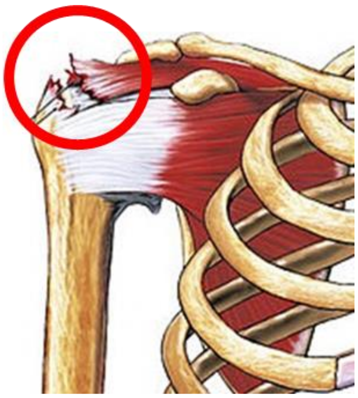
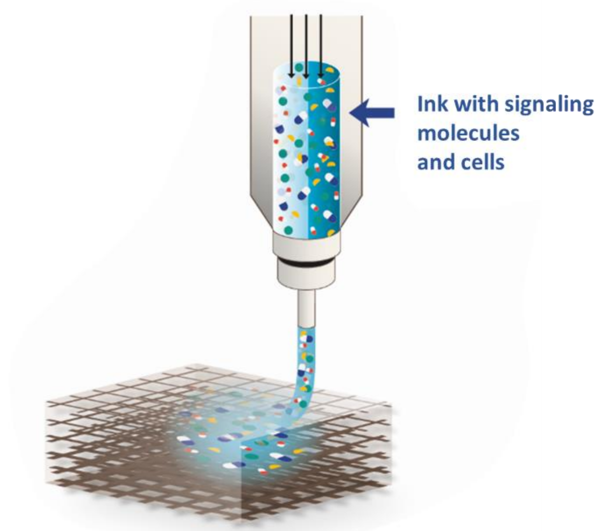
As a consequence of increasing average life expectancies and increasing physical activity, such as high impact sports, our bodies constantly experience high loads, which may lead to contusions. The number of musculoskeletal injuries, causing dysfunctions and chronical pain, requiring medical interventions, is constantly growing. Especially vulnerable are zones where different tissue types are in contact, such as hard bone and soft muscle. They are characterized by a complex structure, with a gradual change in the architecture, composition, cell types and properties. Therefore, the healing is difficult and currently available medical solutions are not satisfactory. The aim of this project is to utilize the newest 3D printing techniques to reconstruct these complex body zones.



An example of a rupture at the connection between hard and soft tissue: rotator cuff tear.
Adapted from: Rotator cuff high.jpg by Nucleus Communications (www.nucleusinc.com)

3D printing is a currently flourishing production technique for biomedical applications. It is based on layer-by-layer deposition of the material (so-called ink) to construct hierarchical and complex 3-dimensional objects. Great control over ink placement, regarding the location and amount of deposited material, is difficult to obtain using other fabrication technologies. In this research, two 3D printing techniques will be employed: melt electrowriting and extrusion bioprinting. Melt electrowriting is a novel approach that utilizes a high voltage to accurately deposit melted polymer into well-organized fine fibers. Extrusion bioprinting, in turn, allows to print a mixture of hydrogel-like material and patient's own living cells. Hydrogels are usually composed of polymers and high content of water, which makes them not only cell-friendly but as well provides a good environment to include signaling molecules for cells. These molecules are like road signs directing cell behavior.

In this project, the scaffolds for cells will be constructed from a biomedical plastic material using melt electrowriting. The influence of different architectures, and resulting mechanical properties, on cell behavior will be studied. In the next step, these plastic scaffolds will be combined with printed hydrogel, containing different cell types, and signaling molecules for the cells. As a result, materials that closely mimic the structure of natural tissues and guide cell organization will be obtained.



Schematic of the production process of the scaffold, with signaling molecules and cells, for reconstruction of the complexity of natural tissues.

The ultimate goal of the research is to construct multicellular synthetic systems that imitate the complex and hierarchical architecture of hard-soft tissue interfaces. In the longer run, this project will lead to the development of patient-specific implants for the improved medical treatment of musculoskeletal injuries.