Summary of Master Thesis

"Characterization of 3D-printed polycaprolactone with molybdenum-doped mesoporous bioactive glass nanoparticle composite scaffolds for bone regeneration"

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Bone defects larger than 2.5 cm can often not be regenerated by the body itself but need support. While autologous bone material is still considered the gold standard to do so, artificially produced biologically active materials have been subject of research for decades. Mesoporous bioactive glass nanoparticles (MBGNs) have recently been researched as biomaterials that boost regeneration of bone tissue. They can be loaded with drugs like antibacterials or doped with ions that further promote bone regeneration or trigger other desired mechanisms. For example, molybdenum ions have shown to promote osteogenic cellular responses and have antibacterial properties and were therefore used to dope the MBGNs. Because pure MBGN scaffolds do not have adequate mechanical properties when compared to natural bone, polycaprolactone (PCL) was chosen in this work as a matrix material to create composite scaffolds. These scaffolds were 3D printed using a dispense-plotting system, to create alldirectional-porous scaffolds. A gelatine/Mo-MBGN coating was applied to further improve bioactive properties. The materials and scaffolds were characterized using different imaging techniques as well as FTIR and XRD. MBGNs were successfully synthesized, doped and homogeneously distributed in their PCL matrix. PCL/Mo-MBGN scaffolds showed higher Young's moduli, compressive strength and toughness values and thus more adequate mechanical properties compared to pure PCL or PCL/MBGN scaffolds. To assess the bioactive behavior, scaffolds were immersed in simulated body fluid (SBF) for different duration up to 24 days. The adhesion of hydroxyapatite (HA) was analzed via SEM and MicroCT imaging as well as FTIR and XRD spectroscopy. The typical flake-like structure of HA was observed in SEM images after three days in SBF on PCL/MBGN scaffolds and after seven days on PCL and PCL/Mo-MBGN scaffolds. The cell viability was studied using an osteoblast precursor MC3T3-E1 cell line. Cells were seeded on each scaffold type and analyzed after three and seven days using a WST-8 assay as well as fluorescence staining and microscopy. After three days, PCL/Mo-MBGN scaffolds showed the highest cell viability while after seven day seeding the cell viability of all scaffold types was similar and lower than that of the control well. To conclude, doping MBGNs with molybdenum ions used in composite PCL 3D printing has shown to significantly improve the mechanical properties and showed a trend of improved cell viability after three days. Interestingly, the bioactivity of scaffolds with Mo-doped MBGNs appears slightly lower than that of undoped PCL/MBGN scaffolds. More research is needed to yield statistically significant data on bioactivity and cell viability and to better understand the underlaying mechanisms in order to create scaffolds that can help patients regenerate bone tissue.