation at 7 <sup>th</sup> month following initial surgery, just distal to tip of PFN. Managed by PFN removal and Interlocking nailing.
c. Superficial infection	1(2.1%)	Culture was negative. Resolution of infection by debridement and intravenous antibiotics use.
d. Proximal lateral thigh pain	3(6.4%)	Mild symptom, no intervention required.
e. Shortening 1-1.5 cm Less than 1cm	2(4.3%) 36(76.6%)	No intervention required.

**Table 7:** Clinical and functional evaluation by using Harris Hip Score

Harris hip score	Number (n =47)	Percentage (%)
Excellent (90-100)	20	42.6
Good (80-89)	16	34.0
Fair (70-79)	5	10.6
Poor (<70)	6	12.8



**Fig 1:** Preoperative x-ray of trochanteric region fracture



**Fig 2:** Fracture united with no lateral slide of lag screw.

## Discussion

The best treatment of trochanteric region fractures remains controversial. Cephalomedullary nails are currently considered the implants of choice for the surgical treatment of patients with these fractures because of their biomechanical advantages, minimally invasive insertion technique, limited soft tissue injury and early rehabilitation [3, 6]. Extramedullary fixation has been associated with complications of fracture collapse and medialization of the femur in these fractures [12]. PFN is one of the cephalomedullary nails, now widely used. PFN has dual cephalic screws. There are benefits of using a dual cephalic screw over a single cephalic screw-in cephalomedullary nails. Dual cephalic screw constructs are believed to improve rotational stability and bony purchase within the femoral head, and to resist cut-out and subsequent fixation failure [12-14]. Based on biomechanical studies, dual cephalic screw nails have shown significantly stronger fixation compared to single cephalic screw nails when loaded to failure in an unstable trochanteric region fracture model [13]. Both cephalic screws of PFN are sliding screws and have configurations like a cannulated partially threaded cancellous screw. These screws were used for intraoperative fracture site compression. At the time of PFN fixation, fracture site compression was done by a combination of two surgical steps. First by giving firm manual pressure towards medial direction with the help of PFN Jig after nail insertion into the medullary canal, maintaining this pressure till fixation of both lag and anti-rotation screws and second, by alternate tightening of the

anti-rotation and lag screws till final sitting of both screws was achieved. Anti-rotation screw was inserted first with the aim to give compression in the lateral (superior) side of the fracture to prevent varus collapse. Next lag screw insertion and alternate tightening of both screws cause compression of the fracture site. Optimal compression of a fracture was determined by serial fluoroscopic images taken during alternate tightening of both screws. Optimal compression of a fracture helps in the union. As union progresses, proximal fragment gets impacted onto distal fragment, leading to lateral slide of both the cephalic screws. Fogagnolo *et al.* [15] in the series of 47 fractures, found that lateral protrusion of screws causing thigh pain was the most common postoperative complication, with an incidence of 21.2%. In this series, lateral thigh pain due to protrusion of screws was 6.4%. The mean lateral slide of compression screws was 3.2 mm (range 0 to 10mm), after exclusion of the case with screw failure. Low incidence of lateral thigh pain in this series is because of optimal fracture site compression achievement by above-mentioned technique at the time of nailing.

Good fracture reduction is an important factor for the successful management of trochanteric region fracture. Ponce *et al.* [16] reported that fracture malreduction has been associated with three times more risk of failure. The quality of reduction in this study as per Baumgartner's criteria [8] was good in 42 patients (89.4%), acceptable in 5 patients (10.6%) and no patient was classified as poor reduction. Conversion to limited open reduction (4.3%) in case of failure of close reduction is the reason behind this result.

Complications of PFN include risk for iatrogenic fracture or fracture comminution during nail insertion, cephalic screw cut out, z-effect, and reverse z-effect phenomena, femoral periprosthetic fracture, nonunion, infection, lateral thigh pain, limb shortening [15, 17]. Fogagnolo *et al.* [15] reported a fracture of greater trochanter during nail insertion in 4 cases (8.6%) while treating 46 patients with PFN (AO/ASIF). Using similar implants, Tyllianakis *et al.* [18] reported 1 greater trochanter fracture as well as 1 shaft fracture in their series of 45 patients. Proximal diameter of PFN (AO/ASIF) was 17 mm in both series whereas 15 mm was used in this study. Smaller proximal diameter of PFN uses was attributed to absence of greater trochanter fracture in the present series. If undue resistance was felt during PFN insertion, position of distal tip of nail was checked under fluoroscopy instead of forceful insertion by hammering. In case of excessive bowing of femur was found, nail length was changed from 240 mm to 180 mm (17.03% cases). This again contributed to the absence of intraoperative shaft fracture in this series.

Incidence of cephalic screw cut out is 0-16% [10, 19]. Cut-out of the head screw is a consequence of incorrect placement of the screw, rather than the type of implant itself. The TAD is a useful index to assess the risk of head screw cutout. A TAD > 25 mm is associated with an increased risk of cut-out [16]. In PFN two special types of screw cut out is seen due to z-effect, and reverse z-effect phenomena. The z-effect involves lateral migration of the inferior head screw and medial migration of the superior screw; reverse z-effect is the opposite [17]. In this study, Z effect occurred in one osteoporotic patient with a TAD of 32 mm resulting from improper length lag screw placement. Fracture united eventually after exchange nailing with long PFN and delayed weight-bearing.

Banan *et al.* [20] reported 2 cases of fracture below the tip of the nail after a second fall, out of 60 patients whereas Al-Yassari *et al.* [21] reported one case of fracture in a total of 76 patients. In this present series, periprosthetic fracture occurred

in a patient, after fracture consolidation of initial fracture, just distal to the tip of PFN at the end of 7<sup>th</sup> month with a history of second fall in bathroom. This case was managed by PFN removal and Interlocking nailing. Tip of nail is a potential stress riser in the anterior cortex of the femoral shaft, leading to fracture during the second fall.

Functional outcome of trochanteric region fracture treated by PFN was assessed by Uzun *et al* [22]. They used HHS to analyze functional outcomes. In their study of 35 patients, the results were excellent in 11 patients (31.4%), good in 15 patients (42.9%), fair in 7 patients (20%), and poor in 2 patients (5.7%). Using the same scoring system, Mavrogenis *et al* [17] in their study of 79 patients with dual head screw hip nailing, found the results as excellent in 16 (28.6%), good in 23 (41.1%), fair in 10 (17.8%), and poor in 7 patients (12.5%). In this study, excellent and good results were found in 42.6% and 34% of cases respectively. As with any other study, this study is also associated with some drawbacks. Sample size is small and there is no control in this study. Adequate sample size with a better design of study is required in future to eliminate these biases.

### Conclusion

Management of trochanteric region fracture by PFN needs good preoperative planning, accurate reduction of fracture, precise positioning of anti-rotation and lag screws with optimal intraoperative compression of fracture site. Intraoperative fracture site compression achieved by alternate tightening of the anti-rotation and lag screws of PFN shows excellent to good results in the management of these fractures and a low incidence of complications.

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