ORIGINAL ARTICLE

The Proximal Femoral Nail - A Minimal Invasive Treatment for the Stabilization of Pertrochanteric and Subtrochanteric Femoral Fractures

Deepinder Chaudhary

Abstract

This study reports the outcome in pertrochanteric and subtrochanteric femoral fractures in 25 patients treated by using PFN. Salvati and Wilson hip function scoring system and Kyle's criteria were used for follow up evaluation. At the end of 24 weeks follow up the Salvati and Wilson hip function was 32 (out of 40) in 88% of patients, the Kyle's criteria described the outcome as good or very good in 92% of patients and the level of function was similar to pre-injury level in 90% of patients. Distal locking difficulty was encountered in 3 cases. Difficulty in placement of neck screw was encountered in 4 cases. Secondary varus was noted in 3 cases and in 1 patient antirotational screw cut through was seen.However all fractures united well in all the patients.PFN was designed by AO/ASIF in 1996 for the treatment of peritrochanteric fractures.It combines the intrinsic advantages of the intramedullary nail and those of sliding screw is a valid and an important option in the treatment of pertrochanteric and subtrochanteric femoral fractures. It is a relatively easy procedure, a bio mechanically stable construct and a minimally invasive device; especially ideal in compromised elderly patients who are the majority population suffering from these type of fractures.With incorporation of single helical blade in place of two proximal screws in PFN, AO/ASIF has further enhanced the treatment modalities by devising PFNA (Proximal Femoral Nail Antirotation).

Key Words

Proximal Femoral Nail (PFN), Arbeitsgemeinschaft Fur Steosynthsefragen (AO/AISF), Pertrochanteric Fractures , Subtrochanteric Fractures

Introduction

This study was conducted to determine the suitability of PFN (1,2,3) (Proximal Femoral Nail) - (*Fig. 1*) as an appropriate method for minimal invasive treatment of pertrochanteric & subtrochanteric femoral fractures which can be difficult to manage particularly in non-compliant and elderly patients having high rate of implant failure and other complications.

The devices used for operative treatment of proximal femoral fractures are classified into extramedullary and intramedullary. Biomechanical studies have shown that intramedullary nail devices are more stable under loading with a shorter lever arm, but some earlier hip screw intramedullary nail devices most importantly the Gamma nail (4,5) were associated with significant number of tip of nail shaft fractures and with technical failures. To overcome these short comings the PFN was designed by AO/ ASIF6 in 1996 with incorporation of two main design differences. First, the introduction of anti-rotational 6.5 mm hip pin to reduce the incidence of implant cutout. Secondly, the fluting of nail tip so as to reduce the stress and therefore low energy fracture at the tip.

Material and Methods

A randomized prospective study was conducted on 25 adult patients with pertrochanteric and subtrochanteric femoral fractures treated with PFN during the period of one year who attended the out patient / emergency

From the Joint Replacement Center, Sir Ganga Ram Hospital, Old Rajinder Nagar- New Delhi - 10060

Correspondence to : Dr. Deepinder Chaudhary, Associate Consultant, Joint Replacement Center, Sir Ganga Ram Hospital, Old Rajinder Nagar- New Delhi

Department of Orthopaedics of Government Medical College, Jammu. The patients were randomly selected and divided into two groups: 12 patients of pertrochanteric fractures (n=12) and 13 patients with subtrochanteric fractures (n=13). AO/ASIF classification as proposed by Muler et al7 was used in classifying the fractures. The Salvati and Wilson hip scoring system (8) and Kyles Criteria (9) were used at follow up assessment. Adult patients above 18 years of both the sexes were selected and patients with polytrauma, old complicated fractures and pathological fractures were excluded from this study. Age, gender, prefracture walking ability and mechanism of injury were recorded. Preoperative walking ability was classified as without support, with a stick or in a wheel chair. Post operative radiological evaluation included fracture reduction and position of screws in the femoral head.

A fracture table and image intensifier were used in all cases.All patients received prophylactic intravenous antibiotics and prophylaxis of deep vein thrombosis. Patients were followed up in the out patient department at 2 weeks interval for the first 3 months and then at 4 weeks interval till the fracture union or fixation failure. At 6 months follow up the ambulatory status was assessed to include the need for assistance devices and pain felt on weight bearing.Radiographic analysis provided information on i). fracture fragment position, ii). lag screw position, iii). nail and fracture alignment and iv). extent of healing.

Standard PFN (Synthes-Stratec, oberdorf, Switzerland), was the implant used in this study. Its design is based upon the anatomical structure of the proximal femur. It is available in titanium alloy (Ti-6A1-7Nb) and stainless steel.It is 240 mm long nail with its distal part available in 9, 10, 11 or 12 mm diameter and its proximal part is 17 mm in diameter. The distal end is flexible with fluting of the nail tip to reduce the stress and therefore the low energy fracture at the tip. There is an anatomical 6o mediolateral bend which is situated 11 cm distal from the top of the nail. Two screws can be inserted through the proximal part; 11 mm neck screw and 6.5 mm antirotational screw. Distal locking is by 4.9 mm locking bolt which can be static or dynamic.An end cap is available to prevent in growth of tissues proximally. Standard PFN is available in CCD (Caput - Callum - Diaphysis) angle of 125^{o}/130^{o}/135^{o}.The lateral femoral line technique (10) was used to identify the correct femoral entry portal for insertion of PFN. A 5 cm incision was made along the lateral femoral line for the entry portal. After careful dissection of soft tissues the tip of greater trochanter was identified as entry portal as was originally described by Ebraheim *et al* (11). The proximal femur was opened by guiding the cannulated 17 mm drill bit over the guide wire through the protection sleeve. The measured nail was loaded on the insertion handle and was placed over the guide wire and inserted manuall After checking the position of the guide wires under C - arm the measured size of 11 mm neck screw and 6.5 mm anti rotational hip pin were inserted.The hip pin was kept 1 cm shorter than the neck screw. Distal locking (static/dynamic) was done free hand with 4.9mm bolt. The instruments were removed. The end cap was applied over the proximal end of nail. The negative suction drain was inserted at the entry point and the surgical wounds were closed back in layers. Aseptic dressing was done and three layered pressure bandage was done.

Results

As tabulated in *Table - I*, 25 patients were available with the mean age of 56.3 years with 17 males and 8 females for outcome analysis. In 58% of the patients fractures were of unstable type (31-A2 & 31-A3 of AO/ASIF classification) and in remaining 42 % patients fractures were of stable type (31- A1 of AO/ASF classification). Pertrochanteric fractures (n = 12) accounted for 48 % and subtrochanteric (n = 13) accounted for 52 % of patients. Mode of injury due to high energy trauma was 64% of the total injuries of which Road Traffic Accidents accounted for 52% and fall from height accounted for 48% of the injuries. Low energy trauma due to trivial injury accounted for 36% of injuries. Average age of fracture at the time of surgery was 7 days (range 0-14 days). In the present study closed reduction was carried out in all cases.Anatomical reduction in 60% and acceptable reduction in remaining 40% was achieved. The tip apex distance of the femoral neck screw within 10 mm was achieved in 92% of patients. Mean Intraoperative blood loss was180 ml and mean post operative drainage in first 48 hours was 80 ml. Average hospital stay was 12 days.

Radiologically, fracture union was seen in 92% of cases at 12 weeks The total score of Salvati and Wilson hip function scoring system was 16 at discharge and 36 out of 40 at 24 weeks follow up. At 24 week follow-up, 88% of patients were having pain free normal activity, 92% of

Table No. I Showing The Fracture Profile of Patients

S.No.	Patient / Fracture Profile	Total No.
1.	**Total No. of Patients**:	25
	Male	17
	Female	8
2.	**Mean Age(Years)**	56.3
3.	**Fractue type (AO's Classification):**	58%
	Unstable (31-A2 & 31- A3)	42%
	Stable (31-A1)	
4	**Fractue Level:**	
	Pertrochanteric (n=12)	48%
	Subtrochanteric (n = 13)	52%
	Mode of Injury:	
5.	**High energy trauma**	64%
	RTA	52%
	Fall from Height	48%
	Low energy trauma	36%
6.	**Pre- operative fracture age (days)**	7
7.	**Fracture Reduction**	
	Anatomical	60%
	Acceptable	40%
8.	**Neck screw Position**	
	TAD within 10 mm	92%
	TAD more than 10 mm	8%
9.	**Average Blood loss (ml)**	
	Intraoperative	180
	Post – operative drainage	80
10.	**Average Hospital Stay (Days)**	12
11	**Fracture Union (At 12 weeks)**	
	Complete	92%
	Partial	8%
12.	**Patient Functional Outcome**	
	Very Good /Good	92%
	Fair / Poor	8%

Fig 3 & 4. 24th Week Post - Operative Follow Up - Showing Full Range of Movements At The Involved Hip - Showing Full Range of Movements at The Involved Hip

Table No. 2 Showing Complications

S.No.	Complication	Total No.
1	**Overall Rate:**	6%
	Systemic	2%
	Local	4%
2	**Distal Locking Difficulty (n = 3)**	12 %
3	**Difficulty in neck screw placement (n= 4)**	16 %
4	**Antirotational Hip Pin Cutout (n = 1)**	4%

Table No. 3 Showing Functional Profile with PFN

S.No.	Functional Profile with PFN	(P value)
1	Operating Time	< 0.001
2	Blood loss	< 0.001
3	Post operative Pain	< 0.01
4	Time necessary to support full weight bearing	<0.02
5.	Time of Hospital Stay	< 0.05

Fig 1 & 2. Instrument & Implants

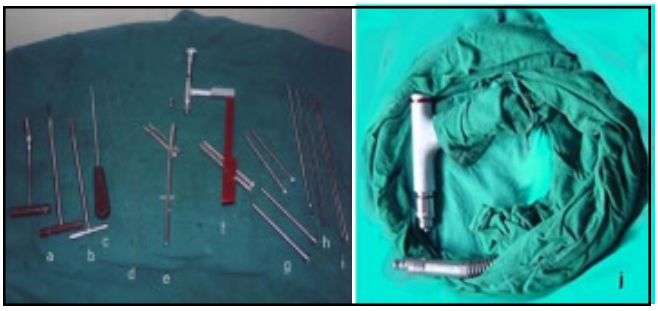
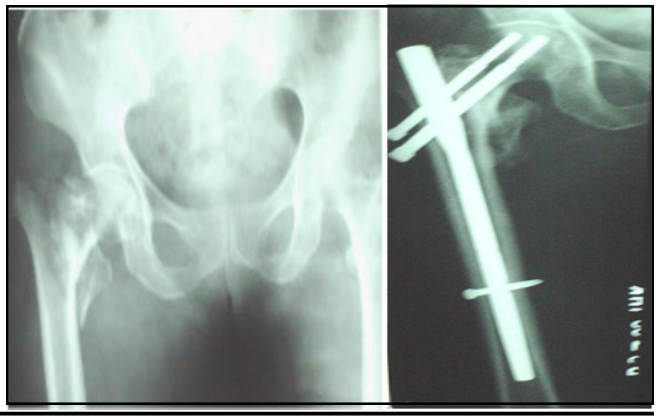


Fig. 5 & 6 Preoperative X - Ray & Postoperative X - Ray At 12 Wks Showing Full Fracture Union



the patients were full weight bearing with no limitation or only slight limitation of hip movement and could normally squat and sit crossed legged (*Fig - 3 & 4*). Outcome was described as good or very well in 92% of patients according to Kyle's criteria. Similar results were reported in Yassari GAL (12) series which had 90 % and Fogagnola *et al* (13) series which had 92 % good to excellent outcome.

As tabulated in (*Table - 2*) , overall complication rate in this study was 6% with 2% of patients having systemic and 4% having local complications as against Singh *et al* study (14) where overall complication rate was 15%.

Distal locking difficulty was encountered in 3 cases (12 %). It was observed that it could be avoided by tightening the bolt joining the nail and the insertion handle at the time of distal locking. Difficulty in placement of necks screw was encountered in 4 cases (16 %). Most of these were short statured female patient with small neck of femur. Secondary varus was noticed in 3 cases this was due to external migration of the femoral neck screw and antirotational hip pin with collapse of the fracture site. In 1 patient (4 %) antirotational hip pin cut through because it was longer than the neck screws which did not allow the sliding of the screws through the nail during weight bearing.

No case of AVN (Avascular necrosis) of femoral head and non - union/ pseudoarthrosis was noted in this study as against in 1 % of cases as reported in Salphale series (15). The Z - Effect (16) and the reverse Z - effect originally described by Werner - Tutschku *et al* (17) of the proximal screws were not observed in this study as also in T Marihara (18) series. Whereas in Salphale series, Z - Effect was seen in 2% of cases and reverse Z - effect in 1% of cases.

Discussion

The best treatment for pertrochanteric and subtrochanteric femoral fractures remains controversial most of the complications from treating these fractures occur with the unstable types. PFN attempts to combine the advantages of the sliding lag screw and those of intra medullary fixation. It being an intramedullary device is very close to calcar, is subjected to less tension and is more stable. Stability can be achieved without anatomical reduction of the posteromedial comminuted fragment (*Fig 5 & 6*). Biomechanically, the intramedullary devices decrease the bending moment of the hip joint force on the implants by 25 % to 30% when compared to laterally fixed plate. Biologically, the intramedullary fixation also allows the surgeon to fix the fracture as a closed procedure with minimal soft issue dissection fulfilling the modern concept of fracture healing.

Fracture geometry was the most influencing factor for the treatment and the time required for union and ultimately the prognosis. In this study the mean age was 56.3 years with significant male female ratio of 4:1. As against 63.7 years seen in series of Reska *et al.*(19). The bimodal age pattern was observed in this study with the peak incidences occurring between 21 to 40 years (36%) accounting for most of the subtrochanteric fractures due to high energy trauma and between 61 to 80 years (40%) accounting for most of the peritrochanteric fractures due to lower energy trauma.

As the peritrochanteric region is well covered by muscle mass and fat all the fractures in this study were of closed type as was also reported in Reska *et al* (19) series. In this study stable fractures accounted for 42% and unstable for 58%. In series of Fogagnalo *et al* (13) series had 74.5% as unstable and 25.5% as stable fractures. The average union time in this study was 12 weeks.

Rapid strides in implant and instrumentations in the quest of an ideal fixation for the pertrochanteric and subtrochanteric fractures has made various options available. PFN combines the intrinsic advantages of an intramedullary nail and those of the sliding screw. It is a minimally invasive implant and because of it being a closed reduction technique has a number of inherent advantages - *Table No.3*. Distinct practical advances of PFN are less limb length discrepancy, the need to restitute the medial buttress made obsolete, healing time is faster, delayed union and non-union are rare and the risk of infection is minimal

Good understanding of fracture bio-mechanics, correct indications and exactly preformed osteosynthesis gives excellent results with PFN especially for unstable fracture types as compared with other implants. It represents an implant of next generation with its crucial design differences eliminating the complications so common with earlier used proximal femoral intramedullary nails like Gamma Nail which was technically demanding and not forgiving with technical and mechanical failure rates of about 10%. These failures were collapse of the fracture

area, cutout of neck screw and fracture of the femoral shaft at the tip of the nail. AO/ASIF has further modified the standard PFN by incorporating a single helical blade in place of two proximal screws - The Proximal Femoral Nail Antirotation(PFNA) (20-22). This has further improved the treatment modalities of unstable peritrochanteric femoral fractures especially in elderly with Osteoporotic bones However, even this implant carries its share of complications, most commonly proximal nail cutout, as has been reported in Cheung JP series (23).

In the light of the results so obtained from the present study one can safely conclude that PFN is a valid and an important option in the treatment of femoral fractures of the peritrochanteric region. Due to the simplicity and lack of aggressiveness of the surgical techniques and low level of technical complications associated with this procedure it becomes an ideal mode of treatment in the compromised elderly and non compliant patients having high rate of implant failure and other complications.

References

1. Simmermecher RKJ, Bosh AM, Vanderwerkenc. The AO/ASIF proximal femoral nail (PFN): a new device for the treatment of proximal femoral fractures. *Injury* 1999; 30:327 -32
2. Pavelka T, Matejka J, Cervenkova H : Complications of internal fixation by a short proximal femoral nail. *Acta Chir Orthop Traumatol Chech* 2005; 72:344-54.
3. Kristek D, Lovric L, Kristek J, Biljan M, Kristek G, Sakic K.The proximal femoral nail antirotational (PFNA) in the treatment of proximal femoral fractures. *Coll Antropol* 2010 ; 34(3): 937-40.
4. Hesse B, Gachter A. Complications following the treatment of trochanteric fractures with the Gamma Nail. *Arch Orthop Trauma Surgery* 2004; 124:692-98
5. Sharma V, Babhulkar S, Babhulkar S. Role of gamma nail in management of pertrochanteric fractures of femur. *Indian J Orthop* 2008;42(2):212-16
6. Steinberg EL, Blumberg N, Debel S. The fixion Proximal Femur Nailing System. *J Biomechanics* 2005; 38:63-68
7. Muler ME , Nazarian S, Koch P, Schatzker J. The Comrehensive classification of fractures of the long bones. *Berlin :Springer-verlag* 1990;21:116-21
8. Salwati EA,Wilson PD.Long term results of femoral head replacement. *J Bone Joint Surgery* 1973;55A:516- 24
9. Kyle RF, Gustilo RB, Premer RF. Analysis of six hundred & twenty two intertrochanteric hip fractures. *J Bone Joint Surgery* 1979; S61A: 216 - 21
10. Kumar G, Ramakrishnan M. Lateral Femoral line:A Technique for easy insertion of newer Femoral Reconstruction Nails. *Orthopaedics* 2004; 27 (5). Available from: http://wwww.healio/orthopedics/ortho%
11. Ebraheim NA, Mekhail AO, Checraun AJ. Entry point of Reconstruction Nail. *Am J Orthop* 1998;27: 474-76
12. Yassari GAL,Langstaff RJ,Jones JW, Lami MAL.The AO/ASIf proximal femoral nail(PFN) for the treatment Of unstable trochenteric femoral fractures. *Injury* 2002;33(5):395-99.
13. Fogagnola F, Kujri Jr M, Paccola CA. Intramedullary fixation of pertrochenteric hip fractures with short AO-ASIF proximal femoral nail. Arch Orthop. *Trauma Surgery* 2004; 124(1):31-7.
14. Singh BN, Singh RN, Kumar R.Comparative prospective study of proximal femoral nail and dynamic hip screw in treatment of intertrochanteric fracture femur.*J Clin Orthopaedics Trauma* 2012; 3(1):28-36
15. Salphale Y S, Gadegone W M. Short proximal femoral nail fixation for trochenteric fractures. *J Orthopaedic Surg* 2010;18(1):39-44
16. Strauss E J, Kummer F J, Koval K J, Egol K A. The "Z-Effect" Phenomenon Defined: A Laboratory Study. [Cite 2007April 30]. Available from: www.interscience.wiley.com.
17. Werner - Tutschku W, Lajtai G, Schmiedhuber G. Intra and perioperative complications in the stabilization of Pre- and subtrochanteric femoral fractures by meansof PFN. *Unfallchirurg* 2002; 105:881-85
18. Morihara T, Arai Y, Takugawa S, Fujitka S,Chatani K,Kubo T. PFN for treatment of Trochentric Femoral fractures. *J Orthopaedic Surg* 2007 :15(3); 273- 77
19. Reska M, Vever K L, Divis P, Konecny J. PFN - A new stage in the therapy of extra capsular Femoral fractures. *Scripta Medica (BRNO)* 2006; 79(2): 115-22
20. Jain HK, Dhakar S, Sharma M, Jain M, Sharma H. Efficacy of proximal Femoral Nail in peritrochanteric femoral fractures of elderly patients. *Int J Biological Med Res* 2012;3 (3):1910- 13
21. Simmermacher RK, Ljunggvist J, Bail H, *et al*. The new proximal femoral nail antirotation (PFNA) in daily practice : results of a multicentre clinical study. *Injury* 2008 ;39(8): 932-39
22. E. Soucanye de Landevoisin, A Bertani, P Candoni, C.Charpail E. Demartiere.Proximal Femoral Nail antirotation (PFNA) proximal femoral fractures in the elderly: Retrospective study. *Orthopaedics & Traumatology: Surgery & Research* 2012; 98 (3): 288
23. Cheung JP, Chan CF.Cutout of proximal femoral nail antirotation resulting from blocking of the gliding mechanism during fracture collapse. *J Orthop Trauma* 2011; 25 (60): 51-55