USING BIOFIDELIC FEMS TO QUANTIFY THE EFFICACY OF INVASIVE PROPHYLACTIC TREATMENTS FOR HIP FRACTURE PREVENTION

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Introduction

Pharmacological treatments for the prevention of hip fractures in the elderly have limited cost-effectiveness [1], consequently a number of prophylactic augmentation methods have been proposed as alternatives. Trials using augmentation methods have been limited as the surgeries are controversial due to potential adverse effects. Therefore, it has not been possible to compare different methods on the same cohort. To compare the biomechanical efficacy of these methods *in silico*, finite element models (FEMs) of a sideways fall simulator have been developed [2], which consider the important role of impact loads to the femur as well as the load attenuation contributions from the soft tissue and pelvis. The purpose of this study was to use the FEMs to examine the fracture outcomes and changes to femoral loading capacity for several different femoral augmentation strategies.

Methods

Validated unaugmented FEMs of five specimens (age 68-94 years) which had fractured in *ex vivo* experiments [3] using a sideways fall simulator were used as controls. Three treatments (Figure 1) were applied to each of the specimens: the implantation of a fracture fixation nail [4], a bulk hydroxyapatite injection [5], and the same injection pattern for a novel bone-strengthening hydrogel currently in development. For the hydrogel augmentation, a local BMD increase of 20% was assumed for the affected elements. The impact velocity for all FEMs was 3.1 m/s.

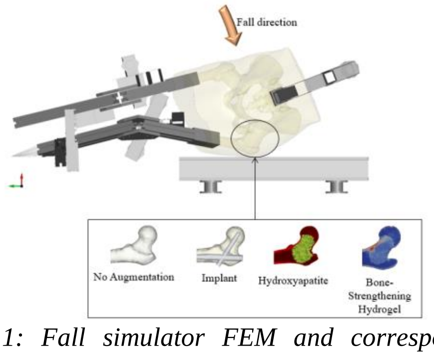

Figure 1: Fall simulator FEM and corresponding augmentation methods tested in the study.

Results

Figure 2 shows the number of fractured femurs for each augmentation method. As expected, all five unaugmented control specimens fractured. The HA injection was the most effective and prevented fractures in all five specimens. The bone-strengthening hydrogel prevented 4 fractures, and the implant prevented 2 fractures. Relative to the unaugmented controls, the peak force at the acetabulum increased by an average of 28.3% for the implant, 35.8% for the hydroxyapatite injection, and 33.7% for the hydrogel injection.

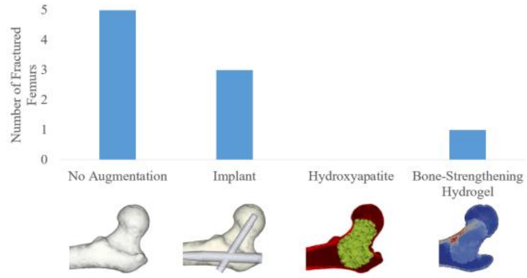

Figure 2: Number of fractured femurs vs. augmentation method.

Discussion

This study compared the mechanical efficacy of several proposed prophylactic augmentation methods: the use of a fracture fixation nail, an injection of a ceramic-based hydroxyapatite cement, and an injection of a novel bone-strengthening hydrogel. The injections of the biomaterials prevented more fractures than the implant, possibly because the injections were able to strengthen the bone at the femoral neck cortex, which is typically where fractures initiate [6]. The percent force increase for the augmentation methods were higher than the estimated strength increases from pharmacological treatment, which is approximately 5.3% [7] for an aBMD increase of 3.3% [8]. An advantage of the FEMs is that they allow for the comparison of the effects of controversial interventions in the same subject models. The results and the FEMs could be used to further improve the placement of biomaterials in order to prevent hip fractures due to sideways falls.

References

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