A BIOMECHANICAL INVESTIGATION OF VERTEBROPLASTY IN OSTEOPOROTIC COMPRESSION FRACTURES AND IN PROPHYLACTIC VERTEBRAL REINFORCEMENT

INTRODUCTION
Osteoporotic vertebral compression fractures (VCFs) are a common problem in the elderly population and can lead to severe pain and morbidity. Percutaneous vertebroplasty (PVP) has become the favoured treatment option for many clinicians treating symptomatic VCFs that do not respond to more conservative interventions1. This procedure involves the injection of cement into the vertebral body (VB) with the aim of reducing pain through stabilisation of the fracture. Rapid pain reduction is seen within 1-2 days of intervention. However, longer-term studies have demonstrated an accelerated rate of failure in the adjacent VB to the one that has been augmented2. One strategy that might reduce these adverse events is to undertake the procedure prophylactically, which has a number of hypothetical advantages3. However, only limited research has been conducted into the biomechanical effects of using prophylactic vertebroplasty in high-risk osteoporotic vertebrae. The objective of this study was to investigate the biomechanical characteristics of prophylactic vertebral reinforcement and post-fracture augmented vertebrae.

METHODS
Twenty-six single vertebral levels were harvested from two female cadavers (age range: 88–89 years; Leeds East Research Ethics Committee, St. James University Hospital, Leeds, U.K.). Vertebrae were dissected free of soft tissue attachments and disarticulated at both the intervertebral disc and the costo-vertebral junction. Posterior elements were preserved and the integrity of the spinal canal was not compromised.

The cranial and caudal surfaces of each vertebra were mounted in PMMA bone cement to provide a flat surface for materials testing. Initial scans were performed on all vertebral segments using a micro-CT system (µCT80, Scanco Medical AG, Switzerland) to quantify the bone mineral density (BMD) and endplate surface areas (SA). Using a correlation previously described4, these values were used to predict the failure load of the individual vertebrae.

Alternate vertebrae from each spinal column were assigned to one of two groups, allowing vertebra from the same level to be treated in two different scenarios. Scenario 1 involved creating an anterior wedge fracture followed by cement augmentation. Scenario 2 involved prophylactic augmentation with vertebroplasty.

In scenario 1, the vertebrae were axially compressed in a materials testing machine (AGS-10kNG, Shimadzu Corp.) at a point 25% from the anterior margin of the vertebral cranial endplate and in the mid-sagittal plane to generate the fracture. Compression was applied in stroke control at 1 mm/min with the definition of anterior wedge fracture taken as deformation of VB height by 25% of the original.

Vertebroplasty was performed using an extra-pedicolar approach with a 13 Gauge needle advanced to the anterior 1/3 of the VB. Cianioplastic cement (CMW, Blackpool, U.K.) was mixed 20% by weight of barium sulphate. The VB was then injected with an estimated 20% volume fill based on the gross dimensions of the VB. Further µCT imaging was performed to assess the cement volume and the augmented VBs were then axially compressed to failure.

RESULTS
Reporting on data from scenario 1, a product of BMD and caudal endplate SA gave the best prediction of failure strength when compared to the actual failure strength of specimens in scenario 1 ($r^2 = 0.70$, $P = 0.007$) (Figure 1). Assessment of all augmented VBs using the µCT scans showed an average percentage cement fill of 23.9% ± 8.07% S.D. with the average volume of cement injected being 4.3 ± 2.57 ml S.D..

In scenario 1, the mean initial failure strength was $1.61kN ± 0.49kN$ S.D. with post-fracture and augmentation failure strength of $2.63kN ± 0.85kN$ S.D. This equates to a significant post-vertebroplasty factorial increase of 1.72 (p<0.05). Figure 2 shows the failure strength of individual vertebra treated with prophylactic augmentation in comparison to predicted initial failure strength. An increase in average

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REFERENCES
1. Peh W et al (2003), British J Radiology; 76(901): 69-75

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