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Proximal Femoral Nail - Solution for Intertrochanteric Fracture Management

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Abstract: *Proximal femoral fractures are most common in old and middle age patients. The dynamic hip screw (DHS) is the most common extramedullary implant used but the failure rate for a DHS is reported to be as high as 21%[(1)] proximal femoral nail (PFN)system was designed to overcome the above mentioned limitations with has an additional anti-rotational screw (hip pin) for unstable trochanteric and subtrochanteric fractures.The present study includes 50 patients of proximal femoral fractures, treated with Proximal Femoral Nail from April' 2013 to May' 2014 at the Department of Orthopedics, Sir Sayajirao General Hospital, Vadodara. Fractures were evaluated by X-rays and classified according to AO classification to assess the stability of fracture. According to fixation, postoperative non weight bearing or partial weight bearing crutch walking was started. On follow up patient was examined clinically on the basis of Modified Harris Hip Score as - excellent, good, fair and poor results. 27 patients had type A-II fracture, 15 patients had type A-III fracture and 8 patients had type A-I fracture configuration. In our study, 54 % patients had excellent results using modified Harris Hip Score. Good and fair results were due to pain, limp, limitation of hip movement and limb length discrepancy. No case of delayed or non union was noted. The main biomechanical innovations of PFN include a the addition of the 6.5 mm anti-rotation hip pin to reduce the rotation of the cervico-cephalic fragment, the smaller diameter and fluting of the tip of the nail to reduce stress forces below the implant and to prevent low-energy fracture at the tip. The PFN is better implant for the treatment of proximal femoral fractures because of the simplicity, close reduction, more stability and low complication rate.*

Keywords: *Orthopedics, Proximal femoral fracture, proximal femoral nail*

I. Introduction

Proximal femoral fractures are the most common in old and middle age patients. The treatment of this fracture requires a considerable experience. The varieties of implants are available for treatment of proximal femoral fractures intramedullary and extramedullary. The dynamic hip screw (DHS) is the most common extramedullary implant used in the treatment but it has a biomechanical disadvantage when compared with intramedullary devices because the load bearing occurs on longer lever arm extending from center of femoral head to the implant axis. DHS is preferred for stable intertrochanteric fracture with lower failure rate. However, the failure rate for a DHS is high for unstable trochanteric and subtrochanteric fractures. Additional, ant rotational screw is recommended in basicervical trochanteric fracture. In cases with greater trochanter fracture, a trochanter stabilizing plate and tension band wiring should also be used to prevent medialization of shaft of femur.

Intramedullary devices such as the Gamma nail (GN) and proximal femoral nail (PFN), have a biomechanical advantage with a short lever arm as distance between the centre of femoral head and the nail is reduced compared with that for a plate, thus diminishing the bending forces across the implant.[2] But the complication rate with gamma nail like fracture of the femur shaft below the tip of the implant,fracture collapse and femoral neck screw cut out are high.[3] The proximal femoral nail (PFN) [4] was designed to overcome the above mentioned limitations of the GN. The proximal femoral nail (PFN) has two hip screw placed in the femoral neck to avoid rotation of the proximal fragments during fracture fixation.[5] PFN allows immediate full weight bearing which is particularly helpful in older individual to decrease the incidence of deep vein thrombosis, bed sore and respiratory compromise. In a retrospective study, we tried to find out whether the PFN is an appropriate method for the fixation of proximal femoral fractures or not.

II. Materials & Methods

The present study includes 50 patients of proximal femoral fractures treated with Proximal Femoral Nail from April'2013 to May'2014 at the Department of Orthopedics, Sir Sayajirao General Hospital, Vadodara . Children, pregnant woman and pathological fractures were excluded from the study. All the patients were explained the study goal and procedure. Consents of each patient were taken prior to inclusion in the study

Patients with Each patient with injury around Hip Joint was reviewed in emergency department and examined thoroughly including general, local and systemic examination to rule out any associated head injury, abdominal injury, chest injury and pelvic injury. X-ray pelvis with both Hips and pelvis with affected hip in antero-posterior view was taken to assess the fracture pattern. Fractures were evaluated by X-rays and classified according to AO classification to assess the stability of fracture. [Figure- 1, 2, 3, 4] All patients were admitted and temporary immobilization was given in form of Proximal tibial skeletal and limb was suspended on a Bohler's splint. Patient was evaluated from cardio-respiratory point of view and if necessary physician fitness was taken before the surgery and essentially in all elderly patients. Preoperatively, nail length, nail diameter and CCD angle was determined from the X-ray to decrease the intraoperative time. Intraoperatively, after general anesthesia, spinal anesthesia or epidural anesthesia, patient was positioned on a traction table. The fracture was reduced by traction longitudinally on the abducted and externally rotated limb under IITV guidance.

After palpating the greater trochanter; 5 cm incision was made approximately from the tip of greater trochanter proximally. Parallel incision was made in fascia. Abductor muscle splitting was done to expose the tip of the trochanter. Entry was made with large curved awl at the tip or slightly medial to the tip of greater trochanter. The guide wire was inserted in center of medullary cavity to a depth of about 15 cms. Proximal part of femur was reamed with help of 13mm entry reamer to accommodate proximal widest part of nail. The nail was carefully inserted manually as far as possible into the femoral opening with slight twisting hand movements and light blows with hammer. The drill sleeve and trocar was inserted through jig with correct version. A stab incision was made and drill sleeve system was inserted through the aiming arm to the bone. A new 2.8 mm guide pin was inserted through drill sleeve, direction and position was checked under IITV in AP and lateral views. The same steps were repeated for the derotation hip screw as above. Insertion of 8 mm hip screw was done with hexagonal screw driver it was followed by insertion of 6 mm derotation screw. Free hand distal locking was done with 4.9 mm locking screws under IITV control. Dynamic locking was done for uncomminuted fractures and static locking was done for comminuted fractures.

Postoperatively**,** Intra-venous antibiotics were given to all patients for first 72 hours and converted to oral antibiotics and continued till suture removal was done on 12^{th} post-operative day. Dressing was seen on 3^{rd}, 6^{th} and 12^{th} post-operative days. Patient was taught static quadriceps exercises in the immediate postoperative period .Knee bending exercises, high sitting exercises and active Quadriceps strengthening exercises were started from 3^{rd} post-operative day, as soon as patient was comfortable and had gained adequate quadriceps strength. According to fixation, postoperative non weight bearing or partial weight bearing crutch walking was started. Patient was discharged on 5^{th} postoperative day.

First follow-up was after 6 weeks and then thereafter patient was reviewed every 6 weeks. Patient was examined clinically on the basis of Modified Harris Hip Score as - excellent, good, fair and poor results and radiographically for the fracture union.

III. Results

In a present study, 50 cases of proximal femoral fractures from April' 2013 to May' 2014 were included. We have used AO Classification to classify the trochanteric fractures and at final follow up did clinical and functional assessment of patients employing Modified Harris Hip Score as illustrated in Table -1 and Table -2. This injury is common amongst middle age group predominantly in males (78%). Most common mechanism of injury was fall while walking (50%). Subtrochanteric fractures were common with high velocity trauma. 27 patients had type A-II fracture, 15 patients had type A-III fracture and 8 patients had type A-I fracture configuration. 22% patients had associated injury such as head injury (8 %), Colles' fracture (8 %), calcaneum fracture (2 %), fracture of superior inferior pubic rami (2 %) and fracture of shaft of femur (2 %); which might have an impact on final outcome. Associated medical condition like diabetes, hypertension and asthma was observed in 12 patients (24 %). Careful surgical technique and preoperative planning considering type of fracture, stability of fracture, quality of bone, diameter of neck, status of greater and lesser trochanter, diameter of shaft, etc lead the procedure smooth and without any complications. In no cases we had to resort to open reduction. Commonest distal diameter of nail used in my study was 9 mm and all the patient was operated with long proximal femoral nail.

On application of modified Harris hip score out of 50 patients,27 had excellent ,15 had good,6 had fair and 2 had poor outcome(Table 1-2). Distal locking had no significant effect at final outcome. Patient having slight pain had good and fair results due to limitation of climbing stairs, sitting cross leg and squatting. 75% of patients without pain had excellent results. Patient having mild to moderate limp had fair and poor results as

compared to patients having no limp. Patients required cane (32%) or crutch (6%) for walking had fair and poor results due to difficulty in daily activity. 87% patients who climb stairs without using railing had excellent results. 8 Patients who can climb the stairs using rail had fair and poor results. Patients with unlimited walking showed excellent and good results. Patient having LLD of >3 cm had fair and poor results due to limitation in walking distance, climbing stairs, pain and limping. In our study, 2 patients having difficulty in squatting and sitting cross leg had poor results. 6% patients had poor results with union time >18weeks due to old age. 5 patients had varus neck shaft angle which caused shortening and limping and significantly affect the final score.

IV. Discussion

In our study Type A-3 fractures had more excellent results compared to Type A-2 fractures as Type A-2 fractures had more comminution involving intertrochnteric region than Type A-3 (Table-2) [Figure- 1, 2, 3, 4]. 10% of the patients had varus neck shaft anglulation at final follow up due to early weight bearing, fracture comminution and osteoporosis. There were no intraoperative, post-operative complication were noted in our study. In our study, total 16% patient had limping due to various reasons like shortening, varus angulation and associated injury. In our study, 16 patients required support of crutch for walking due to associated injury and associated disease like asthma and tuberculosis. Poor results are due to fracture comminution, varus angulation at fracture site, osteoporosis and early weight bearing. Results in the young and middle age group were excellent. In old age group (>60Yrs) were good and fair due to osteoporosis, poor nutrition and associated medical diseases. In comparison to male, female patients had higher rate of fair and poor results due to osteoporosis. In our study, majority of the patients were laborer and they had excellent (46%) to good (39%) results. 2 housewives had poor results due to old age, limp, pain, associated medical condition. In our study, even with high energy trauma during vehicular accidents 80% patients had excellent results. 90% patients who were operated in<5 days had excellent results due to early stabilization of fractures. 54% patients had excellent results despite having associated fractures. Patients having other medical disease had well to fair results compared to others.

In the series of 45 patients undertaken by Minos Tyllianakis,Andreas Papadopoulos et al.; age distribution was 29-93 years with an average age of 72 years. There were 17 males and 28 female patients. 21 patients had type A-II fracture and 24 patients had type A-III fracture. 13(28%)patients were reoperated for total hip replacement (2cases), exchange nailing (2 cases),implant removal (5 cases),dynamization(2 patients) and dynamic hip screw (2 cases).28 (62%) patients required a cane for support while walking.10 (30.4%) patients had implant related complication like cut out of screw(2 cases),Z effect (5 cases), reverse Z effect(1 case) and breakage of nail(2cases). In the series final outcome at follow up was evaluated using salvati and Wilson scoring system with 40% excellent, 33%good, 20%fair and 7%poor results .The difference in the revision procedure and implant failure is due to improper positioning and size of the screws as well early weight bearing.

In a study of 295 Trochanteric fractures treated with a proximal femoral nail by L.J. Domingo • D. Cecilia • A. Herrera • C. Resines, the average age of the patients was 80.1 years (76% of the cases were female). Fractures were classified according to the AO system [11], the most frequent type encountered being the A2 (59%), followed by Al (26%) and A3 (15%). In all cases closed reduction was achieved . The average time required for union was 12 weeks. There were four cases of delayed union. In 248 fractures (84%) the reduction was achieved within 10° of varus or valgus in comparison to the contralateral femur. There was an average 5 mm of shortening of the fractured limb present in 32 patients . No implant failure was seen on follow up.They were encouraged to initiate assisted weight-bearing with crutches or a frame during the first postoperative week and 43% of patients managed this and 71% recovered their previous walking ability.

To decrease the morbidity and mortality due to prolong immobilization, proximal femoral fractures require surgical treatment but the best treatment for these fractures remains controversial with implant selection. Intramedullary device inserted by close procedure provide better results in elderly patients. Closed reduction of the fracture preserves the fracture hematoma, minimize soft tissue dissection to decrease surgical trauma, blood loss, infection, and wound complications.[6, 7]

For stable fractures, DHS is preferred implant but when multiple fragments especially of the greater trochanter are present, we have to fix the greater trochanter with tension band wire or trochanter supporting plate. This minimizes excessive secondary fracture collapse and medialization of the distal fragment. Failure of fixation with DHS plate use still occurs in up to 20% of cases in cases of low subtrochanteric fractures.[8, 9]

For treatment of unstable pertrochanteric fractures because of its higher load ability (Guyer et al. 1991) Gamma Nail becomes the preferred intramedullary implant in the early days (Guyer et al. 1991). [10] GN have some theoretical advantages over the DHS, as they don't require the intact lateral cortex to stabilize the fracture and they have a shorter moment arm, because the load is transmitted to the femur along a more medial axis. So it is more stable implant that provide has greater stability under cyclical loading[11] and greater stiffness under strain.[12] The major disadvantage with use of this implant is significantly increased risk of fracture at the tip of nail, which had reached up to 18% in various studies, and other technical failures like collapse of the fracture

area, cut-out of the implant (8-15% of the cases) resulting in a high risk of reoperation. [13, 14,]

AO/ASIF therefore developed the proximal femoral nail with main biomechanical innovations include a the addition of the 6.5 mm anti-rotation hip pin to reduce the rotation of the proximal fragment, the decreased diameter and tappering of the tip of the nail to reduce stress forces below the implant and to prevent low-energy fracture at the tip, the increased implant length, less valgus angle and placing this angle at a proximal level (11 cm from the proximal end), and the more higher positioning of the distal locking avoid abrupt changes in stiffness of the construct to decrease chance of implant failure. It should be kept in mind that during surgery, the lower(8mm) screw must be near to the calcar to place the ant rotational screw in proper position.

But sometimes because of the entry point being in the fracture site PFN may leads to intraoperative fracture site distraction during manual introduction of the nail mainly in 31-A2 fractures (Guyer et al. 1991) The PFN has a decreased sliding potential due to the absence of a barrel coupled to the proximal screws that leads to Z-effect, migration of the hip pin into the joint .The Z-effect phenomenon is referred as a characteristic sliding of the proximal screw in medial direction during the postoperative weight-bearing period due to impaction of the hip pin into the proximal hole of the nail while the neck screw is normally sliding back during the weight-bearing period. As proximal fragment and the femoral head are moved back due to compression force, the impacted hip pin protrudes through the head. The reverse Z-effect described by Boldin et al [14] is similar but here the neck screw is impacted so it moves medially with weight bearing and hip pin slides laterally.

The results we obtained from the present study, we believe that the PFN is better implant for the treatment of proximal femoral fractures because of the simplicity, close reduction, more stability and low complication rate which is particularly important as majority of patients are elderly, and their general condition is often compromised.

V. Conclusion

PFN is bio mechanically sound implant helping in early mobilization and weight bearing even in unstable fractures and osteoporosis, thus providing good functional activity and early fracture union with excellent results at final follow up. PFN can also be called an intramedullary DHS where the principle of compression is utilized through intramedullary nail instead of a plate on lateral cortex.

VI. Abbreviations

Proximal Femoral Nail (PFN)
Gamma Nail (GN)
Dynamic Hip Screw (DHS)

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PAIN AT FINAL FOLLOW UP	**EXCELLENT**	**GOOD**	**FAIR**	**POOR**	**Total**
None	27(75%)	9(25%)	-	-	36(72%)
Slight	-	6(46.1%)	6(46.1%)	1(7.8%)	13(26%)
Mild	-	-	-	1(100%)	1(2%)
Moderate	-	-	-	-	-
Severe	-	-	-	-	-
TOTAL	27(54%)	15(30%)	6(12%)	2(4%)	50(100%)
LIMP					
None	25(89.3%)	3(10.7%)	-	-	28(56%)
Slight	2(14.3%)	12(85.7%)	-	-	14(28%)
Mild	-	-	3(75%)	1(25%)	4(8%)
Moderate	-	-	3(75%)	1(25%)	4(8%)
Severe	-	-	-	-	-
TOTAL	27(54%)	15(30%)	6(12%)	2(4%)	50(100%)
LIMB LENGTH DISCRIPENCY					
Nil	27(96.4%)	1(3.6%)	-	-	28(56%)
<3.2 cm	-	11(73.3%)	3(20%)	1(6.7%)	15(30%)
>3.2cm	-	3(42.8%)	3(42.8%)	1(14.2%)	7(14%)
TOTAL	27(54%)	15(30%)	6(12%)	2(4%)	50(100%)
SQUATTING					
With Ease	27(62.7%)	13(30.2%)	3(7.1%)	-	43(86%)
With difficulty	-	2(28.6%)	3(42.8%)	2(28.6%)	7(14%)
Unable	-	-	-	-	-
TOTAL	27(54%)	15(30%)	6(12%)	2(4%)	50(100%)

Table -1: Final follow up consist of clinical and functional assessment of patients employing Modified Harris Hip Score.

MODE OF INJURY	**EXCELLENT**	**GOOD**	**FAIR**	**POOR**	**Total**
Walking	8(40%)	9(36%)	6(24%)	2(8%)	25(50%)
vehicular accident	15(78.9%)	4(21.1%)	-	-	19(38%)
Fall from height	4(80%)	2(20%)	-	-	6(12%)
TOTAL	27(54%)	15(30%)	6(12%)	2(4%)	50(100%)
ASSOCIATED DISEASE					
Hypertension	3(70%)	2(20%)	1(10%)	-	6(12%)
diabetes mellitus	-	2(50%)	-	2(50%)	4(8%)
Asthma	-	-	1(100%)	-	1(2%)
Tuberculosis	-	-	1(100%)	-	1(2%)
TOTAL	27(54%)	15(30%)	6(12%)	2(4%)	50(100%)
FRACTURE TYPE					
A-1	3(37.5%)	2(25%)	3(37.5%)	-	8(16%)
A-2	14(51.8%)	11(40.7%)	3(11.1%)	1(3.7%)	27(54%)
A-3	10(66.6%)	2(13.3%)	3(20%)	1(6.6%)	15(30%)
TOTAL	27(54%)	15(30%)	3(6%)	2(4%)	50(100%)
UNION TIME					
14-16 wks.	26(66.7%)	11(25.6%)	3(7.7%)	-	40(80%)
17-18 wks.	1(12.5%)	3(37.5%)	3(37.5%)	-	7(14%)
>18 wks.	-	1(33.4%)	-	2(66.6%)	3(6%)
TOTAL	27(54%)	15(30%)	6(12%)	2(4%)	50(100%)
NECK SHFT ANGLE					
Normal	27(60%)	15(33.3%)	3(6.6%)	-	45(90%)
Varus	-	-	3(60%)	2(40%)	5(10%)
Valgus	-	-	-	-	-
TOTAL	27(54%)	15(30%)	6(12%)	2(4%)	50(100%)

Table -2: Final follow up consist of clinical and functional assessment of patients employing Modified Harris Hip Score

Figures

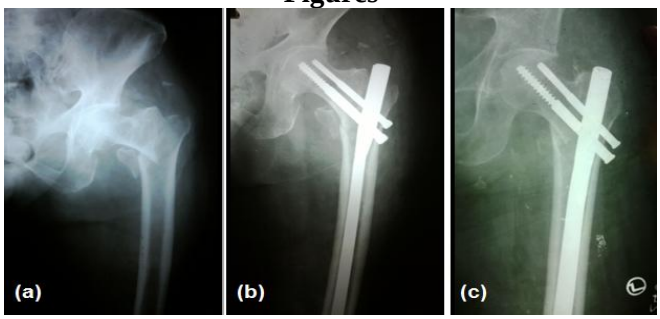

Figure- 1: (a) Post traumatic X-ray left hip joint in AP view shows Type A-I fracture of proximal femur **(b)** Immediate post-operative X-ray **(c)** Final follow up X-ray with good results.

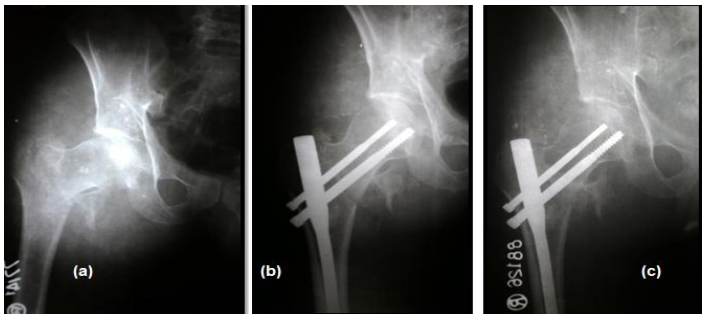

Figure- 2: (a) Post traumatic X-ray right hip joint in AP view shows Type A-II fracture of proximal femur **(b)** Immediate post-operative X-ray **(c)** Final follow up X-ray with good results.

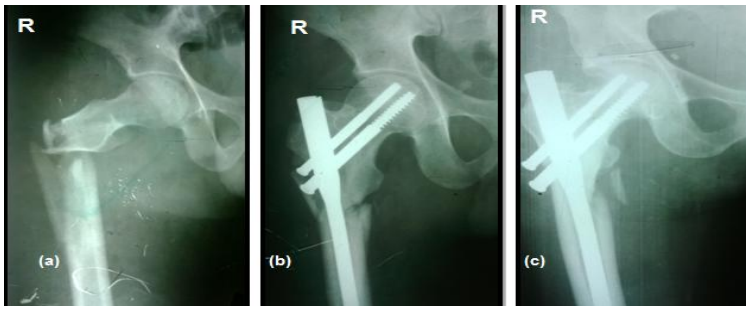

Figure- 3: (a) Post traumatic X-ray right hip joint in AP view shows Type A-II fracture of proximal femur **(b)** Immediate post-operative X-ray **(c)** Final follow up X-ray with good results.

Figure- 4: (a) Post traumatic X-ray left hip joint in AP view shows Type A-III fracture of proximal femur **(b)** Immediate post-operative X-ray **(c)** Final follow up X-ray with excellent results.