TISSUE AND ORGAN MECHANOBIOLOGY

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Research Profile
The Tissue & Organ Mechanobiology (TOM) Group of the Institute for Surgical Technology and Biomechanics (ISTB), University of Bern, conducts translational research in the intersection of tissue engineering, biology and applied clinical research. The group’s primary aim is to understand the cellular response onto biomechanical stimuli and how cellular communities are affected in vivo using 3D tissue and organ culture models. Our research can be divided into two main foci: On the one hand the group investigates causes of low back pain due to intervertebral disc (IVD) degeneration and on the other hand the group focuses on the human knee where they aim to identify cell-based solutions for the non-healing or delayed ruptures of the anterior cruciate ligament (ACL).

The common focus of the TOM group is to advance in vitro organ culture models, which match closely the human situation and where regenerative therapy strategies, such as novel biomaterials and cells, can be tested in a most authentic in vitro set-up.

Low Back Pain and Intervertebral Disc Degeneration and Regeneration
The TOM group conducts research in two main directions: i) IVD research in the area of regeneration using biomaterials and stem cells1,4 and ii) in the area of non-successful spinal fusion and possible involvement of pseudo-arthritis5. For the first research area we use a combination of 3D tissue and organ culture approaches. The research of the second focus is the understanding of the balance between BMP agony and antagonism. Besides the investigation of the exogenous stimulation of BMP antagonists on mesenchymal stem cells (MSC) and osteoblasts, the main focus lies on the observation of the interaction between IVD cells and osteoblast, by performing co-cultures1.

Recently, autochthonous progenitor cells were detected in the human IVD, which could lead the path to cell therapy (Figure 1). Here, we concentrated on the most suitable isolation protocols to “fish” nucleus pulposus progenitor cells (NPPC) from the total population of cells in the bovine coccygeal disc. We also focused on their multipotency capacity and their application for IVD repair (Figure 2). Future research is to understand how these cells can be best isolated and whether these cells can be maintained in vitro to regenerate the IVD4. Furthermore, it would be highly desirable to investigate how induced multipotent stem cells (iPSC) could be used for IVD repair. This is the main aim in an upcoming Horizon 2020 Project named “iPSpine” starting in 2019 for three years in collaboration with internationally well-known scientists and experts in the field of engineering, biomaterials and biomechanics.

Figure 1. Image illustrating the four “classical” cell populations previously characterized in the intervertebral disc. In yellow on the right are the newly detected Tie2+ nucleus pulposus progenitor cells (NPPC).

Figure 2. Confocal Laser Scanning Microscopy of A) nucleus pulposus progenitor cells (NPPC) and B) nucleus pulposus cells (NPC) after seven days of colony unit forming assay in a viscous medium. NPPC do result in more dense and spherical colonies whereas NPC form more loose and wider spread colonies. Cells were stained with a live dye in green. Scale bar = 100 µm.
Stem cell therapy faces the problem of the necessity to rely on fetal bovine serum (FBS) for cell expansion, which proved to have major disadvantages for application in the clinics. Additionally, MSC undergo senescence during expansion in vitro, which impairs their therapeutic potential. Here, alternate serum-free media formulations were investigated in terms of cell proliferation and differentiation potential, which could make their way to a GMP-compliant solution.

Selected Publications


