MRI and Biochemical Properties in Dynamic Loading Studies of Bovine Intervertebral Discs: Effect of Loading Conditions

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INTRODUCTION: Treatment modalities of intervertebral disc (IVD) degeneration currently focus on relieving the symptoms of spinal pain as opposed to intervening before disc degeneration has progressed too far. Quantitative MRI has the potential to become an accurate and non-invasive diagnostic tool of IVD degeneration. We have previously shown that targeting the collagen integrity of the nucleus pulposus (NP) of unloaded bovine coccygeal IVDs influences the MRI parameters [1]. Only upon introduction of 2h of dynamic loading was trypsin able to affect some MRI parameters [2]. The goal of the present study was to determine the effect of 16h of dynamic physiological loading in an open system on MRI and biochemical parameters.

METHODS: The NP of bovine 3-disc segments were injected with 40 µl of either Tris buffer or trypsin (5 mg) and placed in a plastic bag filled with 1L of saline. The disc segments were kept in solution at 37°C under dynamic loading (50N-300N-50N, 1Hz) or left unloaded for 16h. Sample sizes were as follows: n=4 for trypsin, loaded/ unloaded; n=2 for buffer, loaded/ unloaded. MRI and biochemical analyses of the NPs were performed.

RESULTS: Increasing the loading of the IVD segments from 2h to 16h led to a significant decrease in the apparent diffusion coefficients (ADCs) of the NP (Fig. 1A; [2]). Trypsin treatment of the NP in 16h-loaded discs significantly decreased the relaxation time T1 and the GAG content (Fig. 1B).

DISCUSSION & CONCLUSIONS: Results show that increasing the loading time with the use of an open system, i.e. disc segments in solution, caused a decrease in diffusion distances within the NP. Chiu *et al.* [3] reported that diffusion in human discs induced by loading is a function of the pattern of the load, with a step load leading to increased diffusion and a step displacement, as in this experiment, leading to decreased diffusion. Since the sample size is small, it remains to be determined if enzymatic digestion will play a role as expected on diffusion.

Loaded NPs that underwent trypsin treatment had lower T1 than buffer-treated NPs. As expected targeting the core protein of the proteoglycans decreased the water retention in the NP (though this was not significant due to the sample size) which in turn decreased T1. However, this is in contrast to our previous study [2] where 2h of dynamic loading in a closed system increased the GAG content and did not affect T1. Overall these results suggest that MRI and biochemical parameters are sensitive to loading conditions in the IVD.

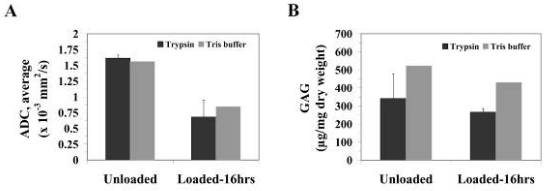

Fig. 1: The GAG content (A) and ADC (B) of bovine coccygeal NP injected with trypsin or Tris buffer and left unloaded or loaded for 16h.

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