BIOMECHANICS OF OSTEOPOROTIC CRUSH FRACTURES USING SYNTHETIC VERTEBRAE

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Introduction

The NIH estimate that 30-50% of women and 20-30% of men will develop a vertebral fracture in their lifetime. 700,000 vertebral fractures occur each year in the United States alone, 85% of which are associated with osteoporosis. Osteoporosis leads to reduced stiffness of vertebral cancellous bone and eventual loss of cortical wall thickness. This study aims to investigate the effects of cortical wall thickness and cancellous bone elastic modulus on vertebral strength and fracture patterns using synthetic vertebrae made from bone analogue materials.

Methods

Synthetic vertebrae were created using rapid prototyping for the cortical shell and expanding polyurethane foam filler for the cancellous core. Dimensions were based on human L1 vertebra as specified in Panjabi et al. (1992). Silicone mouldings were used as intervertebral disk phantoms. The synthetic vertebrae were subjected to uniaxial compression at constant strain rate (5mm/min) using a Hounsfield testing machine. Force and displacement were logged until ultimate specimen failure, as well as video to record gross fracture patterns.

Results

Post-failure examination indicated that successful filling of the synthetic shell by the expanding foam was achieved. Pilot results demonstrate the repeatability of the technique, with <4% variation between specimens compared to mean initial fracture load and <2.5% variation from mean ultimate load. Initial fracture occurred at approximately 67% of ultimate failure load. Initial fracture occurred consistently at the vertebral endplates which is similar to reported in vitro behaviour with cadaveric specimens. Investigation of the effects of cancellous foam elastic modulus is currently underway.

Discussion

A synthetic L1 vertebrae has been successfully developed, providing a highly repeatable analogue for investigation of the biomechanics of osteoporotic vertebral compression fractures. While the magnitude of the force obtained from the synthetic vertebrae differs from real human vertebrae due to differing material properties, comparative biomechanics between the synthetic and real vertebrae appear consistent, and fracture patterns a

re similar to those observed in cadaveric studies.