ELASTIC NAILS: INSERTION APPROACH AFFECTS STIFFNESS OF FIXED DISTAL FEMUR FRACTURES

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INTRODUCTION:
Femoral shaft fractures are the most common reason for pediatric orthopaedic hospital admission in many children’s hospitals. Historically, conservative methods of treatment, such as traction followed by spica casting have been very successful, but require long hospital stays with disruption of school and home routines. In addition, conservative methods are very expensive from a societal prospective. As a result, elastic stable intramedullary nailing (ESIN) has rapidly become the treatment of choice for many pediatric patients.

ESIN is simple in concept but demanding in application. Fracture patterns may affect technique recommendations. The most common recommendation for distal third femoral shaft fractures is antegrade insertion of the elastic nails. Studies have demonstrated clinical success with retrograde insertion techniques, which may have the advantage of greater control of nail placement across a distal fracture site. While mid-shaft fractures have been reported, no previous study has compared the relative biomechanical properties of these two approaches to distal third femoral shaft fractures. The purpose of this study is to determine whether differences exist between construct stiffnesses resulting from antegrade and retrograde insertion techniques for the treatment of distal third femoral shaft fractures.

METHODS:
Ten synthetic composite adolescent-sized femur models (Sawbones, Pacific Research Laboratories, Inc., Vashon WA) and 20 flexible titanium intramedullary (IM) nails (Synthes, Paoli PA) were divided into antegrade and retrograde groups. A simulated transverse fracture was created in the distal third of each shaft. The fractures were then stabilized with ESIN (Figures 1). The specimens were subjected to mechanical tests comprised of 4-point bending followed by axial torsion using a materials test system (MTS TestWorks 4; Intron 4464) and custom fixtures (Figures 2). Bending moments were applied to the medial aspect of the model across the fracture site at a rate of 0.05 mm/sec to a maximum displacement of 3.7 mm (°). Torsional moments were applied to the distal aspect of the model in internal and then external rotation at a rate of 0.75 deg/sec to a maximum of 10°. Each test consisted of five cycles; the fourth cycle was analyzed. Load and stiffness were determined between consistent displacement limits; differences were compared using t-tests (α=0.05, two-tailed).

RESULTS:
In bending, force to maximum displacement was 647 N (±313) with antegrade insertion and 1220 N (±178) for retrograde. Bending stiffnesses were significantly greater in the retrograde group [350 N/mm (±72)] compared to antegrade [195 N/mm (±95)]. With internal rotation, stiffness was 159 Nmm/deg (±65) for antegrade insertion, and 101 Nmm/deg (±69) for retrograde. For external rotation, these values were 153 Nmm/deg (±60) and 107 Nm/deg (±50). While torsional stiffness tended to be greater in the antegrade group, differences were not statistically significant.

DISCUSSION:
The purpose of this mechanical study was to compare the relative stability provided to distal third femoral shaft fractures by ESIN using the retrograde and antegrade insertion techniques. Retrograde insertion of flexible Ti IM nails has the benefit of offering greater stability against bending moments applied across the fracture site of distal third femoral shaft fractures. The torsional stiffness after retrograde insertion, however, was not greater than than that of the antegrade method.

Many studies have shown that ESIN is an appropriate method of treatment for femoral shaft fractures. These studies have found that intramedullary nailing provided a lower rate of both angular deformation and limb length discrepancies. Several studies have also shown ESIN to be a cost effective method of treatment. For the treatment of distal third femoral shaft fractures with ESIN, antegrade insertion has been the general recommendation. However, retrograde insertion may offer the benefit of providing sufficient fracture fragment stability and the possible benefit of more accurate placement of the nails across the fracture site.

REFERENCES:

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Fig. 1. Radiographs of femur models with IM nails inserted from each approach. Top: Retrograde. Bottom: Antegrade.

Fig. 2. Mechanical test fixtures and specimen within the materials test system. Left: Four point bending. Right: Axial torsion.

Fig. 3. Bending results (mean ± standard deviation)

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