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RESEARCH ARTICLE

TREATMENT OF FEMORAL SHAFT FRACTURES USING GREATER TROCHANTER/ PIRIFORM FOSSA AS ENTRY PORTAL WITH SPECIFICALLY DESIGNED NAILS: A COMPARATIVE STUDY

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ABSTRACT

Fractures shaft femur have been treated with antegrade nailing via the piriform fossa(PF). The purpose of this study was to compare results of fracture shaft femur treatment with nailing through the greater trochanter(GT) to nailing through PF with specifically designed nails. 80 patients were included in the study. (GT group;n=37 and PFgroup;n=43) between May 2011- September 2014. Functional outcome was evaluated by Thoresen scoring. Operative time, number of fluroscopy shots required to make the entry point, time to fracture union and complications were compared and evaluated using appropriate statistical methods. 86% patients(37) showed excellent results and 14%(6) good results in PF group and 88%(33) excellent results and 12%(4) good results in GT group(statistically insignificant). The mean operative time of PF=90 mins and GT=75 mins(P<0.005). The average number of image intensifier shots to create the entry point in PF=11 and GT=8(P<0.005). A femoral nail specifically designed for trochanteric insertion is an alternate technique with benefit of decreased radiation exposure and operative time, more so in obese patients.

INTRODUCTION

Femur is the principal weight bearing bone of the lower extremity; its fracture usually leads to considerable morbidity and mortality. [Ricci WM 2009, Farhang K 2014, Court-Brown 1998, Ricci WM 2006, Riehl 2009]. Femoral shaft fracture is often an outcome of high energy trauma in the young, and thus usually associated with multisystem and considerable soft tissue injury; [FarhangK 2014, Court-Brown 1998] while in the elderly even low energy trauma (e.g., falls from standing height), may lead to a break in the cortex. The main predisposing factor, of a low energy trauma precipitating a fracture in the elderly is osteoporosis [Ricci WM 2006, Riehl 2009].

Early fixation prevents some of the potentially fatal complications of femoral shaft fractures including fat embolism and acute respiratory distress syndrome. Such immendiate intervention allows for early active mobilization, which can help reduce or even prevent hip and knee stiffness as well as wasting of muscles like quadriceps and hamstring. Among the various treatment options, intramedullary nail provides predictable restoration of shaft length and alignment as well as uniform load sharing [Ricci WM 2009, Farhang K 2014, Court-Brown 1998, Ricci WM *et al* 2006, Riehl 2009, Keeler KA *et al* 2009, Ricci WM 2006].

The piriform fossa (PF) and the tip of the greater trochanter (GT) are accepted entry portals for antegrade femur interlocking. The PF and the tip of the GT, both the entry points have their own merits and demerits. Both forms of nails have an anterior bowing that resembles the bowing of the femur shaft in sagittal plane.

However, the main difference lies in the design of the nail viz, the trochantericentry nails have a lateral bending of 4°,[Ricci WM 2006, Ricci WM *et al* 2006] while the piriform entry nails are devoid of such coronal plane angulation as the piriform fossa is collinear with the long axis of femoral shaft.[Ricci WM 2006, Ricci WM *et al* 2006]

We conducted this study to compare and contrast the functional outcome, fluoroscopy exposure and the operative time while treating fracture shaft femur with antegrade nailing with specifically designed nails through two different entry portals namely the GT and PF.

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MATERIALS AND METHODS

This was a prospective study conducted over a period of 3 years from May 2011 to September 2014 at JJM Medical College and its allied hospitals viz, Bapuji hospital and Chigateri general hospital. Clearance was obtained from the ethical committee and 80 patients diagnosed with fracture shaft femur were included in this study after obtaining their informed consent. These patients were operated upon by qualified trauma surgeons at our institute. All these patients were managed by antegrade nailing either through GT or PF with specifically designed nails for each entry portal as decided by the concerned operating surgeon.

Inclusion Criteria

- Patient's age > 18 yrs
- Fracture femur involving proximal third / middle third / distal third shaft
- Any associated fractures

Exclusion Criteria

- Patient's age < 18 yrs
- Compound fractures
- Medically unfit for surgery

Patients with shaft femur fracture were treated using either PF entry or GT tip entry nails in parallel series and the outcome of the treatment wasevaluated both clinically and radiologically using a clinico-radiological criteria by Thoresen *et al* scoring system.

Nail design

GT group

Third generation ante grade intramedullary interlocking nail-called Easy Unifemur Nail provided by Sharma Orthopaedic Implants Gujarat based on SIRUS nail design for femur from ZIMMER[Figure 1]. It is a stainless steel, side specific, hollow tubular nail with a circular cross section. Proximal 10 cms is expanded to 12mm to give additional strength for proximal screw fixation. It has position slots to lock the jig. Its 2mm wall thickness gives the nail a certain flexibility on bending. Proximal end has got threads on the inner side that provides secure fixation of the threaded conical bolt for attachment of jig/extractor. The nail has a 12° anteversion and an anterior bow to match the femur and is angled at 4^0 to accommodate the more lateral entry site i-e the tip of greater trochanter. Proximally, there are two locking options:

1. Standard proximal locking with static and dynamic locking options for 4.9mm locking screws
2. Cephalo medullary locking with three screws (recon mode) of 6.0 mmscrews.

Distally both static and dynamic locking modes for locking (4.9 mm) are available and the nail size ranges from 34-44 cm (9,10,11 mm diameters)

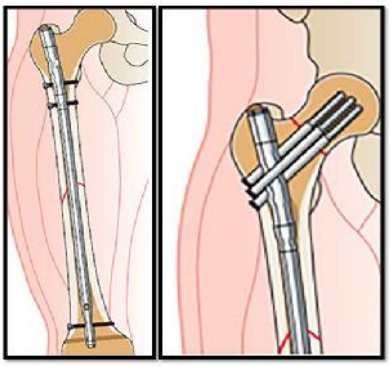

Figure 1 GT group nail design with two proximal locking options

PF group

First generation antegrade intramedullary interlocking nail-called Indian nail. It is a hollow tubular nail with a circular cross section. Proximal 10 cms is expanded to 12 mm to give additional strength for proximal screw fixation. It has position slots to lock the jig. Its 2mm wall thickness gives the nail a certain flexibility on bending. Proximal end has got threads on the inner side that provides secure fixation of the threaded conical bolt for attachment of jig/extractor. Nail has a curvature to the average anatomic curvature of the femur. For locking there are 2 holes on either side, at the proximal and distal ends of the nail. Circular holes for static locking measure 5 mm. Nails are available in diameters of 9,10 and 11 with length from 340-440 mm with increments of 20 mm. Locking bolts are self tapping,4.5mm available from 25-95mm in 2 mm increments.

Procedure

Provisional nail length was decided preoperatively by measuring the distance from the tip of the greater trochanter to the upper border of patella on the patient's uninjured side. Nails of this size along with the next shorter and longer length were kept ready before the surgery.

All patients were operated in supine position on a fracture table and under the guidance of image intensifier to achieve anatomic reduction and fixation. Standard interlocking procedure was followed for both set of patients, except that in the PF group, entry portal was made in the middle of the piriform fossa in line with the femoral shaft along both sagittal and coronal planes with the help of a curved bone awl.

In the GT group, the entry portal was at the center of the trochanter and shaft in lateral view and directed medially towards the medullary canal with the help of a curved bone awl. A modification of the standard nailing technique, which took advantage of the nail's anterior bow was used. The nail would be rotated 90° (such that the anterior bow was apex medial) on insertion. This would help point the tip of the nail away from the medial cortex and closer to the central axis of the femoral canal. Once the nail was inserted beyond the fracture zone, it would be gradually derotated. [Figure-2]

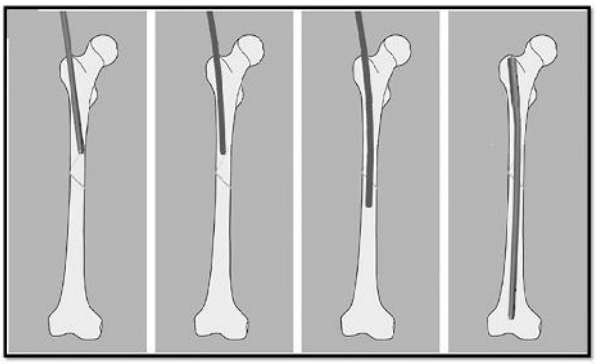

Figure 2 GT group - Modified nail insertion technique

Follow up: Emphasis was placed postoperatively on muscle strengthening of the thigh as well as on the range of motion (ROM) of the knee. Active hip and knee ROM exercises were started as soon as pain subsided, which was usually 24-48 hrs after the surgery. Patients were ambulated within 24-48 hrs after surgery using toe-touch weight bearing with the help of an adjustable walker, in cases of stable fracture and satisfactory stable fixation. Suture removal was done 2 weeks post surgery, on the first postoperative visit. Guarded weight bearing was allowed as soon as bridging callus was seen on radiograph, usually after 4-6 weeks. Full weight bearing was started when the fracture site was completely bridged by callus and fracture site clinically became non-tender. Patients were then examined at intervals of 1 month, 3 months, 6 months, 12 months post operatively and thereafter every 6 months for a period of two years.

The results thus obtained were statistically analyzed using proportion, mean, standard deviation and chi-square tests for significance.

RESULTS

Out of 80 patients enrolled in our study, 43 were in the PF group and 37 in the GT group ($p>0.05$). In the PF group, there were 26 males and 17 females (Male: Female:: 1.52:1) and the mode of injury was mostly RTA. 34 patients suffered from right sided fracture while nine patients had fracture on the left side. Eight patients of the PF group were obese (BMI > 30 Kg/m^2).

In the GT group, out of 37 patients, 23 patients were male and 14 were female (1.64). The mode of injury was mostly RTA, with 25 patients diagnosed with right sided and 11 with left sided fracture. One patient had bilateral Fracture. 7 patients in the GT group were found to be obese (BMI > 30 Kg/m^2).

In our study, the mean operative time of piriform entry nailing and trochanteric entry nailing was 90 minutes and 75 minutes respectively. This difference in operative time was found to be statistically significant ($P<0.005$). The average number of image intensifier shots to create the entry point in PF group was 11(9-13) shots. This was found to be significantly higher than GT group with an average of 8 (6-10) shots. This difference was also found to be statistically significant ($P<0.005$).

In our study, we measured the functional outcome of the patients with Thoresen *et al* scoring. When applied to the two groups under study, we found 86% (37) excellent results and 14% (6) good results in PF group and 88% (33) excellent results and 12% (4) good results in GT group. (Table-1). However, the functional outcome in terms of time to union as well as complications was comparable in both groups and statistically insignificant.

Table 1 Demographic data and Results

Table-1	GT (Greater Trochanter)	PF (Piriform Fossa)
Number of patients	37	43
Gender M/F	23/14	26/17
Mechanism of injury		
RTA	35	42
Fall	1	1
Assault	1	0
Side affected		
Right	25	34
Left	11	9
Bilateral	1	0
BMI (Kg/m^2)		
>30	7	8
<30	30	35
Fluroscopy shots	8(6-10)	11(9-13)
Avg Operative Time (mins)	75	90
Thoresen Scoring (Functional outcome)		
Excellent	88%	86%
Good	12%	14%
Fair	-	-
Poor	-	-

Complications

In PF group, out of 43 cases, five cases (11.62%) reported with complications. Of these, two cases each were diagnosed with varus malunion and limb shortening of <1.5cm and one patient with superficial skin infection. In 37 patients of the GT group, four cases (10.81%) developed complications. Among the complications, one case each had varus malunion, superficial skin infection, limb shortening of <1.5cm and lateral cortex shattering. The difference in the complications of the two groups was not found to be statistically significant.

DISCUSSION

Diaphyseal femoral fractures have been conventionally managed by antegrade interlocking mailing done using PF entry portals. However, using the tip of GT as an entry portal for the treatment of routine diaphyseal femur fractures is a relatively contemporary approach [Keeler *et al* 2009, Robinson CM2005].The main advantage of a PF entry portal is its collinear alignment with the long axis of the femoral shaft, as these nails are devoid of coronal plane angulation [Ghosh 2015].

The conventional PF entry portal reduces the risk of iatrogenic fracture comminution and varus malalignment when compared to off axis entry points such as trochanteric entry points portals. However, it is often technically challenging to obtain the proper entry site, owing to which, the operative time and number of fluroscopy shots are high when this entry portal is used. This is more so when operating on obese patients [Farhang K 2014, Court-Brown 1998].This entry point is also very sensitive to anterior-posterior translation, with anterior

positioning being associated with extreme hoop stresses increased risk of iatrogenic bursting of the proximal segment [Ghosh 2015].

Recently, the nails for trochanteric insertion have been designed with a proximal lateral bend, which has shown to reduce the complications previously associated with the use of straight nails inserted through this entry portal. Attention to a proper trochanteric entry portal using a specifically designed nail combined with a slight modification of the standard insertion technique used for trochanteric nail insertion likely helps avoid iatrogenic fracture comminution and avoids varus malalignments that has been previously described with the use of a straight nail inserted through the greater trochanter. The nail was rotated 90° on initial insertion such that the anterior bow was apex medial. The tip of the nail was therefore aimed more collinear with the shaft axis in the coronal plane. After the nail was safely across the fracture, it was derotated gradually with progressive insertion [Ricci WM *et al* 2006]

In our study, the mean operative time of piriform entry nailing and trochanteric entry nailing was 90 min. and 75 min. respectively. This difference in operative time was statistically significant (P<0.005). The average number of image intensifier shots to make the entry point in piriform fossa was significantly higher as compared to the trochanter entryportal (mean is 11 and 8 respectively; P<0.005).

Our results are concordant with the study conducted by Ricci WM *et al* (2006). In this study, 108 patients of fracture shaft femur were managed with either nailing through a greater trochanter starting point with the trigen TAN nail (GT group) (n = 38) or through a PF starting point with the trigen FAN nail (PF group) (n = 53). 37 of the 38 fractures from the GT group and 52 of the 53 fractures from the PF group healed after the index procedure. Complications in GT group included one case each of secondary infection and external rotation malalignment of 12°. There were no other malalignments or iatrogenic fracture comminution. One infectious complication was seen in the PF group. The average operative time was 75 min for piriform insertion using the FAN nail and 62 min for trochanteric insertion using the TAN nail (P = 0.08). The average fluoroscopy time was 61% greater for the PF group (153 s) than for the GT group (95 s) (P=0.05). Further, these differences were magnified in patients who were obese (body mass index. 30) where the operative time was 30% greater (P,0.05) and the fluoroscopy time was 73% higher in the PF group (P,0.02). Patients from both groups had asimilar initial decline and subsequent improvement in function over time (P<0.05).

In a study conducted by Ghosh (2015), the mean operative time of piriform entry nailing and trochanteric entry nailing was 112.7 min. and 90.7 min. respectively. This difference in operative time was statistically significant (P = 0.005). The average number of image-intensifier shots to perform the entry point in piriform fossa is significantly higher as compared to trochanter (mean is 10 and 8 respectively; P = 0.048) .Functional status assessment was done using Thoresen's Scoring System. Excellent functional status was seen more in the PF group (85.7%) than the GT group (80%) but this had no statistical significance (P = 68), similar to our study.

In our study, the patients were advised full weight bearing around 14- 16 weeks (GT group) and 16- 18 weeks (PF group) without any statistical significance. All cases in our study achieved full union at around 12- 20 weeks. ROM of hip and knee were almost within normal limits in both groups. Two patients in the PF group and one in GT group had limb shortening of < 1.5cm which was acceptable. One case in each group had superficial infection of the operative wound which healed with a course of oral antibiotics. Two patients in PF group and one patient in GT group developed varus malunion of less than 5°, however this did not warrant any additional intervention. One patient in GT group had shattering of lateral cortex of proximal femur when entry was made too laterally, which healed by prolonged immobilization for 8 weeks. We did not come across complications like non union, delayed union of the fracture or any hardware malfunction.

Figure 3 GT group case showing good radiological union and clinical ROM

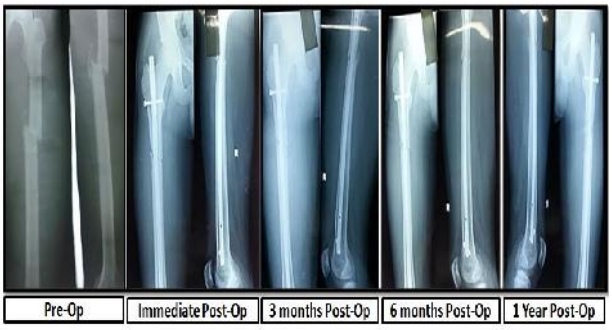

Figure 4 PF group case showing good radiological union and clinical ROM

Functional outcome as measured with Thoresen scoring showed 88% (33) excellent results and 12% (4) good results in GT group (Figure- 3) and 86%(37) excellent results and 14%(6) good results in PF group (Figure- 4). These findings suggest that functional outcome when the fracture is managed by either entry portals is comparable and statistically insignificant.

A retrospective clinical and radiographic review by Keeler *et al*. (2009) of 78 children and adolescents with 80 femoral shaft fractures who underwent IM nail fixation through the lateral aspect of the greater trochanter, with a mean followup of 99 weeks, was performed. All patients went on to union in good clinical alignment without loss of reduction. No nonunions, delayed unions or malunions were observed. Two patients developed infections postoperatively (2.5%).

CONCLUSION

Functional outcome and associated complications of the patients treated with antegrade nailing through the piriform fossa or greater trochanter is comparable. However, femoral nailing through the greater trochanter with specifically designed nails and attention to specific techniques for insertion can be considered superior to the PF approach due to the added benefit of reduced requirement for fluoroscopy and decreased operative time in the former. Hence, we conclude that femoral nailing through the greater trochanter tip with specially designed nails can be considered a rational alternative to femoral nailing through the piriform fossa.

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