INTRODUCTION:

Intramedullary nailing is the fixation method of choice for most tibial fractures however increased malalignment and loss of fixation have been reported in proximal third tibial fractures when compared to fractures of the diaphysis. The cross-sectional area of the medullary cavity increases in the proximal region of the tibia resulting a lack of contact between the bone cement and the cortex, leaving only the proximal screws to biomechanically support the construct in the soft cancellous bone. Lafllamme et al. reported a significant negative influence on bone construct stability with reduced bone density specimens regardless of the type of fixation. Cement augmentation has been shown previously to enhance screw fixation in osteoporotic bone however augmentation of the proximal screws in high tibial third proximal fractures during fixation has not been investigated. The purpose of this study was to quantify the biomechanical effects of augmenting proximal screws with cement in the fixation of high proximal, low density tibial fractures.

MATERIALS & METHODS:

Proximal tibia fragments were dissected from seven pairs of fresh frozen elderly cadaveric tibiae (80±8 years, range 69 to 93 years; 6 female, 1 male). Reamed, stainless steel intramedullary nails (M/DS Zimmer, Warsaw, IN, USA) were inserted and secured into the proximal tibiae using four proximal locking screws. Tibiae were randomly assigned into one of two groups: intramedullary nailing and proximal screw cement augmentation or intramedullary nailing alone. In the cemented specimens, bone cement was injected into the proximal screw holes and screws were inserted when the cement was in the soft, doughy phase prior to final curing to achieve bone-screw-cement integration. Specimens were potted and secured to a servohydraulic testing machine (MTS Bionix 858, Eden, MN). They were loaded in flexion/extension and varus/valgus bending configurations to a maximum bending moment of 12Nm at a rate of 0.5mm/sec and in torsion to a maximum torque of 7Nm at an angular rate of 0.5/sec. Displacement data was generated for each of the three loading configurations and compared between groups using a paired t-test statistical analysis (SPSS/PC, Version 10.0).

Volume and mass were measured from trabecular bone cores retrieved from the distal tibia and apparent bone density was calculated. The effect of bone density on the stability of the fixation was analyzed using linear regression analysis.

RESULTS:

Significant increases in stability of 38.5±7.8% (5.4%) and 29.6±34.9% (3.7mm) were observed in torsion and varus/valgus, respectively, for the tibiae in the cemented group (p<0.05) (Figure 1). No significant differences were observed in flexion/extension.

In varus/valgus, low bone density negatively affected the stability of the implant in the uncemented group (slope = -14.2, r² = 0.49) (Figure 2). The negative effect of bone density was decreased in the cemented group and a small positive correlation was observed between stability and bone density (slope=1.6, r²=0.04). In torsion, cement augmentation decreased rotation in each specimen and also reduced the negative relationship between bone density and stability (slopeuncemented=-6.0, r²=0.18; slopecemented=-2.0, r²=0.05). In flexion/extension, the relationship between bone density and stability was reduced however this reduction was much less pronounced than in the other two load scenarios (slopeuncemented = -5.7, r² = 0.05; slopecemented=-2.6, r²=0.03).

DISCUSSION:

Biomechanical stability of the tibial nail construct must be considered in addition to surgical technique to improve the outcome of intramedullary nailing as the alignment achieved during surgery is more likely to be maintained in a stable construct. The addition of cement to the proximal screws in lower density bones was shown to significantly increase construct stability in both torsion and varus/valgus. In flexion/extension, however, no difference was observed between the groups.

Low bone mineral density decreased the stability of the uncemented construct in all three loading configurations, however the effects are most noteworthy in varus/valgus. Poor reduction combined with the increased construct instability observed in low density bones with valgus loading may contribute to the increased valgus malalignment seen clinically. Cement augmentation of the proximal screws eliminated the negative effect of bone mineral density in varus/valgus suggesting that the impact of cement augmentation may improve the outcome of intramedullary nail fixation in osteopenic patients.

CONCLUSION:

In summary, proximal screw cement augmentation was shown to increase the stability of the nail-bone construct in varus/valgus and torsion however, stability remained unchanged in the flexion/extension load configuration. Cement augmentation of proximal screw holes reduced the negative effects of bone density in all loading configurations and may be considered to improve varus/valgus and torsional stability if intramedullary nailing is selected as a treatment option in the osteopenic patient.


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Figure 1: Biomechanical Stability of Uncemented vs. Cemented Constructs: Significant improvements were observed in torsion and V/V in the cemented group (p<0.05).

Figure 2: Effect of Bone Density on Stability in Varus/Valgus: A negative relationship observed in the uncemented group is eliminated following cement augmentation.

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