KYPHOPLASTY HEIGHT SUBSIDENCE INCREASES FRACTURE RISK AT THE TREATED LEVEL

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Introduction

Vertebral fractures are a major challenge for the medical community with an estimated 1.4 million fractures per annum worldwide [Johnell,2006]. Balloon Kyphoplasty uses an inflatable bone tamp to restore the height of collapsed vertebrae, followed by cement injection to stabilise the structure. Two experimental studies [Kim,2006][Wilke,2006] have demonstrated significant height loss following Balloon Kyphoplasty under cyclical loads. The current study investigates the alteration in load angle corresponding to this height loss and its effect on maximum stresses in the elements of the spinal unit.

Methods

A validated finite element model [Tyndyk, 2007] of a human thoracolumbar spine was used in the present study. This model was segmented into a single L1 vertebral body (Figure 1) and modified to replicate a bilateral Balloon Kyphoplasty procedure.

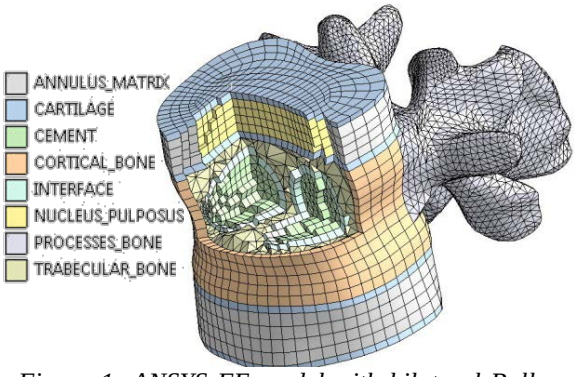

Figure 1: ANSYS FE model with bilateral Balloon Kyphoplasty in human L1 vertebra

Prolate spheroids were used for cement geometry [Lewis,2008], along with an offset region to represent the compacted bone-cement composite. Interface thickness was calculated using a previously developed mathematical model [Purcell,2012] using input parameters for a patient with a bone volume fraction of 0.3 and 50% balloon compaction. An 800N load was applied at angles of 0° and 20° from the vertebral axis.

Results

Figure 2 depicts the resulting stress change for each of the structural components before and after increasing the load angle to 20°.

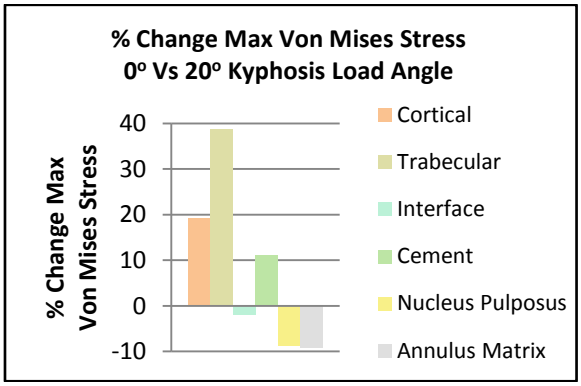

Figure 2: % stress change in spinal components

Discussion

Results from the model indicate increases in Von-mises stress from 11% in the cement, up to 39% in the trabecular bone. These figures demonstrate that changes in the loading direction caused by height subsidence can substantially increase the risk of recurrent fracture at the treated level. While increasing load angle did not significantly alter the magnitude of Von-Mises stress within the interface region, it was found that the minimum principal stress direction became oblique with respect to the primary trabecular orientation. This change in interface loading would have significant implications for the micro-mechanics of the bone-cement composite. Future work will examine the nature of this micro-mechanical environment using data from micro-CT scans.

References

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