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# ULTRASOUND IMAGING OF SPINAL CHANGES IN SPACEFLIGHT

**Abstract**

Introduction: Back and neck pain allegedly related to intervertebral disc (IVD) disease is a frequent problem among spaceflight participants both in-flight and post-flight. Currently, there is no method to assess the forces and/or displacements acting on the spine during flight or flight simulations. We show that clinical ultrasound (U/S) can provide a portable imaging modality to quantify cervical spine IVD displacement and compliance in response to applied operational static and dynamic loads.

Methods: Adult human and sheep cadaveric spines were subjected to mechanical testing to validate the displacement measurements of the U/S system. We compared the ability of U/S to measure dynamic IVD height and compliance ($\Delta h/\Delta F$) of functional spinal units (FSU) subjected to known loads in the mechanical testing device. For*in-vivo* trials a cervical collar was developed to maintain placement of the U/S transducer and visual motion-tracking markers to compare IVD and c-spine displacement in flight analog environments.

Results: Dynamic analysis of isolated ex-vivo ovine cervical spinal segments intervertebral disc displacement with a mounted ultrasound probe demonstrated a measurement uncertainty of 0.2 mm and no bias at low frequency sinusoidal spinal displacement. A similar evaluation in-vivo with humans with an ultrasound probe mounted on a cervical-collar found a 0.8-1.3 mm amount of cervical spine distraction from the C4-5 Functional Spinal Unit. In human cadavers subjected to passive flexion and extension of the cervical spine, ultrasound measurements of the relative flexion/extension angles between consecutive cervical vertebrae were similar to fluoroscopy. In field-testing, the cervical collar provided a feasible platform for maintaining a constant imaging window of the cervical spine.

Discussion: We demonstrated that it is possible to measure cervical spine IVD properties during operational conditions. This suggests that current clinical U/S systems can be used to provide a low cost, portable, non-irradiative method to track cervical spine and cervical IVD disc biomechanics dynamically and provide a method to assess the effects of the continued unloading the spine undergoes in long-term spaceflight. Some improvements in the temporal and spatial resolution of the U/S platform should be developed for future studies. This setup can aslo be used in a variety of operational conditions where operators are subjected to vibration and acceleration, such as other modes of flight and other flight vehicles. Support for this project from the US Army Research Office.