

# The Epiphyseal Scar as a Radiographic Landmark for Retrograde Femoral Nail Insertion

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## Abstract

The purpose of this study was to examine the epiphyseal scar and its relationship to the intercondylar notch on anteroposterior (AP) radiographs of the knee and to establish its usefulness with retrograde femoral nail insertion.

AP radiographs of 100 skeletally mature (50 male and 50 female) knees were used for measurements of the distance from the intercondylar notch to the epiphyseal scar. This data was correlated with intraoperative findings on 34 consecutive patients who underwent retrograde nail insertion. For men, the mean distance from the intercondylar notch to the epiphyseal scar on a "true" AP radiograph averaged 18.55 mm (range, 15.4-24.9 mm). For women, the mean distance measured 16.61 mm (range, 13.2-21.8 mm). Clinical intraoperative correlation revealed that all nails were inserted deep to the articular cartilage and that no intramedullary nails were prominent.

The use of the epiphyseal scar on the AP fluoroscopic view as a landmark for the placement of the most distal interlocking screw of the nail ensures extra-articular nail placement. Good visualization of the epiphyseal scar and an understanding of nail geometry can assist in proper retrograde femoral intramedullary nail insertion without direct visualization of the entry site.

**T**he utilization of retrograde nails for the treatment of femoral shaft fractures has been accepted and has gained in popularity. Proper nail insertion, without impinging on the patellofemoral joint, is critical to ensure a good clinical result. It has been shown that leaving the tip of the nail even

1 mm prominent at the insertion hole leads to increases in the patellofemoral contact pressures.<sup>1</sup> Most surgeons currently use a percutaneous approach that does not allow for direct visualization of the distal femur and the end of the nail.<sup>2-5</sup> On fluoroscopy, the insertion jig and the distal end of the nail are the same diameter, which often makes it difficult to distinguish between the two and to determine exactly where the tip of the nail is located. The epiphyseal scar is a constant, easily visualized radiographic landmark that can be used to determine the depth of retrograde femoral nail insertion if the surgeon

**“The epiphyseal scar can be used to determine the depth of retrograde femoral nail insertion if the surgeon knows the design characteristics of the locking hole location in the retrograde nail.”**

knows the design characteristics of the locking hole location in the retrograde nail. Most retrograde femoral nails have the distal hole at 10 to 15 mm from the end of the nail. This study includes data on the location of the distal



**Figure 1.** Anteroposterior radiograph of the knee in a man showing the area used for measurement. The distance from the intercondylar notch to the epiphyseal scar measured 16.8 mm.

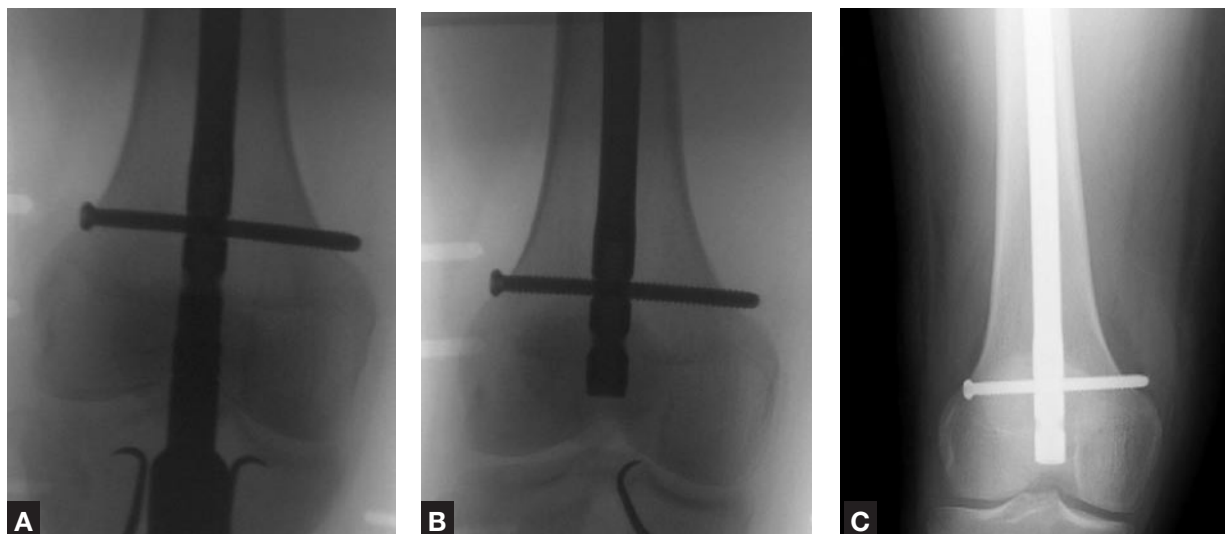
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**Figure 2.** (A) Intraoperative anteroposterior fluoroscopic view demonstrating the femoral retrograde nail being inserted with the distal screw hole proximal to the epiphyseal scar. Note the difficulty in distinguishing the end of the nail from the insertion device. (B) Placement of the proximal of the distal locking screws with the distal screw hole approximately 5 mm above the epiphyseal scar. (C) Anteroposterior radiograph demonstrating final screw and nail placement with the nail 5 mm deep to the articular cartilage as determined by direct palpation in the operating room.

nail hole. This radiographic study measures the distance from the epiphyseal scar to the articular insertion site in the intercondylar notch and correlates these results with intraoperative findings to provide important information for proper retrograde nail insertion.

### MATERIALS AND METHODS

To investigate the epiphyseal scar as a radiographic landmark that may be beneficial for the safe insertion of a retrograde femoral nail, anteroposterior (AP) radiographs of 100 skeletally mature (50 male and 50 female) knees were used for measurements of the distance from the intercondylar notch to the epiphyseal scar. Radiographs were excluded if pathology of the knee was present, a “true” AP image was not obtained, or the epiphyseal scar was not readily visible. A true AP image was defined as one without visible rotation of the femoral or tibial condyles and with the patella centered on the femoral condyles. Measurements were performed using the digital radiography software system Centricity RIS-IC V10.5.0.267 (General Electric Healthcare, Barrington, Ill; Figure 1).

From October 2005 to August 2008, all retrograde femoral nails inserted by a single surgeon were

included in the clinical study. All nails were inserted with the patient supine on a radiolucent table with the knee flexed to approximately 45° over a bolster and the patella oriented to point straight up toward the ceiling. A 3-cm skin-and-tendon incision was made at the medial edge of the patellar tendon from the inferior pole of the patella to the proximal tibial plateau. A retractor was used to protect the soft tissues and a 3.2-mm guide pin was inserted percutaneously using fluoroscopy. A 13-mm entry hole was made with a reamer in the distal femur. After appropriate intramedullary canal reaming, the retrograde nail was inserted. The head of the C-arm was tilted in a cephalad direction to parallel the distal femur and to obtain a true AP fluoroscopic view. The retrograde nail was inserted until the visible “cut outs” in the nail that represented the most distal screw hole were proximal to the epiphyseal scar (Figures 2A-2C). The distal interlocking was performed using the insertion jig, and the insertion device was removed. For all cases, the surgeon then placed the tip of his little finger in the insertion site to ensure that the end of the nail was not prominent, and an estimate was made on how deep the nail was inserted in reference to the articular cartilage.

**Table. Distances From the Insertion End of the Nail to the Distal Screw Hole for Femoral Retrograde Nails**

Nail Manufacturer	Distance (in mm) from center of the distal screw hole to the insertion end of the nail
Retrograde Femoral Nail (Biomet Trauma/EBI, Parsippany, NJ)	15
DePuy/ACE Universal Nail (DePuy, Orthopaedics, Warsaw, Ind)	14
TriGen Nail (Smith & Nephew Orthopaedics, Memphis, Tenn)	10
T2 Femoral Nail (Stryker Orthopaedics, Mahwah, NJ)	15
Synthes Distal Femoral Nail (Paoli, Pa)	15
M/DN Retrograde Nail (Zimmer, Warsaw, Ind)	13

The Table lists the distance in millimeters from the insertion end of the nail to the center of the most distal screw hole for several commonly used retrograde femoral nails.

### RESULTS

For men, the mean distance from the intercondylar notch to the epiphyseal scar on a true AP radiograph was 18.55 mm (range, 15.4-24.9 mm;  $\pm$  2.51 mm). For women, the mean distance measured 16.61 mm (range, 13.2-21.8 mm;  $\pm$  2.19 mm).

In this single surgeon series, 34 consecutive retrograde femoral nails were inserted. There were no cases where utilization of the epiphyseal scar as a landmark led to the tip of the nail being prominent with reference to the articular cartilage. The nail depth insertion ranged from flush to 8 mm deep to the articular cartilage. The femoral nail used was the Synthes Distal Femoral Nail (Paoli, Pa), and the center of the most distal hole is located at 15 mm from the end of the nail. In men, the distal screw hole was inserted just at or slightly above the fluoroscopically visualized epiphyseal scar. In women, an attempt was made to insert the distal screw hole 3 to 5 mm proximal to the epiphyseal scar.

### DISCUSSION

Retrograde femoral intramedullary nailing continues to gain acceptance as a popular choice for the treatment of femoral shaft fractures, especially in large patients and those with associated traumatic injuries. Many authors have discussed at length the optimal starting point, but no clear consensus has been reached.<sup>2-5</sup> However, all authors agree that in order to prevent damage to the patellofemoral joint and to obtain a good clinical result, the end of the retrograde nail must be inserted deep to the articular cartilage of the patellofemoral groove.<sup>2-5</sup>

After measuring the distance from the intercondylar notch to the epiphyseal scar on a true AP radiograph of 50 skeletally mature male and 50 skeletally mature female knees, we found that the average distance for men was 18.55 mm and for women 16.61 mm. The lower range for men was 15.4 mm; however, for women, the lower limit was 13.2 mm. Most retrograde femoral nails

currently available on the market have the center of their first screw hole at 10 to 15 mm from the insertion end of the nail (Table), and this information along with these radiographic landmarks makes extra-articular nail insertion much simpler. To avoid intra-articular retrograde nail protrusion, the epiphyseal scar on an AP fluoroscopic view can therefore be used as a guide. Utilizing the measurements obtained from our radiographic analysis, insertion of the distal interlocking screw at an appropriate distance above the epiphyseal scar in men and slightly higher in women will lead to placement of the distal end of the nail within the distal femur so that it does not interfere with patellofemoral articulation. According to Morgan and colleagues,<sup>1</sup> inserting a retrograde femoral intramedullary nail flush or deep to the articular cartilage did not have any adverse biomechanical effects on the patellofemoral articulation. A properly inserted nail caused no increase in the patellofemoral contact pressures with the knee flexed to 90° or 120°.<sup>1</sup>

### CONCLUSIONS

Based on this study, the authors conclude that the epiphyseal scar on the anteroposterior fluoroscopic view can be used as a landmark along with the distal interlocking screw hole of a femoral retrograde nail and that this will ensure extra-articular nail placement.

### AUTHORS' DISCLOSURE STATEMENT

The authors report no actual or potential conflict of interest in relation to this article.

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