# Trochanteric versus Piriformis Entry Portal for the Treatment of Femoral Shaft Fractures

William M. Ricci, MD,* John Schwappach, MD,† Michael Tucker, MD,‡ Kevin Coupe, MD,§ Angel Brandt, MA,* Roy Sanders, MD,¶ and Ross Leighton, MD||

**Objectives:** The purpose of this study was to compare results of femoral shaft fracture treatment with nailing through the greater trochanter to nailing through the piriformis fossa with nails specifically designed for each starting point.

**Design:** Prospective cohort study.

**Setting:** Four level 1 trauma centers.

**Patients:** One-hundred and eight patients treated by 1 of 4 surgeons for a femoral shaft or subtrochanteric fracture with antegrade nailing between January 2001 and April 2003 were included. Four patients who expired early in the postoperative period and 13 with insufficient follow-up were excluded from analysis.

**Intervention:** Patients were treated with either nailing through a greater trochanter starting point with the Trigen TAN nail (GT group) (n = 38) or through a piriformis fossa starting point with the Trigen FAN nail (PF group) (n = 53).

**Outcome Measures:** Operative time, fluoroscopy time, fracture alignment, fracture healing, complications, and functional outcome based on the lower-extremity measure (LEM).

**Results:** Thirty-seven of the 38 fractures from the GT group and 52 of the 53 fractures from the PF group healed after the index procedure. One patient from the GT group had external rotation malalignment of 12 degrees. There were no other malalignments or iatrogenic fracture comminution. There were 2 infectious complications, 1 from each group. The average operative time was 75 minutes for piriformis insertion using the FAN nail and 62 minutes for trochanteric insertion using the TAN nail ($P = 0.08$). The average fluoroscopy time was 61% greater for the PF group (153 seconds) than for the GT group (95 seconds) ($P < 0.05$). 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 a similar initial decline and subsequent improvement in function over time ($P > 0.05$).

**Conclusions:** A femoral nail specially designed for trochanteric insertion resulted in equally high union rates, equally low complication rates, and functional results similar to conventional antegrade femoral nailing through the piriformis fossa. The greater trochanter entry portal coupled with an appropriately designed nail represents a rational alternative for antegrade femoral nailing with the benefit of decreased fluoroscopy time and decreased operative time in patients who are obese.

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## INTRODUCTION

The piriformis fossa and greater trochanter have each been commonly described as starting points for antegrade femoral nailing.[13,15,19,22] Because the greater trochanter is not colinear with the long axis of the femoral shaft, complications including varus malalignment and iatrogenic fracture comminution have been demonstrated to occur when nails designed for insertion through the piriformis fossa are inserted through the greater trochanter.[22] Nails with a proximal lateral bend that are specifically designed to be inserted through the greater trochanter can reduce the problems of iatrogenic comminution and malalignment.[18–20] Clinical outcomes after trochanteric insertion directly compared to outcomes after nailing through the piriformis fossa remain unknown. The null hypothesis of this study was that results of antegrade femoral nailing using a trochanteric entry portal with a nail designed with a lateral bend for this starting point would be similar to results using the piriformis fossa with an identical nail except without the lateral bend.

## MATERIALS AND METHODS

### Patients

The subgroup of patients with either a femoral shaft [OTA (Orthopaedic Trauma Association) 32] or Russell-Taylor Type IA (OTA 31A3) subtrochanteric fracture[7] treated with antegrade nailing were extracted from a prospective, multicenter (4 centers, 4 surgeons), Institutional Review Board–approved study of adult patients treated with nailing for femur and tibia fractures. Each of the surgeons had greater than 5 years experience and had orthopedic trauma as the focus of their practice. Patients treated with retrograde nailing; those

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From the *Washington University School of Medicine at Barnes-Jewish Hospital; †Swedish Medical Center; ‡University of Texas-Houston; §Medical College of Georgia; ¶Dalhousie University; and ||Florida Orthopaedic Institute.
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Reprints: William Ricci, MD, Washington University School of Medicine, Department of Orthopaedic Surgery, 1 Barnes-Jewish Hospital Plaza, Suite 11300, St Louis, MO 63110 (e-mail: ricciw@wustl.edu).

with pathologic fractures; those with intertrochanteric or Russell-Taylor Type IB, IIA, or IIB subtrochanteric fractures; and those with prior treatments for their femoral shaft fracture were not included. The choice of starting point for antegrade nailing, greater trochanter or piriformis fossa, was at the discretion of the operating surgeon. One-hundred and eight patients treated between January 2001 and April 2003 met these criteria. Four patients who expired early in the postoperative period and 13 with insufficient follow-up were excluded from analysis. Thirty-eight (42%) of the remaining 91 patients were treated with antegrade nailing through a greater trochanteric starting point (GT group) and 53 (58%) were treated with nailing through the piriformis fossa (PF group). Demographic characteristics of the 2 groups were similar and are presented in Table 1.

## Fractures

Fracture characteristics are presented in Table 2. Based on the OTA classification[1] there was no difference in the distribution of 32A, 32B, and 32C fractures between the GT and PF groups ($P = 0.25$). The location of fractures, proximal 1/3 of diaphysis, middle 1/3, or distal 1/3 was similar between the two groups ($P = 0.43$). There were 4 open fractures in the GT group and 5 in the PF group. Neither the number ($P = 0.86$) or grade ($P = 0.64$) of open fracture was different between the GT and PF groups.

## Implants

All nails were cannulated, closed section, interlocking, and made from titanium (Trigen System, Smith & Nephew, Memphis, TN). The nails used for the GT group, trochanteric antegrade nail (TAN), were identical to those used for the PF group, femoral antegrade nail (FAN), with 1 exception. The TAN nail has a 4-degree proximal lateral bend to accommodate trochanteric entry.

**TABLE 1.** Patient Characteristics

| | Group | |
|---|---|---|
| | GT | PF |
| Number of fractures | 38 | 53 |
| Average age (range) | 28 (16–88) | 29 (16–79) |
| Gender | | |
| Male | 25 | 29 |
| Female | 13 | 24 |
| Mechanism of injury | | |
| Motor-vehicle accident | 19 | 37 |
| Fall | 5 | 6 |
| Sports | 4 | 3 |
| Other | 4 | 2 |
| Motor cycle accident | 3 | 2 |
| Gunshot wound | 2 | 3 |
| Pedestrian struck | 1 | 0 |
| Body mass index | | |
| Average (range) | 24 (10–80) | 24 (18–45) |
| ≤30 | 29 | 47 |
| >30 | 9 | 6 |

**TABLE 2.** Fracture Characteristics

| | Group | |
|---|---|---|
| | GT | PF |
| Number of fractures | 38 | 53 |
| OTA | | |
| 32A | 19 | 18 |
| 32B | 9 | 20 |
| 32C | 10 | 15 |
| Location | | |
| Proximal 1/3 | 16 | 29 |
| Middle 1/3 | 18 | 21 |
| Distal 1/3 | 4 | 3 |
| Open grade | | |
| I | 1 | 2 |
| II | 1 | 2 |
| III | 2 | 1 |

## Intervention

All patients from both groups were treated in the supine position using a similar technique. An entry portal tool, a channel reamer with a 12.5-mm inner diameter and 14-mm outer diameter, was inserted into the appropriate starting point over a guide wire and through a protective sleeve. This device protects the local soft tissues by providing a working portal for all instrumentation of the femoral canal. A modification of the standard technique was used for trochanteric nailing to help avoid iatrogenic comminution. The nail was rotated 90 degrees (such that the anterior bow was apex medial) on insertion. This pointed 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 was gradually derotated. All nails from each group were inserted after reaming with the patient in the supine position on a fracture table. The distribution of nail diameters used in the GT group was 14 size 10 mm, 19 size 11.5 mm, and 5 size 13 mm (average nail size 11.1 mm). The distribution of nail diameters used in the PF group was 22 size 10 mm, 21 size 11.5 mm, and 10 size 13 mm (average nail diameter 11.2 mm). All nails from both groups were locked both proximally and distally.

## Follow-Up

Patients were followed prospectively according to a protocol that called for, at minimum, physical and radiographic examinations at 4, 6, and 12 months postoperatively (average 10 months, range 7–25 months). The patient's postoperative weightbearing status was based on fracture pattern. Those with stable fractures (Winquist types I and II) were allowed immediate weightbearing to tolerance, and those with unstable fracture patterns (Winquist types III and IV) were allowed immediate 60-pound weightbearing and then advanced based on clinical and radiographic evidence of healing. Physical therapy for muscle strengthening was initiated when patients were able to bear weight without assistive devices.

 

### Outcome Measures

Operative duration was defined as the time from skin incision to application of dressings and excluded any time for irrigation and debridement of open fractures. Fluoroscopy time in seconds was recorded from the c-arm machines. Union was defined as full painless weightbearing with bridging callus across at least 2 cortices on orthogonal views. Nonunion was defined as no progression of fracture healing over a 3-month period extending beyond 6 months, and delayed union was defined as slow progression of fracture healing extending 4 months beyond. Angular fracture alignment was measured radiographically, and rotational and axial alignments were measured clinically. Malalignment was defined as >10 degrees angulation, >15 degrees malrotation, and >2 cm length discrepancy. All complications and reoperations were recorded. The lower-extremity measure (LEM) was used for functional outcome analysis with baseline scores obtained during the initial hospitalization and follow-up scores at 4, 6, and 12 months postoperatively. The LEM is a validated patient reported outcome score.[11] It provides an assessment of evolving patient recovery on 29 questions related to physical function (ease of performing 29 different activities of daily living). Scores are summed and normalized to 100% with 0 being the minimum and 100 being the maximum score. Higher scores indicate higher function.

### Statistical Analysis

Chi-squared analysis was used to evaluate differences in dichotomous variables, and the student *t*-test was used to compare continuous variables.

## RESULTS

### Healing

Thirty-seven of the 38 fractures from the GT group (97%) and 52 of the 53 fractures from the PF group (98%) healed after the index procedure. One patient from the GT group had a delayed union diagnosed at 7 months and healed after exchange nailing. One patient from the PF group had a nonunion diagnosed at 6 months and healed after exchange nailing. Nine other patients had delayed unions (4 from the GT group and 5 from the PF group) and each healed without further surgical intervention. There were no cases with iatrogenic fracture comminution.

### Operative and Fluoroscopy Times

The average operative time for the PF group was 75 minutes (range 31–131 minutes); for the GT group it was 62 minutes (range 14–193), ($P = 0.08$). The average fluoroscopy time for the PF group was 153 seconds (range 16–662); for the GT group it was 95 seconds (range 20–375). This 61% increase in fluoroscopy time for the PF group was significant ($P < 0.05$). 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 ($P < 0.02$) in the PF group.

### Functional Outcome

Patients from both groups had similar baseline function (average LEM score: GT group = 92, PF group = 99) and similar initial decline and subsequent improvement in function over time ($P > 0.05$) (Table 3).

### Complications

Six patients, 4 from the PF group and 2 from the GT group, required removal of painful interlocking screws (4 distal, 2 proximal). One patient from the GT group had external rotation of 12 degrees. Two patients had infectious complications. One patient from the PF group who was obese had a superficial infection that resolved with local wound care and oral antibiotics. One patient from the GT group with an open (grade II) fracture had a deep infection that resolved after surgical debridement and irrigation and intravenous antibiotics without nail removal.

## DISCUSSION

Küntscher originally popularized the technique of closed, antegrade, intramedullary nailing using an open section, straight, cloverleaf nail for fractures of the femoral shaft.[4] He suggested the lateral decubitus position and the use of the tip of the greater trochanter as the preferred entry portal to minimize risks such as intracapsular infection, avascular necrosis of femoral head, and iatrogenic femoral neck fracture.[14,15] The entry portal was further refined by Böhler, who in 1948 stated: "the awl is placed on the greater trochanter…at the junction of the middle and posterior third…"[5] The AO study group noted that "the nail should not be introduced through the top of the greater trochanter, but somewhat more laterally, so that neither the retinacular vessels nor the hip joint are damaged."[16] The major problems associated with placing a straight nail (ie, without a trochanteric bend) through these starting points was comminution of the medial femoral cortex of the proximal fragment and varus fracture malalignment, especially for proximal fractures.[4,6,12,14,21]

The piriformis fossa starting point became the standard for antegrade nailing since Winquist, et al indicated they "strongly preferred" this starting point with the patient in the lateral decubitus position.[22] Although no specific data were presented, they described eccentric reaming of the medial cortex of the proximal fragment and comminution of the fracture site, especially in the more proximal fractures or varus malalignment when the lateral starting point that Küntscher had advised was used. Lateral patient positioning as recommended by Winquist has largely been abandoned in favor of supine positioning at most centers in the United States.[6,23] However, the piriformis fossa entry point continues to be used

**TABLE 3.** Average LEM Scores

| | GT Group | PF Group |
|---|---|---|
| Baseline | 92 | 99 |
| 4 months | 77 | 79 |
| 6 months | 86 | 85 |
| 12 months | 87 | 91 |

 

despite known difficulties obtaining this starting point when the patient is positioned supine.[17]

The use of a nail specifically designed for trochanteric insertion (one with a proximal lateral bend) has been shown to reduce the complications previously associated with the use of straight nails inserted through this entry portal.[19] The current study is the first to directly compare use of the greater trochanter to the piriformis fossa starting portals with nails specifically designed for each starting point. As expected with modern reamed interlocked nailing techniques, high union rates were found in each group. Of fractures, 97% healed after the index procedure and 100% ultimately achieved union. These are union rates that are compatible with the other large series of femoral intramedullary nailing.[8,13,22,23] For the trochanteric group in the present study, the greater trochanter was used as a starting point in association with a nail with a proximal lateral bend of 4 degrees and a relatively small diameter of the driving end (13 mm). It should be noted that the very tip of the trochanter is not necessarily the proper starting point for trochanteric nailing in every patient. There is anatomic variation with regard to the alignment of the tip of the trochanter relative to the long axis of the femoral shaft.[2] Therefore, the precise proper starting point for trochanteric nailing should be individualized for each patient but is usually at, slightly medial to, or slightly lateral to the tip of the greater trochanter. Attention to a proper trochanteric starting point combined with the use of a nail designed for such insertion resulted in no varus malalignments in any patient. These results are in contrast to those of nailing through the greater trochanter with a nail that is straight in the coronal plane.[22] The slight modification of the standard insertion technique used for trochanteric nail insertion likely helped avoid iatrogenic fracture comminution previously described with the use of a straight nail inserted through the greater trochanter.[22] The nail was rotated 90 degrees on initial insertion such that the anterior bow was apex medial. The tip of the nail was therefore aimed more colinear with the shaft axis in the coronal plane. After the nail was safely across the fracture, it was derotated gradually with progressive insertion. The group treated with nailing through the piriformis fossa was also without malalignment or iatrogenic comminution.

Although fracture union, alignment of the limb, and lack of intraoperative complications are important goals of femoral nailing, alteration of hip function is of great concern. The relative effect on hip function of piriformis compared to trochanteric nailing remains unclear. In a cadaver model, Dora et al demonstrated that the soft-tissue damage was greater with a piriformis entry than with a trochanteric entry portal, especially with respect to the short external rotator tendons and the femoral circumflex vessels.[10] The current study corroborated prior findings of lower-limb dysfunction after intramedullary nailing of femoral shaft fractures.[3,9] Scores for the LEM were reduced by 16–20% compared with baseline at 4 months and remained reduced 5–8% at 12 months. The initial decline and subsequent improvement in LEM scores were similar between the group treated with piriformis nailing and the group treated with trochanteric nailing. Based on this patient-derived function score, outcomes seem to be independent of the entry portal for nailing. A more rigorous comparison of hip function and abductor strength stratified by insertion technique is deserved.

A limitation of this study was that the choice of starting point for femoral nailing was not subject to experimental control, therefore introducing a selection bias. Despite the lack of experimental control for the choice of starting point, variables known to effect outcome of femoral nailing were similar between the 2 groups, including fracture type based on the OTA classification, number of open fractures, grade of open fracture, location of fracture (proximal, middle, or distal portion of diaphysis), or distribution of patients who are not obese and patients who are obese ($P = 0.21$).

In conclusion, the use of a femoral nail specifically designed for trochanteric insertion eliminated complications previously seen when this starting point was used with nails straight in the coronal plane. Our results indicate an excellent rate of union, with no angular malunions and no iatrogenic fracture comminution. Healing rates, complication rates, and functional results were similar to those found with antegrade nailing through the piriformis fossa. Based on these results, femoral nailing through the greater trochanter with specifically designed nails and with attention to specific techniques for such insertion should be considered a rational alternative to femoral nailing through the piriformis fossa with the benefit of reduced requirement for fluoroscopy and decreased operative time in patients who are obese.

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