Osseointegration of resorbable magnesium screws – A SRµCT Study

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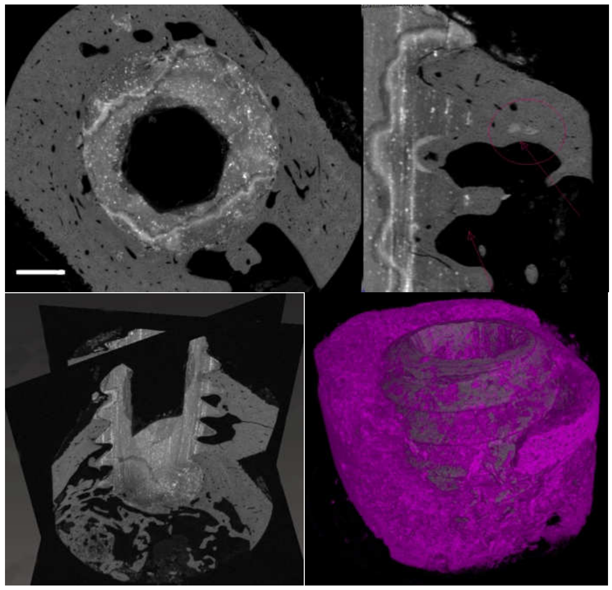
INTRODUCTION: The development of resorbable osteofixation materials that degrade upon substitution by regenerated tissue is highly desirable in orthopaedics. Magnesium is promising as implantable material, because of its biocompatibility, osteoconductivity and biodegradation under physiological conditions [1]. Through the selection of alloying elements, the mechanical properties and corrosion behaviour of magnesium can be modulated for application in load-bearing situations. The aim of our research was to investigate the bone integration and the corrosion process of Al-free Mg-alloys *in vivo*. Our hypothesis was that Mg-based implants stimulate bone growth.

METHODS: Mini-screws of two different Mg-alloys, Mg10Gd and Mg-Y-RE (WE43) were manufactured at HZG. The cytocompatibility of the selected alloys was formerly tested and validated in vitro [2, 3]. The mini-screws were implanted in rats after ethical approval. After 1 and 3 months of healing, cylindrical bone-implant blocks were retrieved. Samples were imaged at the P05 Imaging Beamline (IBL) operated by HZG at PETRA III – DESY (Hamburg). We used monochromatic X-rays at 25 keV to take 900 projections and a field of view of 7mm x 1.8 mm, which resulted in 5X magnification with a resolution of ~2.5 µm. 3D data sets were computed using filtered back projection algorithms.

RESULTS: The inserted implants healed without any observable adverse effect. On the basis of tomographic data, we were able to compute three-dimensional renderings of dvrscrews and bone with high contrast-to-noise ratios. A qualitative evaluation of the data revealed inhomogeneous surface corrosion of the screws, which maintained their original shape within the study period. New bone formation was observed in all of our samples. We found a considerable increase of implant-bone contact sites with progressing healing time. A quantitative analysis of the tomographic data indicated spatial differences in bone density. In proximity of the implant, newly formed bone matured and became dense after 3 months.



Top: Horizontal (left) and vertical (right) sections of a screw after 3 months of healing. Fragments of implants, completely integrated in the bone, are visible. Bar 0.25 mm. Bottom: Orthogonal cut planes (left) and volume rendering (right), showing an implant (gray) into the bone (purple).

DISCUSSION & CONCLUSIONS: The SRµCT showed osseointegration of Mg10Gd and WE43. Although the spatial resolution was not sufficient to fully elucidate the alloys microstructure, we observed the distribution of the high absorbing regions in the materials, possibly intermetallic phases and Y or RE oxides. The corrosion of the alloys was slow. Biocompatibility of the tested materials was confirmed by bone growth in intimate contact with the implants.

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