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Trochanteric entry femoral nails yield better femoral version and lower revision rates—A large cohort multivariate regression analysis

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ABSTRACT

Introduction: 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 three types of nails and to delineate any significant differences in femoral version (DFV) and revision rates.

Materials & methods: Over a 10-year period, 417 patients underwent IMN of a diaphyseal femur fracture (AO/OTA 32A-C). Of these patients, 316 met inclusion criteria and obtained postoperative computed tomography (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. The effect of the following variables on DFV and revision rates were determined via univariate, multivariate, and ordinal regression analyses: gender, age, BMI, ethnicity, mechanism of injury, operative side, open fracture, and table type/position. Statistical significance was set at $p < 0.05$.

Results: A total of 316 patients were included. 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 ± 6.10 vs. 9.5 ± 7.4 vs. $9.4 \pm 7.8°$, $p < 0.05$). Using revision as an endpoint, trochanteric entry nails also had a significantly lower revision rate, even when controlling for all other variables ($p < 0.05$).

Conclusion: Comparative, objective comparisons between 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 to more in-depth study the intricacies of femoral version may lead to improved technology in addition to potentially improved clinical outcomes.

Introduction

Intramedullary nailing (IMN) has evolved into the treatment of choice for femoral shaft fractures in adults. Benefits of this closed technique over plate fixation include less extensive exposure and dissection, excellent healing rates, lower infection rate, and earlier weight bearing. Rotational malalignment is an undesired complication that may lead to functional limitations and unplanned revision surgery [1–5]. Femoral malrotation, defined as a difference in femoral version (DFV) greater than 15°, can be clinically impairing, causing gait abnormalities, pain and often require revision surgery [1,6]. Incidence of clinically relevant DFV has been reported to upwards of 25% following IMN of femoral shaft fractures [7–9].

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As technology and the understanding of the femoral anatomy has evolved over the years, the variations of nails has also followed suit [10,11]. One important technological detail has been the evolution from a piriformis starting point to both trochanteric entry nails as well as retrograde femoral nails. While patient specific factors, such as excessive comminution (i.e. gunshot wounds), or body mass index (BMI), have not been shown to significant predictors of femoral malrotation, nail-type, specifically entry point, has not been studied [12,13]. The purpose of this study is to compare the mean difference in femoral version (DFV) as well as differences in revision rates between trochanteric entry, piriformis entry, and retrograde nails.

Materials and methods

Between 2000 and 2009, consecutive patients treated with IMN for diaphyseal femur fractures (AO/OTA 32A-C) were screened for inclusion. All operations were performed at an academic level 1 trauma center. Inclusion criteria for this study included complete baseline and demographic documentation as well as pre-operative films and post-operative CT scanogram (per institutional protocol) for version of both the nailed and uninjured femurs. Exclusion criteria included incomplete chart data, bilateral injuries, multiple ipsilateral lower extremity fractures, previous injury, and previous deformity.

Institutional protocol dictated that one of the two following methods was used to determine rotation for all fractures in which it could not be assessed intra-operatively by cortical alignment due to comminution: (1) Pre-operatively, the contour of the lesser trochanter on the uninjured side was noted fluoroscopically with the ipsilateral patella facing directly anterior. This saved image was then used in order to match a similar lesser trochanteric contour on the injured femur or (2) the quantitative measurement test published by Tornetta et al. [14]; This test requires that prior to the start of the case, the unaffected femoral version is estimated by obtaining a true lateral of the contralateral hip. The c-arm was then moved to the knee and rotated until the posterior condyles are aligned; the difference in version is estimated as the normal version.

Regarding both methods, prior to the placement of the distal locking screws, proper rotational alignment was assured by rotating the thigh through the fracture until the proper view of either the lesser trochanter (on the AP view) or the calculated femoral version (via the lateral of the hip) was obtained, after which distal interlocking screws were placed.

Post-operative femoral version of both lower extremities was measured on CT scanogram by an orthopaedic trauma fellowship trained surgeon based on previously published methods [15]. The post-operative rotation of the nailed side was compared to that of the uninjured side, and one primary outcome measure was the DFV between the two. The absolute value of this calculation was used when reporting our outcomes. Other data included in our analysis were age, sex, BMI, ethnicity, mechanism of injury, side of injury, open versus closed fracture, and type of operating table. Revision rates were also recorded. Revision was defined as return to the operating room for malrotation or non-union.

Standard descriptive statistics, including mean and standard deviation (SD), were used to report baseline and demographic data. Univariate, followed by stepwise, multivariate regressions were used to test for associations between all of the previously listed independent variables and our primary outcome variables (DFV). Ordinal regression analysis was used to test for associations between the previously listed variables and our secondary outcome, revision rates. Statistical significance was defined as $p < 0.05$. All statistical analysis was performed with SPSS 20.0 (IBM Corp., Armonk, NY).

Results

A total of 417 patients were screened for inclusion. Of the initial 417 subjects, 316 patients met inclusion criteria for analysis. Piriformis entry nails made up the majority (n = 141), followed by retrograde (n = 108), then trochanteric entry nails (n = 67).

Mean age for the 316 included patients was 31.1 ± 13.6 years old (Table 1). The majority of our cohort was male (82.6%) with a mean BMI of 27.2 ± 5.2 (Table 1). Most of the cohort were black (57.3%), and had nearly equal rates of injury side (Table 1). Motor vehicle accidents (MVA) made up the majority of the cause of injury (42%), and about 14% of patients were diagnosed with an open fracture (Table 1).

Piriformis nails made up the majority of the study cohort (n = 141) with a mean DFV of 9.5 ± 7.4°, a similar DFV to retrograde nails (n = 108, 9.4 ± 7.8° Table 2). Trochanteric nails made up a lower number of the cohort (n = 67), but exhibited the lowest DFV (7.9 ± 6.1°, Table 2). Univariate regression analysis did not reveal any significant impact of the previously discussed variable on mean DFV in either piriformis or retrograde nails (Table 2). However, univariate analysis revealed BMI as having a significant impact on mean DFV for trochanteric entry nails (Table 2). Multivariate regression analysis, however, revealed a significantly lower mean DFV for trochanteric entry nails, when compared to piriformis and retrograde nails, when controlling for age, gender, BMI, ethnicity, mechanism of injury, operative side, and presence of open fracture (Table 3).

In regards to overall revision rate, of the 316 included for analysis, 12 were revised (3.8%, Table 4). Of the 12 revised, 9 were piriformis entry nails (all for malrotation), while 3 were retrograde nails (2 for malrotation, the other for non-union, Table 4). Comparison of revision rates between the nail-types via Chi-square analysis yielded significantly lower revision rates with trochanteric entry nails, however, this significance became only a trend when controlling for multiple factors via ordinal regression analysis (Table 4). The only significant predictor of a lower revision rate was the IMN fixation in the presence of an open fracture (Table 4).

Of the revisions performed for malrotation following piriformis IMN, mean DFV was 21.9 ± 7.8°, and the majority revised for distal fragment malrotation (56%, Table 5). Of the revisions performed for

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)