Magnesium diffusion from implant into bone tissue observed by μXRF imaging

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Biodegradable orthopedic implants based on magnesium alloys are of considerable interest, especially beneficial in pediatric surgery, as children’s bones are in dynamic state of growth and remodelling. The implant will degrade gradually to enable the newly formed bone structures to take over the load, and as usual, an additional removal is not needed in children. The exact mechanisms of the process are yet not fully understood. Therefore, the process of degradation of magnesium-based implants was being studied more explicitly in rat model, and the purpose of the study was to observe, how far the components of implant, Mg being the main element of interest, will diffuse into the bone.

The measurements were performed at low power μXRF setup of Atominstitut, optimized for detection of low-Z elements (Rh-low power tube, 30mm² Si(Li) detector, N₂ cooled, with ultrathin polymer window (UTW), under vacuum conditions), which is sufficient for analysis of magnesium, using beam size of 50x50 µm² determined for Cu-Kα.

Six thin sections (range of 150-550µm) of rat bones with Mg-implants, embedded in PMMA, collected at given time points between 1 and 18 months after implantation, were analyzed as well as a reference sample (bone without implant). The scans were performed within predetermined regions of interest, which engage the interface implant/bone and surrounding bone tissue.

The data collected were subsequently processed; elemental maps of the detected elements were created. The information on magnesium, yttrium (the constituents of the implants) and calcium is brought into focus, also in the form of linescans, allowing more distinct comprehension of the diffusion of the elements from the implant into bone tissue.