ABSTRACT

The preclinical imaging method micro-CT (microtomography) allows the visualization and quantification of the structure of samples at a resolution of micrometers. Its' importance is increasing globally. In addition to several advantages (non-destructive, the possibility of direct 3D analysis, time efficiency, etc.), micro-CT also has some significant limitations (problematic validation of results, image artifacts, significant influence of image modifications, etc.). This thesis focuses on the application of micro-CT in the field of research and development of metallic and non-metallic materials promoting bone healing with their possible clinical applications. The first part addresses the limitations of micro-CT through several studies. A comparison of pore sizes in biomaterials utilizing scanning electron microscopy (SEM) and micro-CT was performed, and the complications of pore size evaluation were presented. SEM image analysis leads to significantly higher values than micro-CT (approximately three times), which allows for comparison of the studies using only one of these methods. Validation of micro-CT 3D analysis results based on calibration phantoms with complex structure, to date, is not possible. We therefore developed software generating phantom datasets of 3D objects with well-defined structural parameters. This enabled testing of micro-CT analysis accuracy, along with quantification of bias introduced by many factors (e.g. image processing or image noise). Furthermore, we compared the evaluation of bone structure using micro-CT and two histological methods (ground and decalcified paraffin sections). There were no significant differences between micro-CT and the histological methods, which proves that in this case micro-CT can replace the conventional approach with the advantages of no destruction of samples, time efficiency and whole specimen evaluation. The second part summarizes the studies carried out on the characterization of the structures of tissue engineering scaffolds, in particular their porosity, in order to optimize their fabrication and prediction of their behaviour. Tissue engineering scaffolds are usually evaluated in a dry state, so we focused on changes caused by hydration, as this always occurs after material implantation. Significant alterations of mechanical properties were observed with minimal structural changes. As part of the *in-vivo* experiment, the degradation of metal resorbable osteosynthetic material (WE43 magnesium alloy) was evaluated by determining the changes in volume and surface of the implants over time. Implant degradation accelerated after 12 weeks of healing with decrease of volume and temporary increase of surface - due to implant fragmentation. The studies carried out confirm a significant benefit of micro-CT imaging with the postulation of the future increase of its importance.

Keywords: Micro-CT, bone regeneration, biomaterial, tissue engineering scaffold, oral surgery, maxillofacial surgery