Biomechanical Analysis of Hip Core Decompression Techniques and Fracture Risk
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INTRODUCTION:
Avascular Necrosis (AVN) of the hip is a condition involving disruption of the blood supply to the femoral head with subsequent collapse of the subchondral bone and resultant pain. Early detection in the pre-collapse stage and treatment with a 8-10 mm trephine or cannula, inserted under fluoroscopic guidance, decompresses the lesion allowing for reversal or delayed progression of the disease [1]. However, the use of these large-diameter trephines can weaken the femoral head and neck leading to stress fractures [2]. Recently, a new surgical technique using multiple small diameter holes has also produced promising clinical results [2,3]. The purpose of the present study was to biomechanically evaluate large versus small hole decompression techniques with respect to proximal femur integrity and resistance to fracture. We hypothesized that the two techniques would not differ biomechanically.

METHODS:
Cadaveric femurs (n = 7 matched pairs, n = 14 total femurs) were randomized for side and technique and underwent core decompression via single pass of an 8mm reamer or three passes of a 3.2mm Kirschner wire utilizing the same lateral entry point at the level of the proximal one-third of the lesser trochanter for each of the three passes. Fluoroscopic imaging was used to assure consistent placement of the reamer or Kirschner wire within the femoral neck and femoral head in an antero-superior location where AVN lesions most commonly occur. Samples were mounted in a physiologic position of 10 degrees adduction and loaded to failure using a mechanical testing device at 2 mm/sec, while proximal femoral strain and axial load data was recorded continuously. Strain gauges were placed on the superior femoral neck, the lateral femur (anterior/inferior with respect to the to the entry point), and on the lateral femur (posterior/superior with respect to the entry point). The effect of hole size was evaluated by comparing strain data at these three locations and biomechanical data when loaded to failure. Samples were evaluated before and after loading with computed tomography scans to further characterize fracture patterns. The biomechanical data were normalized based on stress calculations, which accounted for the load, length of the femoral neck, and the cross-sectional properties of the mid-femoral neck as determined by computer tomography imaging of the samples. Groups were compared using a t-test or Mann-Whitney U test for nonparametric data. All data are expressed as the mean ± standard deviation with significance defined as p<0.05.

RESULTS:
The biomechanical analysis of the large versus small hole decompression techniques did not reveal a statistical difference between the two experimental groups. However, there was a trend towards the small hole decompression technique withstanding greater peak tensile stress (125.75 MPa versus 115.81 MPa) and greater principal maximal tensile stress (126.78 MPa versus 116.78 MPa) when compared to the large hole decompression experimental group (Fig. 1). This trend remained after normalization of the data through stress calculations. Strain data did not reveal significant differences between the two decompression techniques. Further, fracture pattern remained consistent for all femurs, as load to failure produced femoral neck fractures in all tested specimens.

DISCUSSION:
There was not a detectable difference in the biomechanical properties of the femurs after the two decompression techniques. We conclude that either large or small hole decompression technique can be performed in the treatment of avascular necrosis of the hip, as the femurs are able to withstand similar tensile stress. These data indicate that patients undergoing either technique of core decompression could participate in similar post-operative rehabilitation with respect to the femur’s ability to withstand the stress of the various activities. We recommend that either technique is biomechanically suitable for treatment of AVN and that the surgeon’s experience and preference should determine which technique is performed. Formal power analysis was not performed and thus the results of our study should be interpreted with caution. Our findings will need to be correlated with clinical outcome findings comparing the two decompression techniques. Future studies will include a finite element analysis of the computer tomography data in order to evaluate core decompression techniques. Analysis of the biomechanical outcomes when the large core tract is packed with bone graft, which cannot be done with the small diameter technique, might also be examined in the future. Our preliminary analysis reveals that decompression angle might influence biomechanical integrity of the femoral neck; however, further analysis is needed to confirm these findings.

REFERENCES: