

Image-based Analysis of Mass Transport Through Cartilage Endplates

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INTRODUCTION: The etiology of lower-back pain (LBP) is multifactorial. The cartilage endplate (CEP) is the spinal tissue receiving the least attention in scientific literature. Yet it plays a crucial role in keeping the intervertebral disc (IVD) healthy since it is the main gateway to nutrients and waste in and out of the nucleus pulposus in the avascular IVD¹. It is also suggested that imperfections and weaknesses in the CEP can be a better anticipator of pain than IVD degeneration² since chemical changes to the CEP are directly related to the intervertebral disc degeneration³. Immunohisto-chemical research showed that the decline of CEP permeability due to calcification causes blood vessels and nerve fibers to infiltrate the IVD from the CEP and subchondral bone in an attempt to repair the damage and this infiltration leads to LBP³. In this study we aim to investigate the mass transport through the CEP in and out of the IVD starting from CT images.

METHODS: Given the scarcity of human CEP, a fresh bovine tail was obtained from the local slaughterhouse and 6 CEPs were harvested from it. 8 mm punches were taken from the CEPs. The samples were incubated with 20% Hexabrix, a contrast agent to visualize sulfated glycosaminoglycans. The samples were imaged on a Nanotom® M (GE nanoCT©) using in-house optimized settings for osteochondral tissues.

The CT images were exported to Salome and manually curated to generate a high-quality volume mesh of the CEP. OpenFOAM® was used to perform Computational Fluid Dynamics (CFD) Simulations to quantify the mass transport through the CEP.

The CEP samples were fitted into the 8 mm silicon tubes of a custom-made mesofluidic setup and fixed in place using clamps. physiological fluid (PBS) and standard growth

medium were passed through the specimens separately. The specimens were left to fill then the time to pass 10 ml of solution was recorded for each specimen in the forward and reverse flows to calculate the volumetric flow rate and the permeability using Darcy's law.

RESULTS: The nCT imaging settings used resulted in a good quality image of the scanned samples. The 20% Hexabrix was unable to fully stain the CEP and a higher concentration is currently being tested. Both the CFD simulations and the in vitro diffusion tests are ongoing.

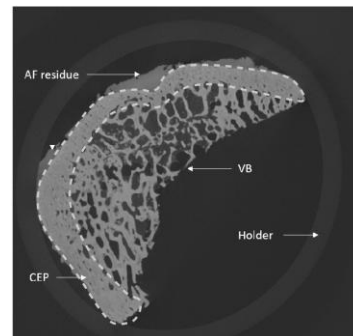


Figure 1: nCT-scan of CEP with vertebrate bone attached (sagittal view)

DISCUSSION & CONCLUSIONS: Combining image-based in silico modelling with in vitro experiments, as proposed in this study, will allow to quantify the fluid dynamics across the CEP, which is the gateway controlling mass transport in and out of the IVD.

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