

Trochanteric Entry Femoral Nails Yield Better Postoperative Femoral Version and Lower Revision Rates than Retrograde and Piriformis Entry Nails: A Large Cohort Multivariate Regression Analysis

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Purpose: Intramedullary nailing (IMN) has become the standard of care for the treatment of most femoral shaft fractures. Different IMN options include trochanteric and piriformis entry as well as retrograde nails, which may result in varying degrees of femoral rotation. The objective of this study was to analyze postoperative femoral version between the three types of nails and to perform a regression analysis controlling for any potential confounding factors to delineate any significant differences in femoral version and revision rates.

Methods: 417 consecutive patients with femur fractures were treated with an IM nail at a Level I trauma and tertiary referral center. Of these patients, 316 met inclusion criteria and obtained postoperative CT scanograms to calculate femoral version and were thus included in the study. In this study, our main outcome measure was the difference in femoral version (DFV) between the uninjured limb and the injured limb. Femoral version was determined on postoperative CT scanograms by a trauma fellowship-trained orthopaedic surgeon. Statistical analysis included initial univariate regression followed by forward, stepwise multivariate regression analysis to compare DFV. Covariables included gender, age, body mass index (BMI), ethnicity, mechanism of injury, operative side, and open fracture.

Results: Total number included for analysis included 316 patients. Piriformis entry nails made up the majority (n = 141), followed by retrograde (n = 108), then trochanteric entry nails (n = 67). Univariate regression analysis revealed that a lower BMI was significantly associated with a lower DFV (P = 0.006). Controlling for possible covariables, multivariate analysis yielded a significantly lower DFV for trochanteric entry nails than piriformis or retrograde nails ($7.9^\circ \pm 6.10^\circ$ vs $9.5^\circ \pm 7.4^\circ$ vs $9.4^\circ \pm 7.8^\circ$, P < 0.05). Using revision as an end point, trochanteric entry nails also had a significantly lower revision rate, even when controlling for all other variables (P < 0.05).

Conclusion: Comparative, objective comparisons of DFV between different nails based on entry point revealed that trochanteric nails had a significantly lower DFV and a lower revision rate, even after regression analysis. However, this is not to state that the other nail types exhibited abnormal DFV. Translation to the clinical impact of a few degrees of DFV is also unknown. Future studies of more in-depth study of the intricacies of femoral version may lead to improved technology in addition to potentially improved clinical outcomes.

1 **Tables**

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3 **Table 1.** Cohort demographic and injury data (n=316)

Parameter	Value
Mean Age (SD), yrs	31.1 (13.6)
Gender (%)	
Male	261 (82.6)
Female	55 (17.4)
Mean BMI (SD)	27.2 (5.2)
Ethnicity (%)	
Black	181 (57.3)
White	65 (20.6)
Hispanic	59 (18.7)
Asian	1 (0.3)
Other	10 (3.2)
Injury Side (%)	
Left	144 (45.6)
Right	172 (54.4)
Mechanism of Injury (%)	
MVA	133 (42.1)
GSW	64 (20.3)
Pedestrian Struck	39 (12.3)
Fall	34 (10.8)
MCA	33 (10.4)
Crush	9 (2.8)
Assault	4 (1.3)
Open Fx (%)	43 (13.6)

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1 **Table 2.** Mean DFV for piriformis, trochanteric and retrograde femoral IMN along with univariate regression
 2 analysis results identifying any significant factors for each corresponding femoral IMN with lower and upper bound
 3 CI (95%). No significant impact was noted for any of the variables on mean DFV on any of the nails except a
 4 significantly correlated DFV with BMI in trochanteric start nails.

Nail Type	Mean DFV, Degrees (SD)	Variable	p value	95% CI	
				Lower Bound	Upper Bound
Piriformis n=141	9.5 (7.4)	Gender	0.48	-2.51	5.28
		Age	0.83	-0.09	0.12
		BMI	0.78	-0.35	0.26
		Ethnicity	0.50	-2.05	1.00
		Mechanism of Injury	0.51	-0.48	0.96
		Operative Side	0.70	-2.17	3.22
		Open Fx	0.68	-3.30	5.02
Trochanteric n=67	7.9 (6.1)	Gender	0.12	-8.75	0.99
		Age	0.16	-0.037	0.23
		BMI*	0.006	-0.94	-0.16
		Ethnicity	0.27	-2.73	0.77
		Mechanism of Injury	0.08	-0.11	1.64
		Operative Side	0.80	-2.69	3.46
		Open Fx	0.18	-1.64	8.45
Retrograde n=108	9.4 (7.8)	Gender	0.051	-0.03	8.57
		Age	0.18	-0.05	0.25
		BMI	0.79	-0.35	0.46
		Ethnicity	0.35	-0.91	2.54
		Mechanism of Injury	0.80	-0.78	1.01
		Operative Side	0.42	-1.92	4.61
		Open Fx	0.53	-6.18	3.19

5 *p<0.05
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1 **Table 3.** Multivariate regression comparison of mean DFV between piriformis entry, trochanteric entry, vs
 2 retrograde femoral nails controlling for gender, age, BMI, ethnicity, mechanism of injury, operative side, and open
 3 fracture. Trochanteric entry nails had significantly lower mean DFV than piriformis start and retrograde nails.

Nail Type	Mean DFV, Degrees (SD)
Piriformis (n=141)	9.5 (7.4)
Trochanteric (n=67)	7.9 (6.1)*
Retrograde (n=108)	9.4 (7.8)

*p<0.05

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 7 **Table 4.** Trochanteric entry nails had a significantly lower rate of revision than piriformis entry and retrograde nails,
 8 however, this significant difference becomes close, but not significant when analyzing via ordinal regression
 9 analysis controlling for gender, age, BMI, ethnicity, mechanism of injury, operative side, open fracture and entry
 10 point. Significant negative predictors for revision included associated open fracture.

		95% CI			
		Variable	p value	Lower Bound	Upper Bound
Revision[†] (%)	n (%)	Gender	0.53	-1.17	2.27
No	304 (96.2%)	Age	0.27	-0.10	0.03
Yes	12 (3.8%)	BMI	0.76	-0.10	0.13
Piriformis	9 (75%)	Ethnicity	0.38	-1.31	0.50
Trochanteric	0 (0%)*	Mechanism of Injury	0.25	-0.13	0.51
Retrograde	3 (25%)	Operative Side	0.97	-1.20	1.25
		Open Fx**	0.03	-2.82	-0.11
		Nail Entry	0.05	-1.61	0.01

[†]Revision was defined as reoperation. All piriformis revisions were indicated for clinically significant malrotation;
 2/3 retrograde nails were revised for malrotation, the other for non-union requiring an exchange nail.

*p=0.005 via chi-square analysis.

**p<0.05 via ordinal regression analysis.

16 **Table 5.** Subgroup analysis of IMN revisions secondary to malrotation

Nail Type	Piriformis (n=9)	Retrograde (n=2)
Mean DFV (SD)	21.9 (7.8)	19.1 (22.2)
Number Proximal Fragment Malrotation (%)	3 (33)	0 (0)
Number Distal Fragment Malrotation (%)	5 (56%)	1 (50)
Number Both Fragment Malrotation (%)	1 (11)	1 (50)

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