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Ian D Engler MD
Department of Orthopaedics, Tufts Medical Center, 800 Washington Street, Boston, Massachusetts, United State

Marco A Romo
Tufts University School of Medicine, 145 Harrison Ave, Boston, Massachusetts, United State

Scott P Ryan MD
Department of Orthopaedics, Tufts Medical Center, 800 Washington Street, Boston, Massachusetts, United State

Corresponding Author:
Ian D Engler
Department of Orthopaedics, Tufts Medical Center, 800 Washington Street, Boston, Massachusetts, United State

Anterior cortical overlap view in evaluation of anterior femoral cortical perforation and impingement during cephalomedullary nailing

Ian D Engler MD, Marco A Romo and Scott P Ryan MD

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Abstract
Cephalomedullary nailing of the femur is a common procedure associated with many pitfalls, including anterior femoral cortical perforation and impingement. Lateral knee radiographs are often inadequate in determining the precise location of the anterior cortex because of the offset of the medial and lateral femoral condyles. Here we present a novel radiographic technique to identify the distal anterior femoral cortex more accurately with the goal of reducing intraoperative and postoperative perforation during long cephalomedullary nailing.

Keywords: Intertrochanteric fractures, femoral fractures, intramedullary nailing, perforation, impingement

Introduction
Cephalomedullary nailing of the femur is a common procedure performed worldwide, and it has an increasingly large place in the treatment of hip fractures. Though it is often considered routine, there are numerous pitfalls that can make the case challenging. One such pitfall is nail perforation or impingement on the distal femoral anterior cortex when placing a long cephalomedullary nail.

Impingement, also called abutment, encroachment, or cortical contact, refers to the tip of the nail being in direct contact with the cortex of the bone [1]. Impingement may concentrate stress on the anterior cortex, increasing the risk of periprosthetic fracture [2]. A study of 302 patients undergoing cephalomedullary nailing found anterior cortical impingement in all five (1.7%) of the observed acute postoperative fractures [3]. All fractures resulted from minor trauma and occurred at the tip of the nail. Such fractures were seen in 23.8% of all patients with impingement.

More concerning than impingement is perforation, in which the nail breaks through the femoral cortex with at least partial cortical disruption. Particularly concerning is that the bony defect is present at the tip of a rigid implant, which acts as a stress riser. This can lead to intraoperative [4] or postoperative [5] periprosthetic fracture.

Preventing femoral perforation and impingement involves both surgeon awareness of these potential complications as well as techniques to recognize and prevent them. With the leg often fixed to the table during hip fracture nailing, the resultant lateral knee radiograph can make it difficult to determine the exact location of the anterior cortex because of the offset of the medial and lateral femoral condyles. We present a novel radiographic method to identify the distal anterior femoral cortex more accurately, allowing surgeons to better recognize and avoid perforation and impingement of the anterior femoral cortex during long cephalomedullary nailing.

Technique
The ideal position of the nail tip at the knee is centered on the lateral radiograph. However, due to a mismatch of the bow of the nail and femoral anatomy or to an error in the starting point, the distal tip often ends up more anterior than expected, risking perforation. In intraoperative radiographic evaluation of distal anterior cortical perforation or impingement,

lateral knee radiographs can be deceiving. The anterior margin of the central distal femoral metaphysis is posterior to the anterior margin of the medial and lateral femoral condyles, so the surgeon cannot rely on the most anterior radiographic lines as the relevant region of the anterior cortex (Fig. 1).

The distal femur anterior cortex of concern when placing femoral nails is the cortex directly anterior to the nail. In the case of a well-centered nail on anteroposterior radiographs, the anterior cortex that the surgeon should evaluate is the proximal continuation of the trochlea, or the central third of the distal femur. If the nail is not centered in the distal femur in the coronal plane, the relevant anterior cortex may be more medial or lateral than this. Therefore, if the nail is not centered in the coronal plane, using the trochlear line alone may not be reliable. In addition, depending on patient anatomy, other radiographic lines can make interpretation of the anterior cortex more difficult (Fig. 1). We propose a radiographic view and a surgical technique to best evaluate for anterior perforation and/or impingement – the anterior cortical overlap view (Fig. 2A-C).

The goal of this radiograph is to superimpose the anterior cortical lines of the distal femur such that they become a single line, similar to what is done when obtaining a perfect inlet of the sacrum. This line clearly demonstrates the true anterior cortex of the femur. In standard practice, most surgeons evaluate for anterior perforation by obtaining a perfect lateral of the knee with overlapping posterior and/or distal femoral condyles (Fig. 2B) or a perfect lateral of the nail for "perfect circle" technique (Fig. 2C). Only when the anterior cortical lines are superimposed will the surgeon have the clearest view of potential impingement or perforation (Fig. 2A). Figure 3 further illustrates the view.

To obtain this view, the lower extremity is externally rotated from the perfect lateral view until a radiograph shows complete overlap of the anterior cortices of the trochlea and the femoral condyles. This may range from 0-20 degrees of external rotation based on the patient's femoral version and anterior femoral condylar height.

This radiograph can be difficult to obtain with the leg fixed in traction on a fracture table because the C-arm cannot angle over far enough. If an intertrochanteric fracture is fixed proximally, the leg may be rotated to obtain this view. With intertrochanteric fractures, the leg should not be rotated until the lag screw has stabilized the fracture. With subtrochanteric fractures, the leg should not be rotated until the distal fixation is already in place. If the surgeon has any concern for perforation prior to interlocking screw placement, a small incision at the distal end of the nail allows a freer to palpate the anterior femoral cortex, ensuring the nail has not perforated. A radiograph with the freer resting on the cortex can then confirm that the nail has not perforated the anterior cortex.

Fig 1: Lateral knee x-ray. Shown are the anterior cortex of the lateral femoral condyle (long arrow) and the anterior cortex of the trochlea (short arrow)

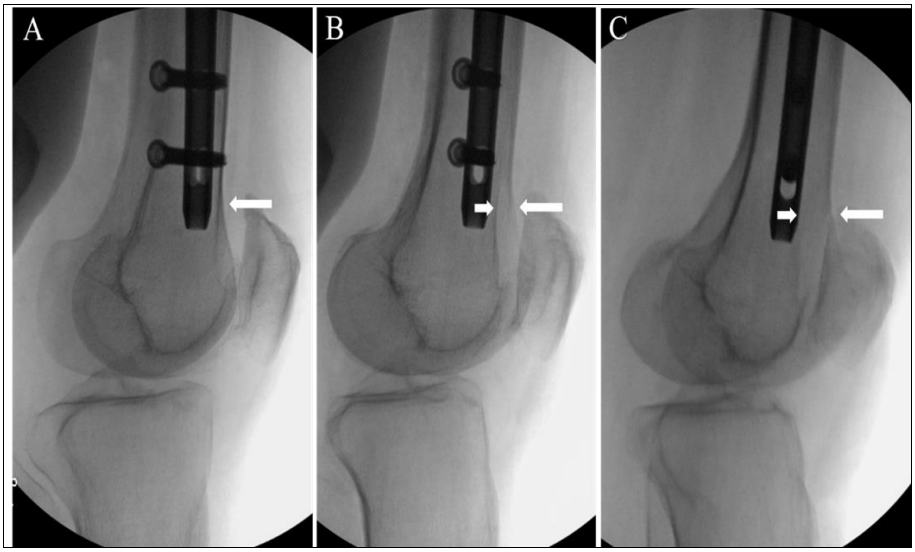

Fig 2: A) Anterior cortical overlap x-ray, with a confluence of the anterior cortical lines of the trochlea and the lateral femoral condyle (arrow). Given that the nail does not contact this line, the nail is confirmed to have not impinged or perforated the cortex. B) Perfect lateral of the knee, with overlapping posterior femoral condyles. Seen are separate lines of the trochlea (short arrow) and lateral femoral condyle (long arrow). C) Perfect lateral of the nail, with a perfect circle of the interlocking hole in the nail. Seen are separate lines of the trochlea (short arrow) and femoral condyle (long arrow)

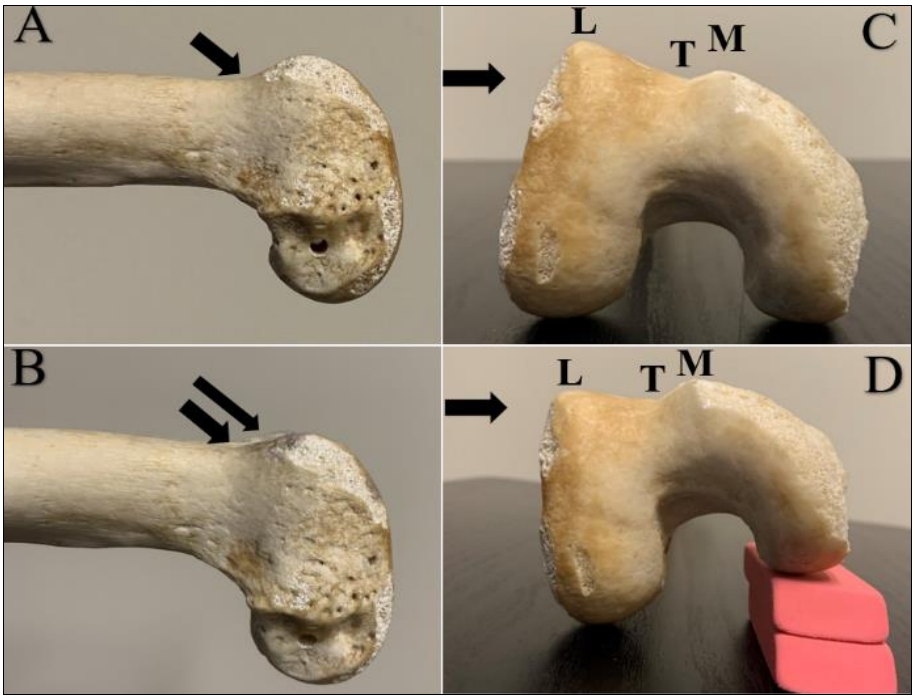

Fig 3: Anatomic demonstration of the anterior cortical overlap lateral knee x-ray. A) Perfect lateral of the femur, in which only the anterior aspect of the lateral femoral condyle is visible. B) Lateral view in 20 degrees of external rotation, in which the anterior aspects of the lateral femoral condyle and trochlea perfectly align (short arrow), and the anterior aspect of the medial femoral condyle is barely visible (long arrow). C) With the x-ray beam in line with the arrow, the anterior aspects of the lateral femoral condyle (L) and trochlea (T) and medial femoral condyle (M) are at different heights. D) In 20 degrees of external rotation, the anterior aspects of the lateral (L) and medial (M) femoral condyles and trochlea (T) are much better aligned

Expected Outcomes: Use of a lateral of the knee or lateral of the nail ("perfect circle view") is commonplace in the operating room. Additionally, much literature on cephalomedullary nailing impingement and perforation simply report use of a "lateral knee radiograph" to evaluate impingement. We believe that these are inadequate to best assess for anterior perforation. By superimposing the anterior cortical lines of the trochlea/central metaphysis, lateral femoral condyle, and medial femoral condyle, the surgeon has the clearest view of potential impingement or perforation. This allows the surgeon to recognize these complications and either prevent them or take action if they do occur, for example via lateral femoral plating in the case of perforation.

Complications: The risk of complications from this technique is very low. The drawbacks are increased intraoperative time and radiation dose. If performed prior to fracture fixation with a lag screw in the case of an intertrochanteric fracture or distal fixation with a subtrochanteric fracture, then there is a risk of fracture displacement.

Conclusion

While most surgeons are aware of the need to avoid distal

femoral cortical perforation or impingement during placement of long cephalomedullary nails, standard radiographic views may provide an inadequate assessment. The anterior cortical overlap radiographic view assesses the nail position relative to the distal femur anterior cortex better than a standard lateral radiograph, allowing the surgeon to better recognize and avoid anterior distal femoral impingement and perforation.

Conflict of Interest
Not available

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Not available

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