INTRODUCTION
Finite element (FE) models of the cervical spine are needed to evaluate injury prevention devices and to improve our understanding of vertebra fractures, which may injure the spinal cord. However, current FE cervical spine models typically do not incorporate trabecular bone heterogeneity or geometrical differences between spines; therefore, the models are not able to address questions related to differences in vertebral failure location or load magnitudes between people. The purpose of this study is to develop specimen-specific FE models of cervical vertebrae and to experimentally validate the results with anterior surface strains. Pilot results are presented.

METHODS
A C6 human cadaver cervical vertebra was obtained, and the posterior elements were removed. The bone was scanned in a high-resolution peripheral quantitative computed tomography scanner (voxel size: 82 μm)(XtremeCT, Scanco Medical). The bone was segmented using ITK-SNAP [1]. Polygonal surfaces were exported to INUS Rapidform where a smoothed surface was created. A tetrahedral mesh was generated. For the heterogeneous bone model, Young’s modulii were assigned using Bonemat [2] based on a published relationship between CT density and Young’s modulus [3] (Figure 1). A homogenous bone model was also created using the volumetric average value of the Young’s modulii of the heterogeneous model. ESI Pam-Crash explicit solver was used to simulate compressive loading of the bone models; the inferior bone was constrained, and load was applied on the superior endplate.

The bone specimen was also tested experimentally. Dental stone potting was used to distribute the load. A speckle pattern was applied on the bone surface to allow for the displacement field to be obtained using digital image correlation. Load up to 3 kN was applied quasi-statically using a materials testing machine (model 8874, Instron Corporation) and was captured using two cameras (Phantom V9, Vision Research). The experimental results were compared with the FE simulations.

RESULTS
Computational results from the simulated compressive loading show differences when comparing the heterogeneous and homogenous bone assignment (Figure 2). The magnitudes of the stresses were higher in the heterogeneous model. In both models, regions of high stress were observed on the superior endplate and on the antero-lateral surface of the vertebra. When the specimen was tested experimentally, failure was also observed in the antero-lateral regions (Figure 3).

DISCUSSION & CONCLUSIONS
This work is the first step towards creating cervical spine models for dynamic loading that incorporate the effects of variable bone geometry and density that occur in the human population. Differences were seen between the heterogeneous and homogeneous models indicating that incorporation of varying bone properties will predict differences in failure load. The high stress regions from the computational models matched the location of fracture in the experiment (Figures 2 and 3). In the future, digital image correlation results will be used to ensure that the anterior surface strains in the model are representative of the experiments.

REFERENCES

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