A Tissue Culture System of the Intervertebral Disc

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Background
Low back pain is a common problem imposing a substantial burden on society, due to commonly accompanying long-term disability. Intervertebral disc degeneration, either induced by herniation (Figure 1) or accumulated over a lifetime, is a major cause of chronic low back pain.

Figure 1: A healthy and a herniated disc [1]

Current treatments like conservative therapy, spinal fusion and disc prosthesis (Figure 2) are not functional and fail to address the cause of disc degeneration.

Figure 2: Disc prosthesis and spinal fusion

Treatments aimed at aiding the disc in restoring its original functionality, i.e. regenerative therapies, are proposed to be more successful.

Project description
For these regenerative therapies, regenerative stimuli, compounds that counter the degeneration of the disc, are needed. In the final phase of pre-clinical testing, the efficacy of these stimuli should be tested in near in vivo conditions. However, all current animal models have known dissimilarities with the human disease making them of limited use. Hence the aim of this project is to develop an in-vitro human degenerated intervertebral disc tissue culture system and to use it for testing various regenerative strategies developed by partners in the BioMedical Material consortium.

Approach
As a first approach, bovine tail tissue is used, which can be used as a model of the human disc [2]. The key challenge of this project will be to maintain the disc tissue in its unique physiological environment. In situ, the tissue is hyperosmolar with its swelling tendency balanced by tension in adjacent structures. Furthermore the tissue is naturally in hypoxic and low nutrient conditions. Finally, it has been demonstrated that the tissue is highly mechanobiologically responsive in both anabolic and catabolic behaviour to its loading conditions, which will be simulated in a bioreactor.

Ongoing work
The characteristic properties at harvesting, like cell-viability (Figure 3), biochemical content, gene expression, etc are being determined to establish a baseline of the tissue.

Figure 3: Cell viability at day 1; live cells are stained green, dead cells are stained red

Besides that, intelligent solutions to keep the tissue in its unique environment are devised. To balance the osmolarity of the tissue, semi-permeable membranes in combination with a hyperosmolar solution are investigated. Furthermore, a setup is under development to measure the oxygen pressure and the osmolarity in the tissue.

References
[1] M. Schünke et al., Thieme atlas of anatomy I general anatomy and musculoskeletal system, Thieme Stuttgart, 2006