Using upright MR to evaluate disc mechanics in healthy and degenerated lumbar discs in human subjects

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MOTIVATION
Degenerative disc disease is a prevalent problem, especially for the aging population. Degenerative discs are found in 10% of people aged 20-29, and increases with age to 96% in those over 60 years old [1]. A common symptom of disc degeneration is lower back pain, which can be profoundly debilitating. Lower back pain is one of the most common reasons for missed work, and over $50 billion dollars is spent annually on back pain in the US alone [2].

Structural changes that occur with intervertebral disc (IVD) degeneration have been established. However, there has been a major challenge in differentiating changes that occur solely due to ageing from those that might be considered pathological; uncertainty still exists regarding the exact anatomic and physiologic basis for several clinical symptoms [3].

There is a need to understand the effect of degeneration on the mechanical behaviour of the disc, which may be a better indicator of clinical symptoms than simply anatomic changes.

OBJECTIVES
- Develop a tool for non-invasive, in vivo assessment of disc mechanics
- Evaluate the mechanical behaviour of the disc under different physiological loading in vivo
- Evaluate how the mechanical behaviour is affected by degeneration

BACKGROUND
T2-weighted imaging in MRI is used extensively for grading degeneration of the IVD based on changes such as a loss of signal intensity, loss of distinction between the nucleus and the annulus, and decreased height of the disc space. The Pfirrmann grade can effectively describe anatomic variations and morphologic changes [4]. However, Pfirrmann grade is unable to distinguish painful discs from asymptomatic ones.

Diffusion imaging, an MR technique, has strong potential for assessing the IVD. The lumbar IVD is the largest avascular structure in the body. Diffusion is therefore a critical mechanism for nutrient delivery and waste removal. MR diffusion measurements are sensitive to changes in matrix composition and integrity [5], as well as different loading conditions [6], all of which are not evident on a conventional T2-weighted MRI scan. However, these previous studies have only been performed on cadaver discs and as a result are not easily translated to a clinical setting.

METHODS
We have a unique opportunity at CHHM to study both loaded and unloaded IVDs in vivo using our upright open MR scanner (MROpen, Paramed, Genoa, Italy). This allows us to study a range of postures (Fig. 1) and to understand such factors as influences of muscular activity and contribution of posterior elements.

![Figure 1 - Subject in the open MR in positions of A) Supine B) Sitting C) Standing and D) Standing, bent 45°](image)

POTENTIAL IMPACT
In vivo investigation of the IVD will shed light on currently unaddressed physiological parameters with diffusion imaging. Once we are able to do this, we hope to use this as a tool to establish changes in mechanical behavior of the IVD resulting from different degrees of degeneration that can be related back to clinical symptoms.

REFERENCES