INTRODUCTION
Traumatic cervical facet dislocation (CFD) is often associated with devastating spinal cord injury [1]. The injury mechanisms leading to traumatic CFD are complex and have not been replicated in biomechanical testing [2]; however, anterior shear and flexion loading modes are likely associated with dislocation [3]. Concomitant facet fracture is commonly observed in cases of CFD [4], yet quantitative measures of facet strain, stiffness and failure load have not been reported. Strain behaviour [5] of the posterior elements during facet loading has been measured in isolated lumbar vertebrae, but not for the cervical spine. A better understanding of the mechanical behaviour of the facets during cervical trauma is important for the validation of finite element models and the development of preventative measures. The aim of this study was to determine the mechanical response of the facets when loaded in directions thought to be associated with traumatic CFD.

METHODS
Thirty functional spinal units (FSUs; 6 C2/3, C3/4, C4/5, C5/6 and C6/7) were dissected from thirteen fresh-frozen human cadaver cervical spines (mean age = 70 yrs [range 48-92], seven male and six female). Musculature was removed and the vertebral disc and bilateral facet joint capsules were preserved. Vertebral bodies of each FSU were embedded such that a rectangular block of polymethylmethacrylate (PMMA) protruded approximately 50 mm from the superior endplate of the superior vertebra. The specimen-PMMA assembly was rigidly mounted to the base of a materials testing machine (Instron 8874) via a custom support apparatus attached to a rotary table. Using the rotary table, the inferior articular facet surfaces of the inferior vertebrae were positioned relative to the actuator to simulate in-vivo 1) flexion and 2) anterior shear loading. Three cycles of uniaxial sub-failure loading to 100 N (10 N pre-load) were applied bilaterally at 1 mm/s using 6 mm diameter hemispherical loading pins, in each loading direction; the last cycle was used for analysis. Each specimen was failed in a randomly assigned direction at 10 mm/s. Deflection of the facets was measured using a motion capture system (Optotrak Certus, Northern Digital). Peak principal strains at the base of the bilateral articular pillars were calculated from the output of rosette strain gauges (TML, Tokyo). Apparent facet stiffness was determined from the linear region of load-displacement data and peak failure load was quantified for destructive tests. Paired and independent t-tests were used for comparison of non-destructive and destructive parameters, respectively (α=0.05). For this analysis FSUs from different vertebral levels were grouped together.

RESULTS AND DISCUSSION
Apparent facet stiffness and peak failure load were significantly greater in flexion than in anterior shear (Figure 1). Sagittal facet deflection was also greater in flexion for both the non-destructive and destructive tests (0.38±0.18 vs 0.32±0.16 deg, p=0.009; and, 5.81±3.14 vs 2.64±1.11 deg, p=0.008). There was no significant difference in maximum principal strains (210.6±122.6 vs 248.1±183.3 μstrain, p=0.207). Failure occurred through the facet tip when subjected to anterior shear loading, while failure through the pedicles was most common for simulated flexion loading. Subsequent linear mixed effects models will be used to account for vertebral level, specimen sex and age, and bone mass density.

CONCLUSIONS
Cervical facets tended to be stiffer, and have a higher failure load, when loaded in flexion compared to anterior shear, and failure location was dependent on loading mode. This is the first of a series of experimental studies relating to CFD and it is anticipated that the information gained will assist with the validation of finite element models of cervical trauma.

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