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Three Dimensional Micro-Structure of Scaffolds for Tissue Replacement

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INTRODUCTION: Bone tissue engineering aims to fulfil the need to provide bony tissue for skeletal use. In spite of the fact that the allogenic bone or autogenous grafts have been used for decades, disadvantages like failure of complete resorption of autogenous bone raises the demand to have alternative approaches, which puts bone tissue engineering into play. Usage of three-dimensional (3D) porous ceramic scaffolds in bone tissue engineering manifests itself as a promising methodology for treatment of a wide range of clinical situations, challenging to replace former methods like allografts, synthetic materials etc. Scaffold characteristics such as porosity, interconnectivity and especially morphology on the micrometer scale are crucial for optimizing cell attachment and the related osteointegration.

METHODS: In this study, the micro-architecture of hydroxyapatite scaffolds with the diameter of 8 mm and the height of 4 mm is uncovered. The scaffolds (Engipore; Fin-Ceramica Faenza, Faenza, Italy[1]) have a total porosity of 83% ± 3%. In order to determine the interconnectivity, the scaffold was embedded into paraffin.

Synchrotron radiation-based micro computed tomography (SRµCT) in absorption contrast mode[2] from the beamline W 2 at HASYLAB/DESY, Hamburg, Germany with the photon energy of 30 kV provided the morphology of the opaque constructs with a pixel length of 4.3 µm and a spatial resolution of 7.4 µm.[3]

RESULTS: Figure 1 shows the morphology of the porous scaffold by means of two virtual slices perpendicular to each another. The pores do have a spherical shape. Many of them seem to be connected. In order to determine the degree of interconnectivity the pores were filled with paraffin, which is visualized in Fig. 1 on the right by the red color. Paraffin was segmented by intensity-based thresholding possible as the consequence of the lower X-ray absorption with respect to the scaffold material. The paraffin clearly penetrated through all pores. Some pores, however, are incompletely filled with the paraffin. They are just covered at their periphery by a thin film with a thickness of at least 40 µm.

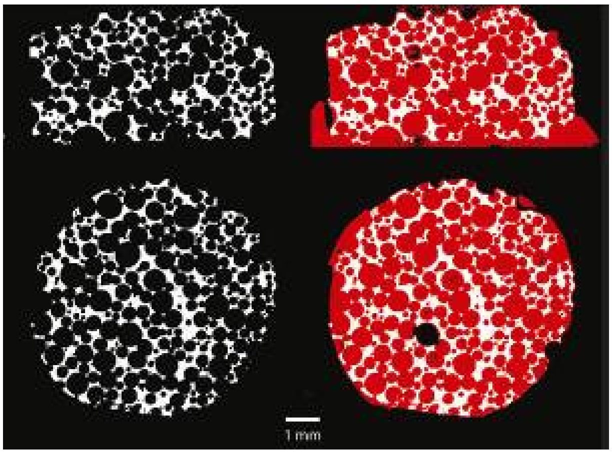

Fig. 1: The frontal and axial slices virtually cut from the SRµCT data demonstrate the spherical shape of the pores. The same slices are reproduced together with the penetrated paraffin (red colored) to verify the interconnectivity of the pore network.

DISCUSSION & CONCLUSIONS: 3D micro architecture of porous ceramic scaffolds is made visible using SRµCT. The visualization of penetrated paraffin revealed that the pores are well interconnected. The channels between the spherically shaped pores, however, are quite thin and are, therefore, incompletely filled.

The data allows further quantification based on sophisticated computer vision tools including component labelling, growing region and dilatation procedures.

REFERENCES: [1]http://www.finceramica.it [2]F. Beckmann et al. (2006) *New Developments for synchrotron-radiation-based microtomography at DESY*, Proc SPIE **6318**:631810. [3]B. Müller et al. (2002) *Non-destructive three-dimensional evaluation of biocompatible materials by microtomography using synchrotron radiation*, Proc SPIE **4503**:178-188.

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