Additive manufacturing using polycaprolactone in combination with stem cells and morphogens for bone regeneration

Martijn van Griensven[1]

[1]Department cBITE, MERLN Insitute for Technology-Inspired Regenerative Medicine, Maastricht University, the Netherlands

Bone tissue normally has the ability of healing spontaneously. However, in some cases the healing ability is impaired. Delayed healing is occurring when the bone doesn't unify within nine months. When after nine months the bone is still not unified, the term non-union is used. Regeneration of such defects can be achieved by different methods, depending on the patient's condition. The “diamond concept” can be applied using 1) cells, 2) biomaterials, 3) growth factors, and 4) mechanical stimulation. All factors can be used or just one of the four. As a biomaterial we have used a mixture of medical-grade polycaprolactone and β-tricalciumphophate. This can be matched to the defect based on a CT scan and using additive manufacturing. The microstructure (pore size, structure, interconnectivity) can also be adapted in order for cells to adhere, proliferate, and differentiate. The pore architecture is of utmost importance for the regenerative success. The cells that are applied should be mesenchymal stem cells. They have the ability to proliferate, differentiate, and excrete important cytokines and growth factors. These mesenchymal stem cells can be derived from different tissues, but mainly bone marrow or adipose tissue. Nowadays, several machines exist for automated isolation of these mesenchymal stem cells intraoperatively. The biomaterial can be combined with morphogens such as bone morphogenetic proteins or bone-stimulating peptides for inducing bone formation and act as drug delivery platform. This tissue regeneration concept of applying a biomaterial together with cells and morphogens can lead to an increased success rate of healing of non-union fractures. We have successfully applied these techniques in docking site non-unions and in large defect non-unions of the tibia. Importantly, regenerative medicine uses techniques for personalized medicine including additive manufacturing and drug delivery.