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Femoral fracture malrotation caused by freehand versus navigated distal interlocking

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Summary

Objectives: Rotational deformity following intramedullary nailing of femoral shaft fractures is a clinically significant and underdiagnosed problem. Intraoperative determination of rotation is difficult and may be caused by several factors. The insertion of interlocking screws at a slightly oblique angle may cause a substantial degree of rotational deformity, and this factor has not been evaluated as a cause of malrotation.
Methods: In eight paired cadaveric femurs, a midshaft transverse fracture was created and an antegrade nail was placed. The specimens were placed in a custom jig which allowed free rotation of the distal segment. Distal interlocking was performed using either a freehand technique or with navigation, and femoral anteversion was measured before and after interlocking to determine the change caused by the interlocking screw.
Results: Freehand placement led to rotational shift up to 7° (mean, 5.8°; range, 4—7°), and navigated insertion led to a change of 2.0° (range, 1—3°; $p < 0.05$). In addition, drill—nail contact and a visible shift of the fracture site occurred in all freehand trials, whereas in the navigation group, contact occurred in only one trial without fracture movement.
Conclusions: Freehand distal interlocking may be a substantial cause of rotational deformity, and the assistance of computer navigation systems may improve this malrotation.

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Introduction

The standard treatment for the majority of femoral shaft fractures is statically locked intramedullary nailing.[31,32] Malrotation deformity following nailing may occur for a variety of reasons, and clinically significant malrotation of 15° has been reported in up to 28% of cases,[1,5,33] and in up to 50% in patients with comminuted fractures.[26] Small degrees of fracture malunion have been shown to be directly related to development of osteoarthritis of the knee.[4,9,19,27] Due to the fact that up to 60% of patients with this degree of deformity may be asymptomatic,[1] and because malrotation cannot be detected on standard radiographs, this phenomenon has not received substantial attention. Several techniques have been described which may allow for accurate intraoperative assessment of femoral rotation,[6,12,26] and once the desired rotation is set, distal interlocking is performed.

Although insertion of distal interlocking bolts for intramedullary nails is a common procedure for orthopaedic surgeons, it can be one of the most technically challenging parts of the procedure.[30] When using conventional methods of freehand distal interlocking screw insertion, the drill bit frequently contacts the screw hole in the nail. If the angle of the drill is slightly oblique or off centre, manual adjustment of the drill may still allow it to pass through the nail. However, this may cause rotation of the distal fragment around the nail. Because the average femoral shaft circumference is 90 mm,[3] a linear shift of 4 mm along the arc leads to 16° of rotation. We hypothesised that freehand interlocking screw placement may be a cause of rotational deformity of femoral shaft fractures, and that computer navigation assistance with screw placement decreases the degree of malrotation.

Materials and methods

Eight paired embalmed cadaveric femurs were obtained for the study. An oscillating saw was used to create a transverse midshaft osteotomy in each specimen to simulate a mid-diaphyseal fracture (AO/OTA 32-A3; Winquist Type I).[31] A starting hole was made in the piriformis fossa, and an unreamed antegrade femoral nail (UFN, Synthes, Bochum, Germany), 9 mm × 400 mm in size, was inserted and stabilised proximally. With the nail in place, the femur was mounted into a custom apparatus, which stabilised the proximal and distal fragments, but allowed free rotation of the distal fragment (Fig. 1).

Figure 1 The custom femur holding apparatus allowed for immobilisation of the proximal segment and nail, while the distal fragment was free to rotate.

A surgical navigation system was then used to measure the anteversion of the femurs (BrainLAB, Feldkirchen, Germany). Two tracking devices were placed on the proximal and distal fragments, and were rigidly stabilised using clamps. Using a trauma module (VectorVision, Trauma v 2.6.1), five fluoroscopic views were obtained to register the specimen in the system: AP views of the femoral neck and fracture site, and lateral views of the femoral neck, fracture, and femoral condyles. The tracking of the system is accurate to within 1°.[10]

A single interlocking screw was then placed in the most proximal of the distal holes using one of the two methods. Specimen pairs were randomised to determine which side received which method. In the first method, the interlocking screw was placed using a traditional freehand technique. Under fluoroscopic visualisation, a perfect circle view was obtained of the target hole. The tip of a 4.3 mm drill bit was obliquely oriented at the correct starting point, and the drill was then brought into the plane of the fluoroscopic beam. The hole was drilled through both cortices with a drill guide placed on the bone for stabilisation. Fluoroscopy was used when necessary to ensure that the drill was within the locking hole. A 5.0 mm titanium locking screw was slowly inserted by hand through both cortices. After the screw was seated, the femoral anteversion was once again recorded from the navigation system.

The second method for interlocking screw insertion was using navigated guidance.[21,24,25] To use this feature in the navigation system, two additional fluoroscopic views, an AP and lateral of the locking hole, were obtained. A tracking device was placed on a drill (Synthes AirDrive I), which was calibrated and registered with the system. Using the navigation, real-time AP and lateral views of the vector