Journal of Clinical Orthopaedics and Trauma 10 (2019) 912–916

Contents lists available at ScienceDirect

Journal of Clinical Orthopaedics and Trauma

journal homepage: www.elsevier.com/locate/jcot

Analysis of different entry portals for femoral nail with two different nail designs-straight nail versus lateral angulated nail - Does it make a difference?

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ARTICLE INFO

Article history:
Received 3 November 2018
Received in revised form
27 December 2018
Accepted 2 January 2019
Available online 9 January 2019

1. Introduction

Femoral fractures are one of the most common fractures of the lower limb. It affects the knee and hip function and stability. The incidence is on the rise due to fast life and increase in road traffic accidents. The fracture patterns are also evolving with more comminution and open fractures. With technical advances like fracture table and image intensifier, closed reduction and stabilization with aim of biological healing became the preferred treatment.

Intramedullary interlocking nailing is the current treatment of choice wherever possible for majority of femoral shaft fractures. The ideal entry point for antegrade nail is however a point of contention despite design and engineering developments. Kuntscher originally introduced nail through the tip of trochanter which was medialized further to greater trochanter by Winquist and Hansen.[1,2] The piriformis fossa (PF) as entry point for the nail was proposed by McMaster. This entry point is in-line with the medullary canal. Gradually PF became the starting point of choice, due to its favorable biomechanical results.

The discussion involving the optimal entry point was revived when the intramedullary nail featuring proximal valgus bend was introduced. These nails were specifically intended to address the pitfalls associated with inserting a straight nail through the greater trochanter (GT).[3]

The GT and PF entry points during antegrade nailing of femoral shaft fractures were initially compared by Ricci et al. No difference in union rate and complications between the two entry points was found but shorter operative and fluoroscopy times were reported with the GT entry point.[4] Greater trochanter entry has also been suggested in obese patients.[5–7]

This study was done to compare both the entry points and nails at a tertiary level high volume trauma center with regards to patient and procedure related outcomes. The primary aim was to compare both the groups- Greater trochanter (GT) versus Piriformis fossa (PF) entry group with respect to the operative and fluoroscopic time required for intramedullary nail fixation in femoral diaphyseal fractures, time taken for making entry, the amount of blood loss, incision length and complications in the form of iatrogenic femoral neck fractures, and avascular necrosis.

It was also determined whether there were any differences in fracture union, delayed/non-union), fracture alignment and functional outcomes in the form of Harris Hip score between the two entry points.

2. Materials and methods

The present study was conducted at a tertiary level trauma center in eastern India from June 2015 to June 2017 to compare the entry points taken during surgery in interlocking nail in femoral shaft fractures- GT versus PF. This was a retrospective analysis of prospectively collected data.

Fifty consecutive patients who presented to the emergency department with femoral shaft fractures and operated were

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https://doi.org/10.1016/j.jcot.2019.01.004
0976-5662/

included. Selection of patients was done as per following inclusion criteria: All traumatic fractures of femoral shaft (diaphyseal fractures), adults aged 20–60 years, closed fractures, without associated injuries and comorbidities. Patients with pathological fractures, age <20 and >60 years, segmental fractures, bilateral shaft fractures, head injury, poor soft tissue around hip joint (Moralle-Lavelle lesion), bleeding disorders, polytrauma, associated comorbidities, patient not giving written consent for the study and patients with any history of allergy were excluded.

Patients were assessed according to ATLS protocols. Primary and secondary survey was done to find out associated injuries. Patient was immobilized and relevant radiographs were obtained. Femoral fracture was assessed and classified according to AO/OTA classification.

Surgical tactic: Standard AO technique was used for nailing in supine position on fracture table. Two different nail designs were used in the study as shown in Fig. 1.

Intra-operatively, fluoroscopy time taken in taking entry, total operative time, total fluoroscopy time, nail diameter, blood loss as per number of mops used, complications like iatrogenic fracture of greater trochanter or femoral neck and malalignment were noted.

Post-operatively, patients were advised static quadriceps and knee range of motion exercises. Intravenous antibiotics were given for first two days and then switched to oral medications. Patients were discharged on postoperative day 3/4. Suture removal was done after 2 weeks. Toe-touch down/partial weight bearing walking was started as soon as possible. Regular follow-up was done every 6 weeks till fracture union and full weight bearing was allowed. Three monthly follow-up was done thereafter till 1 year. Functional outcomes based on Harris hip score, abductor strength, fracture healing and late complications including delayed or non-union were analyzed. Statistical analysis was done using SPSS software, IBM Corporation.

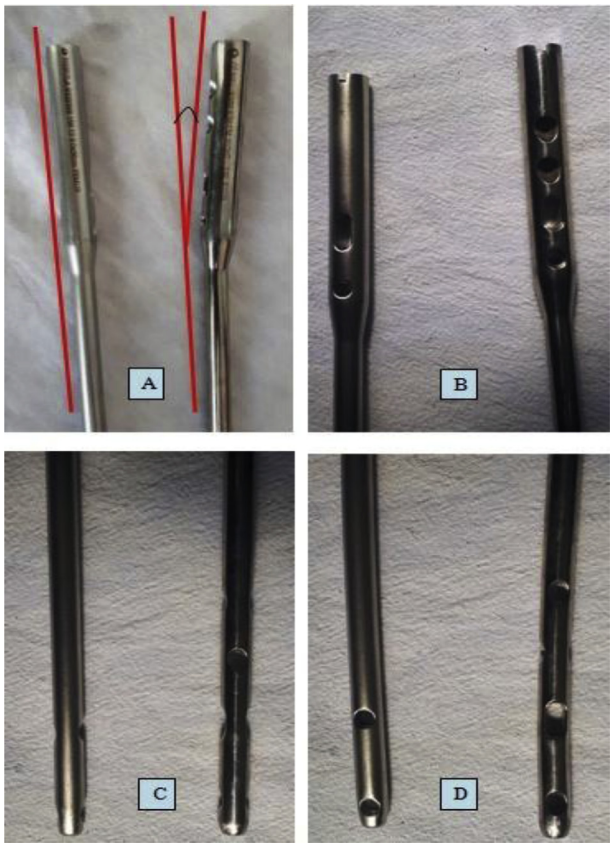

Fig. 1. Different nail designs used in the study are shown. PF entry nail is on the left side in each image. GT entry nail is on the right in each image. (A) Shows proximal valgus bend in lateral entry nail (B) Shows locking options proximally (C and D) Shows locking options distally in AP and lateral planes.

3. Results

The present study included 50 consecutive patients treated with intramedullary interlocking nailing with 25 patients in each group. The commonest age group involved was 2nd to 4th decade (68% cases) with mean age of 35.6 ± 9.4 years. Males were more commonly involved (76%). Right side was more commonly involved than left side (68%). Road traffic accident was the commonest mode of injury seen in 74% of patients. Fall was the most common injury mechanism in fifth decade (75%).

Surgery was carried out within 2–3 days. Average union time was 18.2 weeks in GT group and 14.8 weeks in PF group which was not statistically significant. In femoral shaft fractures, total time taken for entry and total fluoroscopy time showed significant differences between groups- GT < PF group (Table 1). In obese patients, these differences were more significant. Total blood loss was less and incision shorter in GT group (Table 2).

One patient had superficial infection in GT group, 2 required dynamization in PF group. Platelet rich plasma was injected at facture site to achieve union in one patient in PF group.

Iatrogenic femur neck fracture occurred in 2 patients in piriformis fossa entry and isolated greater trochanter fracture occurred in 1 patient in greater trochanter entry group (Table 3).

Abductor strength initially showed difference between the groups (MRC grading) but at final follow-up, both groups had similar strength (Table 4). Harris hip scores were comparable between the two groups at 1 year (89.9 in GT and 90.8 in PF group) (Table 5).

4. Discussion

Fractures of femoral shaft are one of the commonest fractures that orthopedic surgeons encounter. These often result from high energy trauma and may be associated with other system injuries. Intramedullary interlocking nailing is the current standard of care for such fractures as it has biomechanical advantage and tolerates bending and torsional loads better than plates. Closed nailing caused minimal damage to extra-periosteal soft tissues with favorable biological environment.

The technique of intramedullary nailing using a straight, cloverleaf nail for femoral shaft fractures was initially described by Kuntscher.[1] Lateral position and trochanter tip was used as the preferred entry portal to minimize risk of intracapsular infection, avascular necrosis and iatrogenic femoral neck fracture.

The entry portal was modified by placing the awl at the junction of middle and posterior third trochanter by Bohler. But when lateral starting point was used with straight nail, there was eccentric reaming of medial cortex of proximal fragment and comminution of fracture site. This was significant in more proximal fractures and

Table 1
Comparison of intraoperative parameters between GT and PF groups.

	GT group	PF group	P value
IITV shots for entry	6.8 ± 1.8	10.69 ± 1.9	<0.001
IITV shots for complete procedure	97.2 ± 34.1	146.6 ± 25.7	<0.001
Total surgery duration	77.9 ± 20.2	99.3 ± 8.1	NS
Incision length	5.7 ± 1.0	6.09 ± 8.1	NS
Intraoperative blood loss (mop number)	3.25 ± 1.0	4.5 ± 1.0	NS

Table 2
Comparison of operative and fluoroscopy times in obese patients (BMI >30).

	GT group (median)	PF group (median)	P value
IITV shots for entry	7.1 ± 1.8	11.7 ± 1.9	<0.001
Total fluoroscopy time	108 (72–148)	156 (138–178)	<0.001
Total operative time	83 (48–104)	102 (86–110)	NS

Table 3
Comparison of peri-operative parameters between GT and PF study groups.

Parameter	GT group	PF group
VAS (pain)	36 ± 6.6	39 ± 8.7 (p > 0.5)
Malalignment (>10°)	Nil	Nil
Trendelenberg test (1yr)	Nil	Nil
Average union time (wks)	18.2 ± 2.8	14.8 ± 2.8
Non-union	Nil	Nil
Intraop femur neck #	Nil	2 (7.4%)
Intraop GT #	1 (4.3%)	Nil
AVN femoral head	Nil	1 (3.7%)
Infection	1 (4.3%)	Nil
Secondary bone grafting	Nil	Nil
Dynamization	Nil	2 (7.4%)
PRP injection	Nil	1 (3.7%)

Table 4
Comparison of Abductor muscle power between two study groups.

Abductor strength	At 6 months		At one year	
MRC grade	GT	PF	GT	PF
3	8 (34.8%)	10 (37%)	Nil	Nil
4	14 (60.9%)	13 (48%)	6 (26%)	10 (37%)
5	1 (4.3%)	2 (7.4%)	17 (73.9%)	17 (63.0%)

Table 5
Comparison of Harris Hip Scores between two study groups.

HHS	GT	PF	P value
1 m	58.9 ± 5.5	56.6 ± 5.1	0.1 (NS)
6 m	88.3 ± 6.9	80.4 ± 8.2	0.9 (NS)
12 m	89.9 ± 2.9	90.8 ± 2.7	0.2 (NS)

caused varus malalignment.[8]

The piriformis fossa starting point became the standard for antegrade nailing.[2] Its main advantage was being in-line with the long axis of the femoral shaft which reduced the risk of iatrogenic fracture, comminution and varus malalignment.[9,10] However, difficulty in making proper entry point in obese patients is a disadvantage of PF entry point as revealed by comparatively higher operative and fluoroscopy times. Anterior placement of PF entry point is associated with excessive hoop stresses, increased risk of iatrogenic bursting of the proximal segment while medial positioning increases the risk of iatrogenic femoral neck fracture.[11]

It was noted that moving the entry further lateral on GT doesn't damage the retinacular vessels or the hip joint, but placing a straight nail without a trochanteric bend through this starting point leads to comminution of the medial femoral cortex of proximal fragment and fracture malalignment.[12,13] Representative case examples are shown in Figs. 2 and 3.

In current study, majority of the patients were from productive age group of 2nd to 4th decade (68%). The average age was 35.6 ± 9.4 years. Male preponderance was observed as in most trauma series. Right side was more involved (68%) than the left side. This can be due to left lane driving in our country making right lower limb more vulnerable to injury.

The average operative time was 99.3 ± 18.1 min for piriformis insertion and 77.9 ± 20.2min for trochanteric insertion. The average fluoroscopy time was 51% greater for the PF group (147s) than for the GT group (97s) (P < 0.001). These differences were magnified in patients who were obese (body mass index- 30) where the operative time was 22% greater and the fluoroscopy time was 44% higher in the PF group (P < 0.001).

In obese patients, the average number of IITV shots to prepare the entry point in piriformis fossa was significantly higher as compared to trochanter (mean-10.7 ± 1.9 and 6.8 ± 1.8 respectively) (P < 0.001).

Average union time was 18.2 ± 2.8 weeks in GT group and 14.8 ± 2.8 in PF group which was statistically insignificant. Within 4 months, 85% fractures united and within six months all fractures had united. Patients from both groups had a similar initial decrease and subsequent improvement in function with time.

Majority of cases in both the groups were allowed full weight

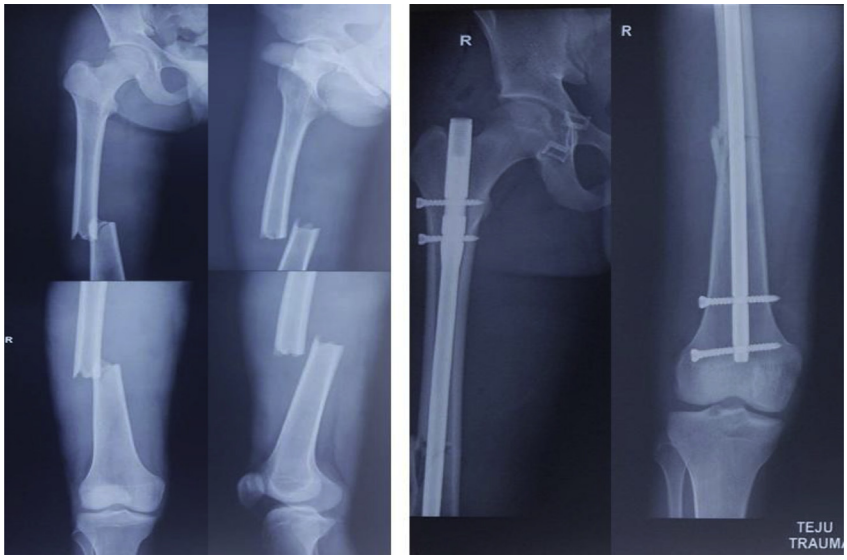

Fig. 2. Case example 1- Shaft femur fracture treated with piriformis fossa entry nail. The entry point is along the axis of femoral shaft and medially closer to neck of femur. This can predispose to femoral neck fracture.

Fig. 3. Case example 2- Shaft femur fracture treated with greater trochanteric entry nail. The entry point is lateral to the axis of femoral shaft and medially away from the neck of femur. This avoids femoral neck fracture but may predispose to trochanter fracture due to inappropriate technique.

bearing between 16 and 18 weeks. Hip and knee range of motion were within normal limits.

Few complications were noted. One patient in the GT group had delayed union which united after dynamization and one patient had iatrogenic GT fracture. In the PF group, 3 patients had delayed union, of which 2 patients united after dynamization and 1 underwent PRP (platelet rich plasma) injection.

The duration of surgery in PF group was approximately 1.5 times of the GT group. The incision length was more by 25% in the PF group. The intra-operative blood loss was greater in PF group by 30%. Pain and abductor muscle weakness on the operated side were common in both the groups which recovered with longer follow up. Functional assessment was done using Harris hip scoring system. Excellent functional status (93% and 88%) was seen at one year follow up in the two groups.

In our study the average fluoroscopy time required for the PF group (154 s) was greater than that of GT group (88 s) with p value-less than 0.001. Especially in obese patients the duration of surgery and fluoroscopy time is less if they are operated by the GT portal.[4]

In study by Ricci et al., the average operative time for PF entry group was 75 min and for the GT entry group was 62 min.[4] Another study by Stannard et al. had mean operative time of 104 min in PF as compared to 62 min in the GT group. These findings match very closely with our study (98.14 min and 68.06 min respectively).[14]

The blood loss was kept as low as 110–155 cc according to the number of mops used. Starr et al. in their study concluded that the two groups did not differ with regard to blood loss, incision length and the duration of surgery or intra operative complications.[9] Our study concludes positively the benefits of the GT entry technique.

Another study by Sheth et al., in 2016 supported the use of the GT entry point during antegrade nailing of femoral shaft fractures over the PF entry point, with regard to shorter operative and fluoroscopy times. Healing and complication rates were not related to the entry point.[15]

5. Conclusion

We can conclude that the GT portal entry is better than PF portal entry in diaphyseal femoral fractures with respect to image intensifier time in entry point preparation and total surgical duration with added advantage in obese patients (BMI>30) with similar union rate and functional results. The application of femoral nail with valgus bend through trochanteric insertion point reduces the possibility of iatrogenic femur neck fracture.

Authorship declaration

All authors listed meet the authorship criteria as per ICMJE guidelines and all authors are in agreement with the manuscript. The authors have no financial disclosures to make.

Conflicts of interest

There are no conflicts of interest associated with this work.

References

1. Kuntscher G. Die makknaelunguon knochen. Langenbecks Archiv Kl in intramedullary femoral nail in close femur factures. *Chir*. 1940;200:443–455.
2. Winquist RA, Hansen Jr ST, Clawson DK. Closed intramedullary nailing of femoral fractures. A report of five hundred and twenty cases. *J Bone Joint Surg Am*. 1984;66(4):529–539.
3. Gausepohl T, Penning D, Koebke J, Harnoss S. Antegrade femoral nailing: an anatomical determination of the correct entry point. *Injury*. 2002;33(8):701–705.
4. Ricci WM, Devinney S, Haidukewych G, Herscovici D, Sanders R. Trochanteric nail insertion for the treatment of femoral shaft fractures. *J Orthop Trauma*. 2005;19(8):511–517.
5. Ostrum RF. A greater trochanteric insertion site for femoral intramedullary nailing in lipomatous patients. *Orthopedics*. 1996;19(4):337–340.
6. Tucker MC, Schwappach JR, Leighton RK, Coupe K, Ricci WM. Results of femoral intramedullary nailing in patients who are obese versus those who are not obese: a prospective multicenter comparison study. *J Orthop Trauma*. 2007;21:523–529.
7. Ansari Moein CM, Verhofstad MH, Bleys RL, van der Werken C. Soft tissue injury related to choice of entry point in antegrade femoral nailing: piriformis fossa or greater trochanter tip. *Injury*. 2005;36(11):1337–1342.
8. Strum RF, Marcantonio A, Marburger R. A critical analysis of the eccentric starting point for trochanteric intramedullary femoral nailing. *J Orthop Trauma*. 2005;19(10):681–686.
9. Starr AJ, Hay MT, Reinert CM, Borer DS, Christensen KC. Cephalomedullary nails in the treatment of high of high-energy proximal femur fractures in young patients: a prospective, randomized comparison of trochanteric versus piriformis fossa entry portal. *J Orthop Trauma*. 2006;20(4):240–246.
10. Ghosh S, Das J, Chaudhuri A, Kumar A, Datta S, De C. Comparative study of

treatment of fracture shaft femur by intramedullary interlocking nails through piriformis fossa entry and tip of the greater trochanter entry approach. *Saudi J Sports Med*. 2015;15(2):148–152.
11. Linke B, Ansari Moein C, Bosl O, et al. Lateral insertion points in antegrade femoral nailing and their influence on femoral bone strains. *J Orthop Trauma*. 2008;22(10):716–722.
12. Ha SH, Kim W-H, Lee GC. Results of intramedullary nailing of femoral shaft fracture - trochanteric entry portal (Sirus nail) versus piriformis entry portal (M/DN nail). *J Korean Fract Soc*. 2014;27(1):50–57.
13. Robinson CM, Houshian S, Khan LA. Trochanteric-entry long cephalomedullary nailing of subtrochanteric fractures caused by low-energy trauma. *J Bone Joint Surg Am*. 2005;87(10):2217–2226.
14. Stannard JP, Bankston L, Futch LA, McGwin G, Volgas DA. Functional outcome following intramedullary nailing of the femur: a prospective randomized comparison of piriformis fossa and greater trochanteric entry portals. *J Bone Joint Surg Am*. 2011;93(15):1385–1391.
15. Sheth U, Gohal C, Chahal J, Nauth A, Dwyer T. Comparing entry points for antegrade nailing of femoral shaft fractures. *Orthopedics*. 2016;39(1):e43–e50.