STABILITY OF ONE VS. TWO DISTAL INTERLOCKING SCREWS IN FEMORAL INTRAMEDULARY NAILING

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Introduction:
Locked intramedullary nail has become the standard of care in the management of diaphyseal femur fractures. The benefits are many and include: minimization of soft tissue dissection and fracture fragment devitalization during implantation, reduced operative morbidity, stabilization of the fracture allowing for early postoperative mobilization and restoration of function, and maintenance of alignment during the healing process. Some of the problems associated with intramedullary fixation of femur fractures are related to intraoperative technical difficulties and operator experience. Placement of the distal interlock screws can be technically challenging, particularly in settings where the surgeon and the support staff do not frequently engage in this procedure. The placement of two distal interlocks has shown a significant increase in operative time and radiation exposure (up to 50%) compared to the placement of a single screw. Because of the interests in minimizing operative time, anesthesia duration, blood loss, and radiation exposure, the use of one versus two distal interlocking screws in the intramedullary fixation of femoral fractures remains an active clinical issue.

Several investigators have evaluated the mechanical stability of one versus two screws (1,2,3). All of their findings indicate that a single distal interlocking screw can be used safely in the fixed fracture in the distal third of the femur, provided that the distance between the interlocking screw and the fracture is at least 5 cm. The 1.0 cm difference in design is likely reflected in their differing stability. To maximize the stability of intramedullary nail constructs in distal third femoral shaft fractures with currently used femoral nails, inserted using an unreamed nailing technique, which have potential less bone-nail contact. Given these facts, the current study was performed to further define and compare the stability of one and two distal interlock screws in static intramedullary nailing of distal third femoral shaft fractures with currently used stainless steel and titanium 10mm and 13mm diameter nails.

Materials and Methods:
Twenty-four composite fiberglass femora [Pacific Laboratories, Vashon, WA, USA] were divided into four groups of six specimens. Composite femora were utilized to eliminate specimen variation in bone mineral density and strength, and all were left femora. Following standard implantation technique, the femora were then sequentially reamed in 0.5 mm increments with standard flexible reamers to a diameter of 1.0 mm greater than the implanting nail diameter. All nails were 40 cm in length. Six 10mm stainless steel Russell-Taylor nails [Smith & Nephew–Richards Inc., Memphis, TN, USA] and six 10mm and six 13mm titanium Synthes nails [Synthes, USA, Paoli, PA, USA] were then implanted and statically locked. Of note, the 10mm Synthes nail is solid, and the other 3 nail types tested are cannulated. A single proximal interlock and two distal interlock screw holes were drilled using the jig attachment and the “free-hand” technique respectively. Then the appropriate 60mm length screws/bolts were placed for all nails (5.0 interlock screws were used in the 10mm diameter Russell-Taylor nails, 6.4 interlock screws were used in the 13mm diameter Russell-Taylor nails, and 4.9 interlock bolts were used in all of the Synthes nails). Bicortical fixation obtained with the screws/bolts in all cases. Radiography was used to confirm placement of the screws engaging the nail. The femurs were osteotomized with a band saw 5.0cm and 6.0cm proximal to the proximal-most interlock screw. The 1.0 cm segment of diaphysis between the two osteotomies was removed to prevent contact between the proximal and distal femoral segments during testing. This was done to eliminate any stability due to segmental contact from the analysis, and to reproduce a situation of maximal instability. The femurs were then mounted in an MTS utilizing custom molded clamps holding the femoral shaft in 7 degrees of valgus, with loading centered proximally over the center of the femoral head to reproduce the normal mechanical axis. Reflective markers were placed circumferentially around the femora just proximal and distal to the fracture site and their locations calibrated.

The sequence of interlock configuration testing was randomized for each specimen, with all three different distal interlock configurations evaluated: a single screw in the proximal-most distal interlock site, a single screw in the distal-most distal interlock site, and both distal interlocks in place. The constructs were cycled loaded for 500 cycles at 1 Hz with concurrent axial compression (amplitude: 2000 Newtons) and torsion (moment: +/- 10 Newton-meters) to reproduce the physiological loads associated with weight-bearing during normal gait. Axial, anterior-posterior and medial-lateral bending, and rotational displacements were measured via the calibrated markers with a two-camera video system. Continuous monitoring of displacement data was sampled at 100 Hz for 5 cycles prior to cycling, every 100 cycles of loading, and immediately following cycling. The received data was then converted by the system software, recording axial displacement in mm, bending in the anterior-posterior and medial-lateral planes in degrees, and rotation in degrees. The data was analyzed for statistical significance using one and three way ANOVAs, and the t-test.

Results:
The mean axial deflection, for all nail types with all interlock configurations, ranged from 1.4 to 2.9 mm. The mean A-P bending ranged from 1.1 to 2.7 degrees. The mean M1 deflection, for all nail types with all interlock configurations, ranged from 0.8 to 1.6 degrees. And the mean rotation ranged from 6.7 to 12.7 degrees. Statistical analysis identified several significant differences in construct stability related to nail diameter, interlock position, and nail type. The 13mm nail was found to be more stable than the 10mm nail in all measured parameters, for all distal interlock configurations, for both nail constructs (p<.0001 – one-way ANOVA). The stability of all interlock possibilities was not equivalent, which had two interlocks was more stable in rotation than a single interlock (p<.02 – one-way ANOVA). Additional rod-specific variations in stability related to interlocks were also noted. For 10mm stainless steel Russell-Taylor, and 13mm titanium Synthes nails, two interlocks were more stable than a single interlock in a-p bending (p<.0041 – one-way ANOVA, and p<.0004 – one-way ANOVA, respectively). In axial displacement, both types of 13mm nails were less stable with a single distal interlock than with either a single proximal interlock or both interlocks (whose stability was equivalent) (p<.0001 [Ti] and p<.0007 [SS] – one-way ANOVA). Except for this finding with 13mm nails, the stability of a single interlock was equivalent in either the proximal or distal position. The titanium Synthes and stainless steel Russell-Taylor nails demonstrated equivalent stability in 10mm and 13mm diameters, with the following exceptions: for 10mm nails, the titanium Synthes nail was more stable in axial displacement than stainless steel Russell-Taylor nail (p=.001 – t-test); and, for 13mm nails, the stainless steel Russell-Taylor nail was more stable in rotation and a-p bending than the titanium Synthes nail (p<.001 and p<.001 respectively – t-test).

Discussion:
The results of this study indicate that the most consistently important factor affecting intramedullary nail construct stability is nail diameter, followed by interlock placement. Two distal interlocks are more stable than a single screw, and the stability of a single distal interlock is basically equivalent in either position. Implant material appears to have the least impact, with material properties being interconnected with nail design; for example, the 10mm titanium Synthes nail is solid, whereas the 10mm stainless steel Russell-Taylor nail is cannulated, and this difference in design is likely reflected in their differing stability. To maximize the stability of intramedullary nail constructs in distal third femur fractures, the largest possible nail diameter, as dictated by the patient’s anatomy, with two distal interlock screws, should be utilized.

References:

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