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Factors affecting the functional outcome and implant failure of proximal femoral nail (PFN) for treatment of intertrochanteric fractures

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Abstract

Background: Various implants have been developed to stabilize intertrochanteric fractures from the earlier days. Recent techniques of closed reduction and internal fixation by intramedullary device are more popular and have given favorable results, as these devices are bio-mechanically more stable, cause less trauma to the soft tissues and also preserve the fracture hematoma. This study was conducted to know the functional outcome, technical complications, and factors predicting the failure of the implant by treating intertrochanteric fractures by proximal femoral nailing (PFN).

Methods: From October 2017 to December 2019 we treated 60 patients with stable and unstable intertrochanteric fractures with PFN. Mean age of the study population was 64.10 years. Those who had bilateral hip fractures, patients with pathological fractures, who underwent previous hip surgery for the same or opposite side are excluded from the study.

Results: 81.7% patients had excellent and good outcome and 18.3% patients had fair and poor outcome at the end of 1-year follow-up. Fair and poor results were observed in patients who belonged to higher age group ($p=0.001$), associated with co-morbid conditions ($p=0.01$) and who had complications. 4 patients developed complications related to the implant (3 –proximal screw cut-out and 1 z-effect). Complications were observed in patients in whom fractures were fixed with high values of tip apex distance (TAD), calcar referenced tip apex distance (CalTAD), Parker's ratio index ($p<0.001$).

Conclusion: We are concluding that the age and co-morbidities are the important factors which affect the functional outcome and TAD, CalTAD, Parkers' ratio index are important factors which predict the failure of the implant. Gender, laterality and mode of injury, Type of fracture will not affect the final outcome.

Keywords: Intertrochanteric fractures, proximal femoral nail, tip apex distance, calcar referenced tip apex distance, Parker's ratio index

Introduction

The incidence of intertrochanteric fracture increases with advancing age. Growing population and number of road traffic accidents have resulted in an enormous increase in these type of fractures [1,2]. Various operative procedures with different implants have been described for the treatment of these fractures. The introduction of intramedullary devices which theoretically provide more efficient load transfer and the shorter lever arm decrease tensile strain thereby decreasing the risk of implant failure. Follow up studies with early intramedullary devices showed serious implant related complications like femoral shaft fractures, failure of fixation and difficulty in distal locking. A new intramedullary device, Proximal femoral nail (PFN) was designed in 1997 which gives the advantage of all intramedullary devices like reduced operating time, minimal operative blood loss, better biomechanical stability and allow early weight bearing with minimal implant related complications. Different parameters like TAD, CalTAD, Parker's ratio index are described for determining the correct position of neck screw and anti-rotation screw in the head and neck fragment and to minimize the complications like screw cut-out, Z-effect and reverse Z-effect but none of the parameter is proved superior to the other in predicting the implant failure [3, 4, 5]. CalTAD differs from TAD only in the AP view with the apex of the femoral head determined using a line parallel to the femur neck that runs

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adjacent to the calcar instead of the center of the femoral neck. It therefore favors inferior-central placement of the lag screw. In this study we investigated how these factors will predict the failure of the PFN and the other factors which influence the functional outcome.

Material and Methods

From October 2017 to December 2019 we treated 60 patients with stable and unstable intertrochanteric fractures with PFN. The study population had an age distribution of 41 to 90 years with the mean age of 64.10 years. The gender distribution was 36 male and 24 females. In 78.3% of patients the fracture was a result of accidental fall and in remaining patients was due to RTA. As recommended by the AO/OTA, the fractures were classified on the basis of the preoperative radiographs as 16-I (stable pertrochanteric), 30 -II (unstable pertrochanteric), 14 - III (unstable intertrochanteric). The mean duration of interval between injury and surgery was 2.8 days with mean duration of hospital stay was 6.2 days. The mean duration of surgery was 69.1 minutes from the time of skin incision to wound closure. The standard PFN (with a length of 240 mm) or other lengths (320–420 mm) were implanted. All the fractures were reduced with initial closed reduction by slight internal rotation of the femur with traction. The alignment of the medial cortex in AP view and reduction of the proximal fragment and shaft fragment in lateral view is checked. Lateral linear incision of 5 to 6 cm size extending proximally from the tip of greater trochanter was made. The point of entry was made just medial to the tip of trochanter at the junction of its anterior one - third and posterior one - third with a curved bone awl. The 17 mm cannulated proximal femoral reamer was used to ream the proximal femur for up to 7 cm. Then the nail was inserted with the help of the jig over the guide wire with hand by gentle twisting movements and the progress of the nail was done under image intensifier control. The load bearing cervical lag screw of adequate length was inserted into the subchondral bone upto 10mm from the articular surface with the screw driver under image control, followed by the insertion of derotation - hip pin of adequate length into the upper half of neck. Distal locking also was done with the aid of distal targeting guide and drill sleeves using 4.0 mm drill bit.

Post-operative X-rays were evaluated by measuring TAD, CalTAD, Parker's ratio index and cervico-diaphyseal angle. Patients were encouraged to sit on the bed after 24 hours after surgery. Follow up of cases was done at regular intervals of 4 weeks for minimum of 6 months and there after once in 3 months till one year. At every visit patient was assessed clinically regarding hip and knee function, walking ability, fracture union, deformity and shortening. X-ray of the involved hip with femur was done to assess fracture union and implant bone interaction and all patients were assessed with modified Harris hip scoring system.

Results

Descriptive statistical analysis has been carried out in the present study. we found that mean age of the patients who had Excellent and Good outcome was lower than mean age of the patients with Fair and Poor outcome ($p=0.001$). In our study, 23(38.3%) patients had co-morbid conditions. 10 out of 23 had fair and poor results ($p=0.01$). But we did not find a significant association between type of fracture and functional outcome ($p=0.23$). In 51.7% of patients, fracture united between 10-12 weeks (fig.1A, 1B, 2A, 2B). In 7 patients union took more than 15 weeks because all these patients

belonged to higher age group had co-morbid conditions and highly comminuted fractures. The mean duration of fracture union was 12.2 weeks. 7% of the study population developed complications related to the implant of which 3 patients had proximal screw cut-out (fig.3) and one patient developed z-effect (fig.4). 4% of patients developed superficial infection and no cases of deep infection. Antithrombotic drug prophylaxis was instituted in all cases postoperatively. In 2 patients DVT was diagnosed, they were managed with DVT stockings and Heparin injections. In this study, 49(81.7%) patients had excellent and good outcome and 11(18.3%) had fair and poor outcome. Fair and poor results were observed in patients who belonged to higher age group, associated with co-morbid conditions and who had complications.



Fig 1A, 1B: Pre-op X-ray showing intertrochanteric fracture and Post-op at day-1



Fig 2A, 2B: On follow-up at 6 weeks and at 14 weeks showing union



Fig 3: Proximal screw cut-out



Fig 4: Z effect

Discussion

Many authors have investigated the functional outcomes after treating intertrochanteric fractures by PFN in order to achieve rapid pre-operative status and early union with less complication. Others have sought to identify the role of certain implant fixation factors which predict the failure of proximal femoral nailing. Al-Yassari G *et al.* [6] in 2002 from Middlesex, UK treated 76 patients with unstable trochanteric fractures with PFN and reported it as a relatively easy procedure and a biomechanically stable construct allowing early weight bearing, whereas femoral neck screw positioning as critical. Schipper IB *et al.* [7] in 2002 from Netherlands after studying biomechanical behavior of PFN suggested slotted hole for the de-rotational hip pin to decrease the excessive weight loading of the hip pin thereby preventing its cutout, which is the most serious complication encountered. Morihara T *et al.* [8] in 2007 after studying 87 patients with means age of 85 years with intertrochanteric fracture, the lateral side of lag screw of PFN after fracture consolidation was measured by comparing the immediate post op and final antero-posterior (AP) radiographs found that it is 10mm more in unstable A2 fracture than in stable fractures and cut out of lag screw did not occur suggesting that free sliding of lag screw facilitates direct impact between fragments. Kuzyk PR *et al.* [9] in 2012 created unstable pertrochanteric fractures in 30 synthetic femurs and fixed with long Gamma nails and concluded that inferior placement of lag screw in AP view and central in lateral view provides highest axial and rotational stiffness to the cephalomedullary nail.

Most common postoperative complication encountered during radiological evaluation is proximal crew cut-out, with incidence of range 0.7 to 10.6% [10]. In our study 6.6% of patients developed complications related to the implant (3 cases of screw cut-out and 1 case of Z-effect). Probably short neck screw, high TAD (more than 25 mm), CalTAD, and Parker's ratio index were the factors that determined proximal screw cut-out in our study. Patients were managed with removal of the cut-out screw. Z effect was seen in one patient (1.6%), and then patient was re-operated at 3 months with calcar replacing cemented bipolar hemiarthroplasty. In Gadegone *et al.* [11] study, 7% of patients had cut-out, 3% of patients had Z-effect and 7% of patients had superficial infection, these results were comparable to our study. They attributed that severe osteoporosis was the cause of screw cut-out. Christian boldin *et al.* [12] treated 55 patients with unstable intertrochanteric fractures with PFN, on follow-up 7(12.7%) patients had developed complications (2-screw cut-

out, 3-Zeffect, 2-reverse Z effect). They concluded that crew cut-out was because too short hip screws were used and were allowed full weight bearing and there was no relation to the type of fracture or adequacy of fracture reduction.

In our study, 81.7% patients had excellent and good outcome and 18.3% patients had fair and poor outcome at the end of 1 year follow-up. A wide variation was observed between various studies with regards to the functional outcome. In Richard *et al.* [13] 65% of patients had poor and fair results probably because the mean age of the study population was 77.7 years and 83.8% of patients had co-morbid conditions. In Gadegone *et al.* [11] study, 35% patients had excellent and good outcome and 65% patients had fair and poor outcome; the less favorable results observed is probably because, in 14% of patients fracture reduction was achieved by opening the fracture site and mean age of the population was on higher side as compared to our study, whereas all fractures were treated by closed reduction and internal fixation.

In our study, Singh's osteoporosis index was not considered during the management of these fractures. This is because other than Singh's osteoporosis index many other significant implant fixation factors which predict the failure of proximal femoral nailing have been reported in literature. Kashigar A *et al.* [4] in 2014, retrospectively reviewed 77 proximal femoral fractures with an objective of determining the factors predicting the failure of cephalomedullary nailing and observed that non-significant parameters were age, gender, fracture type, Singh's osteoporosis index, reduction quality and significant parameters were TAD, CalTAD, cervical angle difference, Parker's ratio index.

Our study has some limitations, including small sample size and mean age of the population is on relatively younger side (64.1 years) and we are not considered osteoporotic component of proximal femur in evaluating the results. Therefore, large multi-centre trial composing larger population should be conducted using parameters like TAD, CalTAD and Parker's ratio index to know the validity of these factors to predict failure of the implant and to extrapolate these results to general population.

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