Feasibility of Detecting Spinal Instability in a Goat Spine Segment Using MR Elastography
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Introduction: It has been reported that up to 85% of people will experience low-back pain (LBP) in their lives.1 Degenerative disc disease (DDD) and spinal instability are two of the most common causes of LBP. There are many imaging techniques that have been developed to characterize the disc and grade the level of degeneration, but there is no way to directly assess the material properties of the IVD in vivo. The nucleus pulposus has been shown to undergo substantial changes in shear stiffness with degeneration.2 Magnetic resonance elastography (MRE) is a sensitive, phase-contrast-based imaging technique for non-invasively mapping the mechanical properties of tissues.3 Cortes et al demonstrated the feasibility of using MRE at very high frequencies in the IVD in vitro to estimate the nucleus pulposus stiffness.4 However, there has been no attempt at using MRE to measure the shear vibration response in a spine segment. The purpose of this study is to determine if MRE is capable of detecting spinal instability in an in vivo goat spine segment with induced disc degeneration and mechanical destabilization. The target audience of this research is MRI scientists involved in developing spinal imaging methods, radiologists involved in spinal imaging, clinicians involved in managing patients with low-back pain and disc-related spinal disorders, and basic scientists investigating DDD. Also, scientists working in MRE technique development may have interest in this research.

Methods and Materials: (1) Intervertebral Disc Specimens. An entire goat thoraco-lumbar spine (T8-S1) was removed with musculature and ligamentous structures intact. All posterior elements of the spine segment were removed to increase flexibility of the specimen, such that the entire spine segment consists of only vertebral bodies and discs. (2) Test Conditions. First, the control was taken as the spine segment before any alterations. Then, a series of four changes were made to the spine sequentially to cause varying amounts of mechanical instability: 1 – Transection of disc specimen and examining the entire spine segment with induced disc degeneration and mechanical destabilization. The target audience of this research is MRI scientists involved in developing spinal imaging methods, radiologists involved in spinal imaging, clinicians involved in managing patients with low-back pain and disc-related spinal disorders, and basic scientists investigating DDD. Also, scientists working in MRE technique development may have interest in this research.

Conclusions: These initial results suggest MRE may be capable of detecting spinal instability. Additionally, the data shows that low frequency MRE (~120 Hz) can be used to vibrate the entire spine from a single vibration source. Further work is needed to determine and improve the detectability of small changes in local spine mechanical properties.