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Greater trochanteric versus piriformis fossa entry nails for femur shaft fractures: Resolving the controversy

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ABSTRACT

Background: Intramedullary nailing is the treatment of choice for shaft of femur fractures in adults. Antegrade nails involve entry through either piriformis fossa (PE) or greater trochanteric (GT) tip. The superiority of one entry point over the other is a matter of debate, and the present review was done to determine the same.

Research question: Is GT entry for antegrade femur nailing superior to the PE for shaft femur fractures in adults?

Objective: The present systematic review was conducted to determine the superiority of one entry point over the other by comparing the outcome parameters like operative time, exposure to fluoroscopy, malunions, non unions, abductor weakness, varus malalignment and Harris Hip scores (HHS).

Methodology: Three databases of PubMed, EMBASE and SCOPUS were searched for relevant articles that directly compared GT with PE for nailing in shaft femur fractures in adults.

Results: We analysed a total of 9 studies published between the years 2011–2017. There were 5 retrospective and 4 prospective studies, out of which 3 were randomised. The total number of patients was 256 in GT group and 460 in PE group.

Outcomes: There was significant superiority of GT entry over PE on meta analysis; lesser operation time: standard mean difference (SMD): -21.01; lesser exposure to fluoroscopy : SMD: 36.36; lesser incidence of abductor weakness: Odd's ratio (OR): 14.35; better functional outcome (HHS): SMD -2.48.

Conclusion: GT entry nails are superior to PE nails for treating shaft of femur fractures in adults. They have a shorter learning curve and better functional outcomes, however the rates of union are comparable in both.

Introduction

The management of femur fractures has evolved since the introduction of intramedullary nailing technique by Kuntscher in the 1940's [1]. Close reduction and internal fixation with an intramedullary nail is the preferable and widely acceptable treatment for femur shaft fractures [2–5]. The nailing technique, along with the nail design and configuration have also been improvised over past few decades. Although the piriformis fossa and the greater trochanter (GT) are the two recognised entry points for antegrade nails, the debate for optimal entry point and the superiority of one over the other is not settled [6–8].

Piriformis entry (PE) nails usually require unavoidable surgical dissection through the hip abductors and external rotators, thereby, leading to more soft tissue damage than trochanteric nails [9,10]. Additionally, higher incidence of iatrogenic injury to medial circumflex femoral artery and superior gluteal nerve have been reported with the piriformis fossa entry [10,11]. These may lead to suboptimal functional outcome in the patient along with residual hip or thigh pain and a discrete limp due to muscle weakness [11–15]. There are also higher incidence of avascular necrosis of femoral head and iatrogenic femur neck fractures reported with piriformis entry nails [16]. Trochanteric tip entry nails with proximal lateral bend, theoretically avoid these complications, thereby, increasing their popularity among the surgeons [17–19]. However, the GT entry nails could also be associated with iatrogenic fractures. Overall, the rates of union and complications have been shown to be comparable between the two entry points [20].

Although systematic reviews have been done previously for ascertaining the superiority between the two entry points, the

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0020-1383/

Table 1
Search strategy used for the systematic review in PubMed, EMBASE and SCOPUS databases.

Database	Date : 15.1.2019	Results
PubMed :		100
"femoral fractures" [MeSH Terms] OR ("femoral" [All Fields] AND "fractures" [All Fields]) OR "femoral fractures" [All Fields] OR ("femur" [All Fields] AND "fracture" [All Fields]) OR "femur fracture" [All Fields] AND ("nails" [MeSH Terms] OR "nails" [All Fields] OR "nail" [All Fields]) AND entry [All Fields] AND point [All Fields]		
Embase:		97
nail entry point' OR ((('femur'/exp OR femur) AND ('fracture'/exp OR fracture) AND ('nail'/exp OR nail) AND entry AND point)		
Scopus:		114
TITLE-ABS-KEY (femur AND fracture AND nail AND entry AND point)		

number of studies they included were very less, which do not provide adequate strength to the results [21,22]. Hussain et al concluded that giving recommendations based on their review was difficult and they could not confirm the superiority of one entry point over the other [21]. Sheth et al concluded that further research is needed to determine effects of the entry point on the musculature and functional outcomes [22]. There were only 4 studies in both these reviews.

Hence the present review was conceptualised to review and meta analyse the data available in literature with a more extensive search of three databases, and determining which entry point is superior than the other with respect to specific variables; fluoroscopy exposure and operative durations, varus mal-alignment, rates of mal-union and non union, Harris Hip scores (HHS) and effects on the abductor mechanism/Trendelenberg gait.

Methods

Search methodology

We designed the study according to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta analysis (PRISMA) [23].

Three databases of PubMed, EMBASE and SCOPUS were searched on 15th January 2019 using specific keywords depicted in Table 1. A total number of 311 hits were obtained. A secondary

Table 2
Preoperative data in the studies.

Serial no.	Authors	Year	Type of study	Types of fractures	Groups (1-GT, 2- PE)	Nail used	No. of patients	Percentage of females (%)	Mean age (years)	Mean follow-up (months)
1	Kim et al [24]	2017	Retrospective	Atypical Shaft femur (OTA 32)	GT	A2FN (Synthes), Sirus (Zimmer) and CHN (TDM, Seoul)	19	100	NA	26
					PE	CFN (synthes), UFN (Synthes)	46	100	NA	
2	Yoon et al [25]	2016	Retropective	Diaphyseal fractures (OTA 32 A-C)	GT	NA	67	17.4	31.1	NA
					PE		141			
3	Moein et al [26]	2011	Retrospective trial	Proximal third shaft of femur fractures (OTA 32 A-B)	GT	Long PFN (Synthes)	8	0	48	26
					PE	UFN (Synthes)	9	0	40.5	
4	Ricci et al [20]	2006	Prospective cohort	Shaft or subtrochanteric (OTA 32 A-C)	GT	Trigen TAN	38	34.2	28	10
					PE	Trigen FAN	53	45.3	29	
5	Sadagatullah et al [27]	2017	Retrospective	Proximal or midshaft femur (OTA 32 A-B)	GT	SFN (Synthes)	88	10.1	29.15	NA
					PE	Aesculap Targon F/T nail (B. Braun)	91			
6	Stannard et al [28]	2011	Prospective RCT	Mid shaft femur (OTA 32 B)	GT	Trigen TAN	59	55NA	33 35	14.1 17.7
					PE	Trigen AFN; AFN (Synthes)	55			
7	Meena et al [2]	2016	Prospective RCT	Shaft femur fractures	GT	NA	25	16	76% under 40 years	12
					PE	NA	25	4	80% below 40 years	
8	Ghosh et al [29]	2015	Prospective pilot study	Shaft femur (OTA 32 A-B)	GT	NA	15	76.7	60% under 40 years	12
					PE	Indian ILN	15			
9	Kumar et al [30]	2017	Prospective RCT	Shaft femur	GT	Identical nails in both groups	25	NA	36.6	6
					PE		25			

RCT- randomised controlled trial; GT- greater trochanter; PE- piriformis fossa entry; OTA- Orthopaedic trauma association; AFN- antegrade femoral nail; SFN- shaft femur nail; UFN- unreamed femoral nail; PFN- proximal femoral nail; TAN- trochanteric antegrade nail;FAN- femoral antegrade nail; ILN- interlocking intramedullary nail NA- Not available.

Table 3
Reported Outcomes in the studies.

Study	Groups (1- GT, 2- PE)	Operative time; fluoroscopy time	Intraoperative events	Radiological Union rates and weeks	Delayed and non unions	Post-operative implant related complications/ revisions	Femoral version/ Varus malalignmnt	Functional outcome score (HHS), LEM, WOMAC, Mean Residual pain scale; muscle strength, Trendelenburg test; TUG test; Thoresen's score	Authors' Conclusions
Kim et al[24]	GT	NA	0	89.5%; 17.8 ($p = 0.020$)	6 cases (31.6%)	1 distal lock screw breakage and 1 nail breakage	NA	NA	Union rates are better in nails with trochanteric entry
	PE		2 iatrogenic fractures	84.8%; 21.2	18 cases (39.1%)	0	NA	NA	
Yoon et al[25]	GT	NA	NA	NA	NA	0 revisions	7.9+-6.10 ($p < 0.05$)	NA	Malalignment and malrotations are more in nails with piriformis entry
	PE		NA	NA	NA	9 revisions for malrotations	9.5+-7.4	NA	
Moein et al[26]	GT	NA	NA	NA	2	NA	NA	Pain scale:4.5 with 6 patients having interference in daily activities; HHS:82; Trendelenburg positive: 0 ($p = 0.01$)	Comparable results and functional outcome; hip abduction weakness is more in PE nails
	PE		NA	NA	4	NA	NA	Pain scale: 3.3 with 2 patients having interference in daily activities; HHS 89.8; Weakness of abductors/ Trendelenburg positive: 5 patients	
Ricci et al[20]	GT	62 min (14-193) [$p = 0.08$]; 95 seconds (20-375) [$p < 0.05$]	0 iatrogenic fractures	97%	1 delayed union at 7 months requiring exchange nailing and 4 having delayed unions that united without intervention	2 patients had locking screws removal for pain; 1 deep infection needed debridement and irrigation	No varus malalignment	LEM: 92	GT entry surgeries are faster with less exposure to c arm for the surgeon and patients
	PE	75 min (31-131); 153 seconds (16-662)	0	98%	1non union at 6 months, healing after exchange nail; 5 had delayed unions that united without intervention	4 patients needed locking screw removal; 1 superficial infection treated with antibiotics	No varus malalignment	LEM: 99 ($P > 0.05$)	
Sadagatullah et al[27]	GT	NA	NA	NA	NA	NA	2.8% (5 patients had varus malalignment >10 degrees) ($p < 0.001$)	NA	Gt entry nails may cause more varus malalignment specially if the fracture is proximal. However implant design may be a factor in this study
	PE		NA	NA	NA	NA	0	NA	
Stannard et al[28]	GT	75 min (35-187) ($p = .0001$); 118 seconds (29-320)	NA	23.1 weeks	1 non union; 1 delayed union	No deep infections; 1 patient had a large hematoma requiring evacuation;Distal locking screw breakage occurred in 5 patients	2 patients healed in varus malalignment	TUG: 8.72 sec; Hip abductor strength: 18.38 pounds; WOMAC score: 27.13; Pain scale: 2.15	Gt entry surgeries are faster and require lesser c arm exposure; have lesser non unions and better functional outcomes
	PE	104 (41-233); 149 seconds (48-311)	NA	22.9 weeks	3 non unions; 4 delayed unions	No deep infections; 2 patients needed surgical evacuation of large wound hematoma; 1 patient had breakage of the nail requiring revision and 1 patient had breakage of distal lock.	4 patients had varus malalignment	TUG: 9.72 sec ($p = 0.71$); Hip abductor strength: 16.45 pounds ($p = 013$); WOMAC: 27.03; Pain scale: 2.49	

(*continued on next page*)

Table 3 (*continued*)

Study	Groups (1- GT, 2- PE)	Operative time; fluoroscopy time	Intraoperative events	Radiological Union rates and weeks	Delayed and non unions	Post-operative implant related complications/ revisions	Femoral version/ Varus malalignmnt	Functional outcome score (HHS), LEM, WOMAC, Mean Residual pain scale; muscle strength, Trendelenburg test; TUG test; Thoresen's score	Authors' Conclusions
Meena et al[2]	GT	64.20 min; 5.88 shots	NA	88%	3 patients had delayed union (2 needed dynamisation); 1 had non union with broken nail, managed with exchange nail	1 patient with non union had broken nail	NA	HHS: excellent 92 percent cases; good: 4%	GT entry surgeries are faster with lesser c arm exposure
	PE	76.44 min (<0.001); 10.08 shots ($p < 0.001$)	NA	84%	4 patients had delayed unions; 2 had non unions requiring exchange nail	1 case of delayed union had infection requiring debridement and antibiotic beads	NA	HHS: Excellent: 84%; good: 16%	
Ghosh et al[29]	GT	69.3 min; 8 shots	NA	13 (86.7%) patients united within 19 weeks	13.3% delayed union (needed dynamisation)	26.7% hardware prominence; no infection	13.3% malunions	Restrictions of knee/hip movements in 40%; hip abduction weakness in 33.3%; Thoresen's score: good to excellent in 93.4%	Trochanteric entry nails are faster to insert with less requirement of c arm shots; union rates are comparable between groups and so is the overall functional outcome
	PE	75.7 min ($p = 0.005$); 10 shots ($p = 0.048$)	NA	13 (86.7%) patients united within 19 weeks	20% delayed union (needed dynamisation)	6.7% infection; 13.3% hardware prominence	20% malunions	Restrictions of knee /hip movements in 26.7%; hip abduction weakness in 20%; Thoersen's score: good to excellent in 100%	
Kumar et al[30]	GT	68.05+- 12.16 min; 88 shots	Iatrogenic GT fracture in 1 patient	88% in 4 months	Delayed union in 3 patients (united at 6 months)	1 infection	none	HHS at 4 months 73.37; LEM score: 86.08; Thoersen score: good to excellent in 84%	Better functional outcome in trochanteric nails which are faster to insert requiring lesser c arm shots to make the entry point.
	PE	98.14+-18.45 min ($p < 0.001$); 154 shots ($p > 0.001$; however shots needed for making entry point was significantly more in PF)	Neck femur fracture in 3 patients	84% in 4 months	Delayed union in 4 patients (united at 6 months)	1 infection	none	HHS at 4 months 68.67 ($p < 0.002$); LEM score: 88.7; Thoersen score: good to excellent in 88%	

GT- greater trochanter; PE- piriformis fossa entry; NA- Not available; WOMAC: Western Ontario and McMaster Universities osteoarthritis index; LEM: lower extremity measure; min: minutes; HHS- Harris hip score; TUG- timed up and go.

search from the references of relevant articles was also done to include any missed articles from the three databases.

Inclusion & exclusion criteria

Relevant articles directly comparing the outcomes of intramedullary nails for shaft of femur fractures in adults, via the two entry points (piriformis fossa and greater trochanter) were analysed. Conference abstracts, case reports, cadaveric studies and any other studies that included intra-articular or inter-trochanteric femur fractures were excluded. We also excluded articles that were not in English and previous reviews.

Data collection and analysis

Three reviewers (PK, RK and DN), independently screened the studies. The relevant articles as per the study question were identified, and their abstracts were read. In case of any doubts during abstracts screening, full texts were read. Short listed articles were included in the review for the analysis. Any selection conflicts among the authors were resolved by group discussions to arrive at a final consensus.

Data extracted were collected and registered under two groups (Group 1- Greater trochanteric entry or GT; Group 2- Piriformis entry or PE). This included names of the authors and the journals, year of publishing, type of study and the fractures, type of nails used, demographic parameters like age, sex and number of patients, mean followup time, operative and fluoroscopy times, intraoperative fractures, delayed and mal-unions, post-operative complications, varus mal-alignment and functional outcomes [Tables 2 and 3].

Statistical analysis

We analysed our data with Review Manager Software (RevMan 5.3). Meta-analysis was performed if two or more studies reported on the outcome of interest. For dichotomous data odds ratio (OR) and 95% confidence intervals (CI) were calculated. For continuous data weighted mean difference (WMD) and 95% CI were calculated. We used fixed effects model to estimate overall effect sizes. I^2 value and chi-square test were used to assess statistical heterogeneity. P-value $>$ 0.1 pointed to statistical heterogeneity.

Identification of studies

A total of 311 studies were identified by the word search in all three databases. After refining the search and assessing the titles for comparative evaluation of both the techniques and excluding overlaps, 16 studies were identified. Abstracts were read for all these studies and finally full texts of 12 studies were accessed and read, out of which 9 studies were included in the review [2,20,24–30] [Fig. 1].

Risk of bias

Risk of bias was calculated by two methods. Firstly, two reviewers (VK and SA) independently read each article about randomisation, blinding methods and outcome parameters. Secondly, RevMan 5.3 software was used to generate risk bias graph.

Evidence grading

Quality of evidences for the outcomes were graded using GRADE system (Grading of Recommendations Assessment, Development and Evaluation). We assessed strength of evidence with the "Grade system pro" and summarised the results [Fig. 2].

Results

Study characteristics

The 9 studies included in the review were published between 2011–2017. There were 5 prospective and 4 retrospective studies. The total number of patients was 256 in GT group, and 460 in PE group. The mean followup period was 15.1 months. The preoperative parameters in terms of demography, anaesthesia risk and mobility prior to injury were comparable between the two groups in all the included studies. 7 studies were used in the meta analysis and every outcome parameter which were assessed by two or more studies were meta analysed [2,20,26–30].

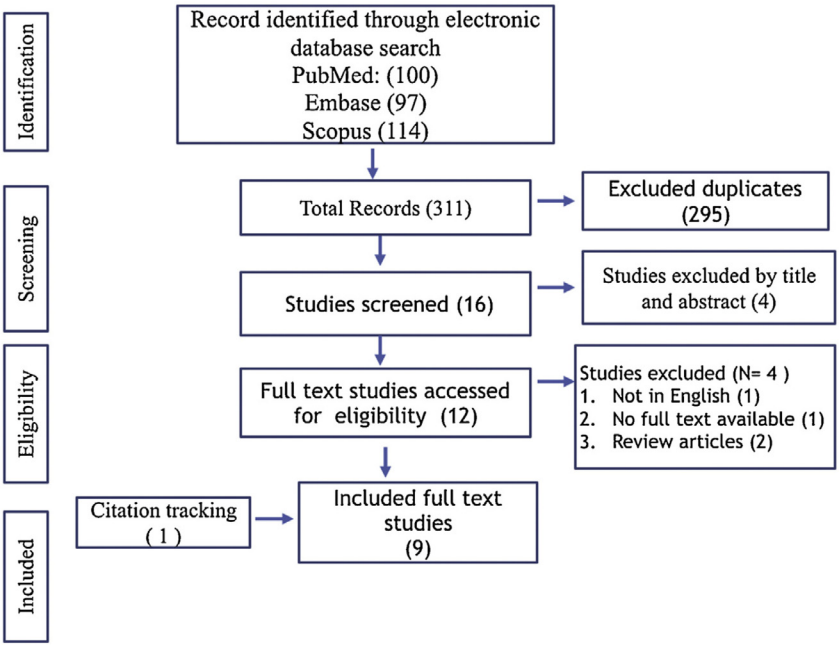

Fig. 1. Flowchart depicting selection of articles.

operative time												
5	observational studies	not serious	not serious	not serious	not serious	none	172	159	-	MD 21.01 higher (10.34 higher to 31.69 higher)	⊕⊕◯◯ LOW	CRITICAL
flouroscopy time (assessed with: c arm shots duration)												
3	observational studies	not serious	not serious	not serious	not serious	none	132	119	-	MD 36.36 higher (13.26 higher to 59.46 higher)	⊕⊕◯◯ LOW	CRITICAL
Non union (follow up: 9 months)												
3	observational studies	not serious	not serious	not serious	not serious	none	6/132 (4.5%)	1/119 (0.8%)	OR 3.38 (0.68 to 16.74)	19 more per 1,000 (from 3 fewer to 116 more)	⊕⊕◯◯ LOW	CRITICAL
delayed union (follow up: 6 months)												
3	observational studies	not serious	not serious	not serious	not serious	none	10/132 (7.6%)	9/119 (7.6%)	OR 0.92 (0.24 to 3.43)	6 fewer per 1,000 (from 56 fewer to 144 more)	⊕⊕◯◯ LOW	CRITICAL
varus malalignment (follow up: 12 months)												
2	observational studies	not serious	not serious	not serious	not serious	none	34	33	-	MD 4.97 lower (9.28 lower to 0.66 lower)	⊕⊕◯◯ LOW	CRITICAL
positive trendelenburg (follow up: 4 months)												
2	observational studies	not serious	not serious	not serious	not serious	none	9/34 (26.5%)	0/33 (0.0%)	OR 14.35 (1.65 to 125.17)	0 fewer per 1,000 (from 0 fewer to 0 fewer)	⊕⊕◯◯ LOW	CRITICAL
Harris Hip Score (follow up: 6 months)												
3	observational studies	not serious	not serious	not serious	not serious	none	59	58	-	MD 2.48 lower (4.91 lower to 0.06 lower)	⊕⊕◯◯ LOW	CRITICAL

CI: Confidence Interval; **MD:** Mean difference; **OR:** Odds ratio

Fig. 2. Assessment of strength of evidence.

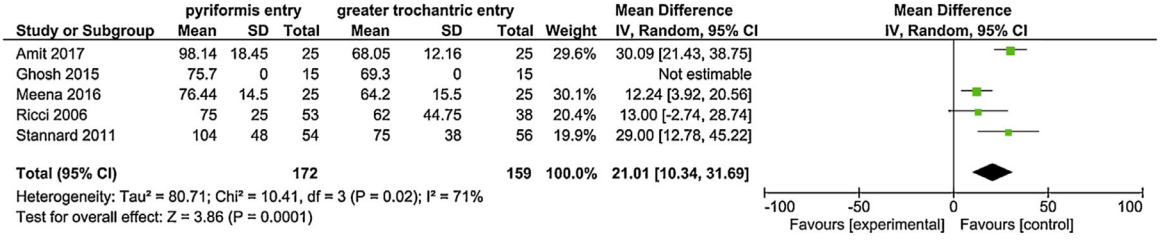

Fig. 3. Meta analysis for duration of surgery.

Outcome meta-analysis

Operative time and exposure to fluoroscopy

5 studies reported on duration of surgery [2,20,28–30]. The average duration of surgery in the GT group in these studies was 67.7 min, while in PE group it was 85.9 min. On meta analysis the duration of surgeries in PE group was significantly higher with a standard mean difference of 21.01 (range 10.34–31.69); p = 0.0001 [Fig. 3].

3 studies reported on the exposure to fluoroscopy during the surgeries [20,28,30]. The average time of exposure in GT group was 100.3 s. The PE group had an average exposure of 152 s which was significantly more with standard mean difference of 36.36 (13.26–59.46) [Fig. 4]. So these results favour the GT entry suggesting it to be technically simpler than PE entry.

Delayed and non- unions

There were 9 cases of delayed union in the GT group and 10 in the PE group with OR 0.92 (range 0.24–3.43) [2,20,28]. No significant difference was seen in both the groups [Fig. 5].

4 studies reported on the incidence of non-unions with only 1 case in GT group and 6 in the PE group [2,20,26,28]. However, on meta analysis, although the incidence was more in the PE group it was not significant (OR- 3.38; Range- 0.68–16.74) [Fig. 6].

So overall in terms of union, although the results point towards the superiority of GT entry nails, but they are not conclusive.

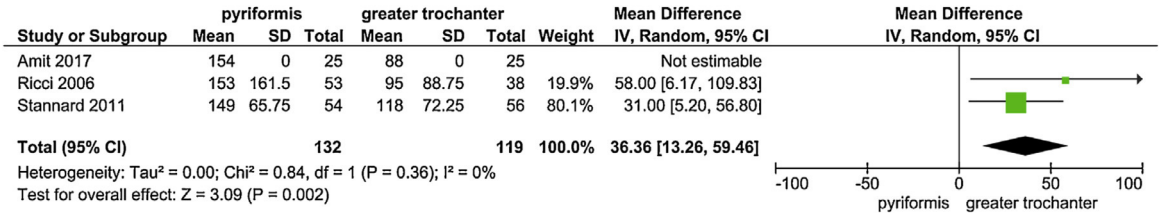

Fig. 4. Meta analysis for fluoroscopy exposure.

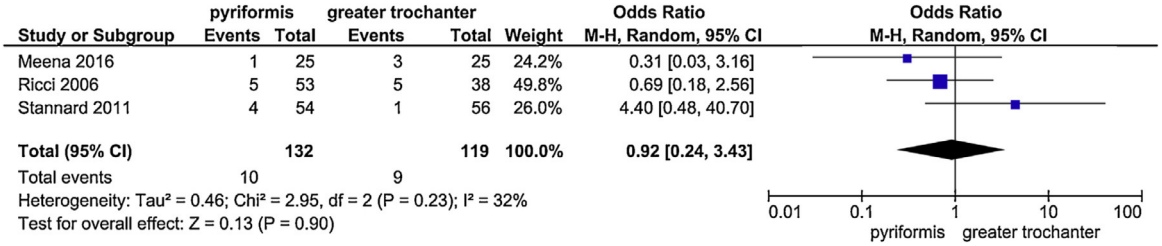

Fig. 5. Difference in delayed union.

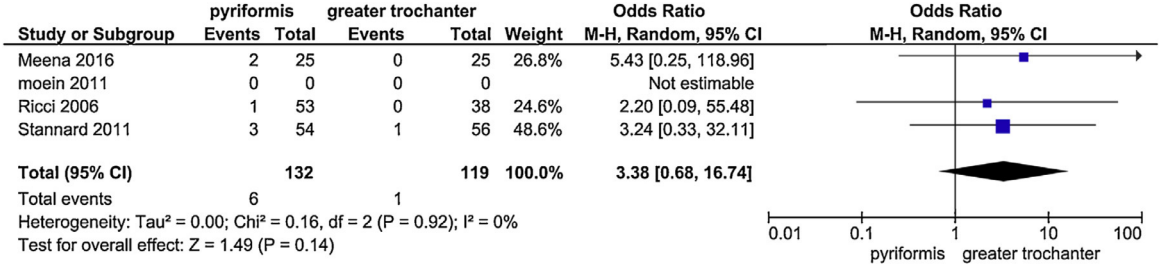

Fig. 6. Meta analysis for non union rates.

Varus malalignment

2 studies reported on varus malalignment with 9 cases in GT group and 2 in the PE group [27,28]. The meta analysis favours the PE group with lesser incidence of malalignment (OR- 0.25, Range 0.06–1.04), but it is not significant since the forest graph touches the midline [Fig. 7]. Also, in the study by Sadagatullah et al where 5 cases were reported in the GT group and whose weightage was very high in the meta analysis, the authors considered inclusion of proximal fractures as the factor responsible for more varus, along with the designs of the nails they used [27]. Therefore, varus malalignment which is a serious complication with Gt entry nails in inter-trochanteric or subtrochanteric femur fractures, may not be such a big issue in shaft femur fractures.

Abductor weakness/Trendelenberg gait

Only 2 studies have assessed this important parameter that may lead to long term limp and gait issues [26,30]. There were 9 cases who had abductor weakness in the PE group while none of the patients in the GT group were affected. The meta analysis confirmed higher rates of abductor issues in PE group with an OR of 14.35 (Range-1.65–125.17) [Fig. 8].

Functional outcomes

HHS is the tool used in 3 studies to demonstrate the functional outcome differences between the 2 groups [2,26,30]. Meena et al got good to excellent scores for their patients in both the groups [2]. On meta analysing, the average HHS in the PE group was 80.02, while in the GT group it was 84.65. The standard mean difference after meta analysis was -2.48 (range: −4.91 to −0.06) [Fig. 9]. This is a very important parameter favouring the GT entry nails.

Risk of bias

Risk of bias about methodological quality of the included studies are shown in Figs. 10 and 11. Only 3 studies were randomised [2,28,30]. We did not find any publication bias in the included studies. The studies did mention about number of cases lost to follow up but did not specify the groups affected. However the parameters analysed in the present study were not affected by this issue.

Discussion

Piriformis fossa is anatomically aligned with the femoral shaft long axis which aids in insertion of straight antegrade intramedullary nails through this entry [31,32]. On the other side, the GT tip is lateral to the long axis which requires the nail to have either malleability or an approximate angle of 6 degrees proximally, for entrance into the canal [33]. GT entry provides better rotational stability and theoretically avoids intracapsular infections, iatrogenic neck of femur fractures and femoral head devascularisation, which are reported in PE nails [6,34]. It has also been reported to be technically simpler, specially in very obese patients [6].

The present review compared the two entry points by studying the evidence in literature and confirms the superiority of GT entry over the PE nails. GT entry nails require shorter surgical time and the exposure to intra-operative fluoroscopy was also found to be significantly lesser than the PE group. These two important findings confirm the simplicity of GT entry, which has a shorter

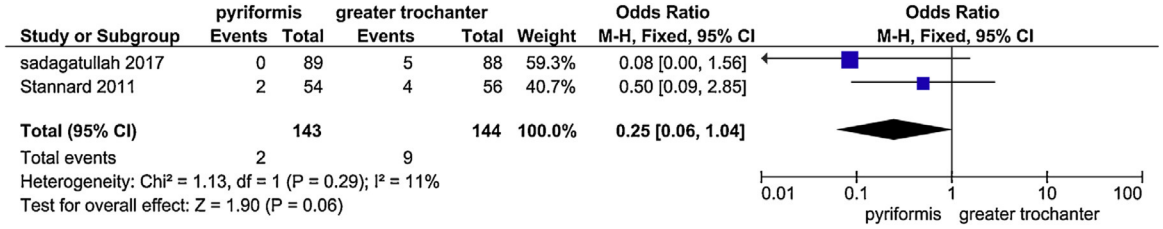

Fig. 7. Meta analysis for varus mal-alignment.

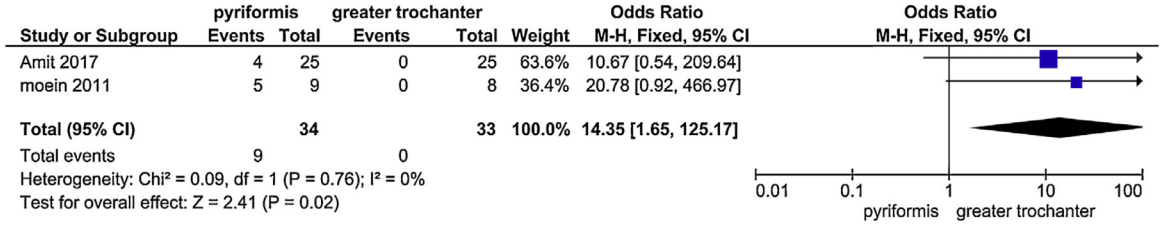

Fig. 8. Comparison of abductor weakness.

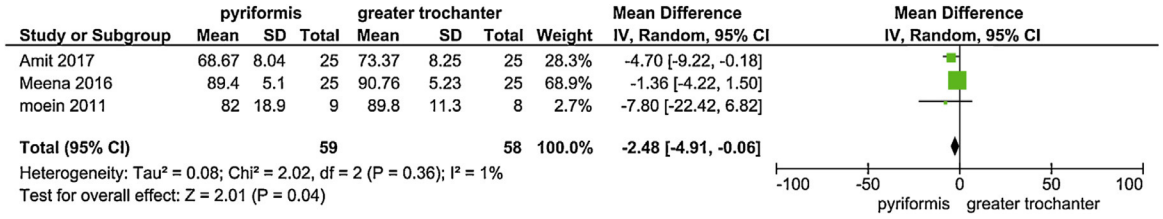

Fig. 9. Difference in functional outcome (HHS).

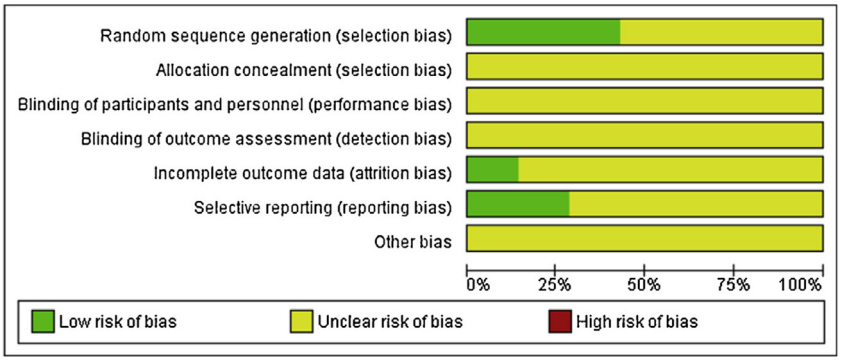

Fig. 10. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

learning curve than the PE nails. The shorter duration of surgery implies shorter anaesthetic duration and associated morbidity. Additionally, turnover of cases in the operation theatre increases, which is of importance, specially if the patients' footfall is high at a trauma centre.

In terms of union rates and mal-unions, both the entry points showed comparable outcomes implying that the entry point has no effect on process of union. This is particularly important, because if the union is comparable, it is better and more sensible to use a simpler and shorter surgery with GT entry nails for these fractures. GT entry nails have been shown to be associated with varus mal-alignment leading to problems with union, in intertrochanteric and subtrochanteric femur fractures; we did not find this to be the case in shaft femur fractures, when compared to the PE nails. The modern nail designs with proximal bends minimise the chances of eccentric reaming and subsequent malalignment [6,9].

An important consideration against PE entry nails is that they may require dividing the fibres of hip abductors, to access the piriformis fossa [9–11]. There may be damage and scarring of these important muscles, which may lead to weakness and subsequent lurch. In the present study, this complication was significantly higher in PE group and therefore these nails may affect long term functionality, and adequate physiotherapy and rehabilitation are of paramount importance in minimising this complication. Additionally in terms of HHS, our results suggest that GT entry nails provide better outcomes than the PE entry nails. None of the previous reviews could establish this important finding [21,22].

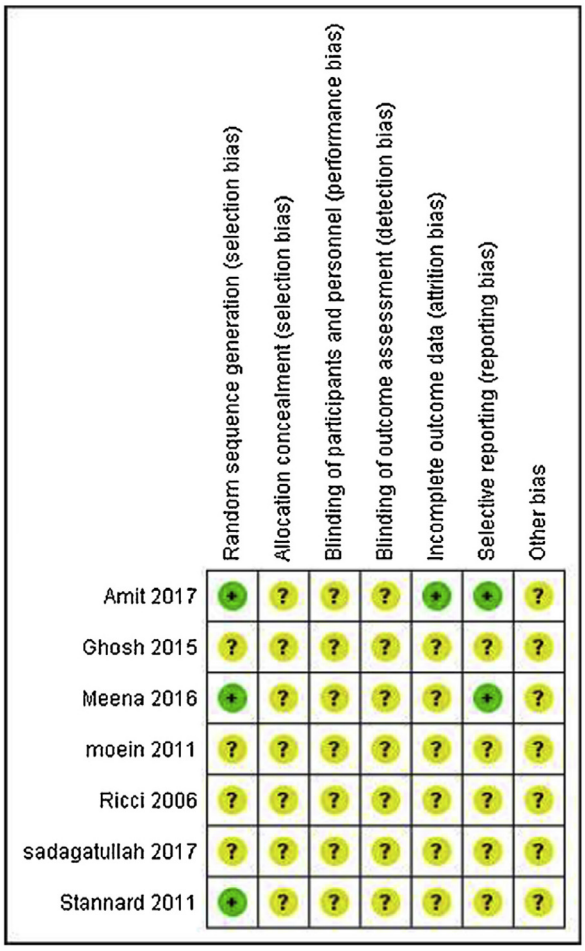

Fig. 11. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

Overall, with this extensive literature search and analysis, the present study establishes the fact that GT entry nails are superior to the PE nails, with shorter duration of surgery requiring lesser radiation exposure; lesser damage to musculature and better functional outcomes. Varus collapse and issues with union are not significantly different between the two groups. Therefore, based on our statistically significant results we advise against usage of PE nails for these fractures to minimise associated complications in the patients and provide them with better functional outcomes; moreover as the GT entry nails are readily available and must be preferred.

The limitation of the present study is that the certainty of evidence is low as per our grading scores, because there are limited level 1 studies in literature. Additionally we have meta-analysed a combination of prospective and retrospective studies, therefore the strength of the evidence may be affected. Future prospective randomised controlled trials could further substantiate the important results from our meta analysis.

Conclusion

Intramedullary nails are the treatment of choice for shaft femur fractures in adults. Greater trochanteric tip is a simpler and better alternative to the conventional piriformis fossa, for antegrade entry point of these nails, as it provides better functional outcomes and has a shorter learning curve.

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Declaration of Competing Interest

The authors declare no Conflict of interest.

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