INTRODUCTION

Early loosening and implant migration are two problems that lead to failures of cementless (press-fit) femoral knee components of total knee replacements. Fehrig et al. (2001) found 27% and 3% of early revision surgeries were a result of implant migration and loosening, respectively. Sharkey et al. (2002) found implant migration to be the cause of 21.2% of early (< 2 years) revisions and 22.2% of late (> 2 years) revisions. They found loosening to be the cause of 16.9% and 34.4% of early and late revisions, respectively. To begin to address these early failures, this study determined the anterior-posterior (AP) mechanical properties of trabecular bone from four locations in the human distal femur.

METHODS

Twenty-eight cylindrical specimens were removed perpendicular to the press-fit surface after the surgical cuts on ten human cadaveric femurs (age 71.5 ± 14.2 years) had been made. The longitudinal axis of each cylinder was approximately in the anterior-posterior direction. These specimens were taken from four locations, shown on the bone and the femoral knee component in Figure 1.

The bone mineral apparent density (BMAD), which is a volumetric density measured using dual energy X-ray absorptiometry, was measured for each specimen. Compression testing was performed utilizing methods to reduce the effects of end-artifacts (Keaveny et al., 1997). The apparent modulus of elasticity, yield and ultimate stress, and yield and ultimate strain were measured.

RESULTS AND DISCUSSION

An unbalanced two-way analysis of covariance (ANCOVA) was used to determine that the apparent modulus, yield and ultimate stress, and yield and ultimate strain each significantly differed (p < 0.05) between the superior and inferior locations. Linear and power law relationships between the mechanical properties and BMAD in each location were determined, as shown in Figure 2. The figure shows that for the same density, the apparent modulus was higher in the inferior region than the superior region. The same result was found for the stresses. These results show that the press-fit fixation characteristics of the femoral knee component differ on the anterior shield and posterior condyles.
SUMMARY/CONCLUSIONS

The significance of this study is the property-density relationship of the distal femur varies as a function of superior and inferior location. This is important for the press-fit fixation of the bone-implant interface because the anterior shield is press-fit in the superior region and the posterior condyles are press-fit in the inferior region.

There are difficulties in comparing the results measured in this study with past studies because BMAD was used here and apparent or quantitative computed tomography (QCT) density has been used in past studies. The power law constants for the superior location (1920 MPa and 0.857) seem to be lower than the previously reported results. But the results of the inferior and pooled locations (16100 MPa and 1.37; 12100 MPa and 1.37) seem to be on the same order of magnitude as the proximal femur multiplicative constant (15010 MPa - greater trochanter) and power constant (1.49 - femoral neck) reported by Morgan et al. (2003).

These property-density relationships will be critical to the assignment of mechanical properties in finite element models for further investigation of the press-fit interface of femoral knee components. Quantifying the loads of this interface will provide a better understanding of the mechanical interaction between the implant and the bone. This research addresses the primary failure mode of femoral knee components and will ultimately lead to improved implant survival rates.

REFERENCES


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![Figure 2](image_url): Apparent modulus of elasticity versus bone mineral apparent density. Each of the linear and power coefficients was significantly different for the superior and inferior regions, except the linear constant, which was not significantly different from zero.