Speciation of Pb at the Tidemark of Articular Cartilage and in Trabecular Bone

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The vast majority of the toxic trace element lead (Pb) is stored in the skeleton. We have recently shown that Pb specifically accumulates in the tidemark (TM) of human articular cartilage at much higher levels compared to trabecular bone. However, the accumulation mechanisms as well as the chemical species of Pb at the TM, which is the border between calcified and non-calcified articular cartilage, and in trabecular bone, are unknown.

X-ray absorption spectroscopy was used to determine the chemical speciation of Pb in human bone. Pb L3 edge XANES spectra were recorded at the TM of a human patella, at a trabecular bone and of Pb doped synthetic hydroxyapatite standards (one with increased carbon content).

Since the estimated thickness of the TM is in the order of 10-20µm it is necessary to measure the spectra with a small beam focus (about 28 µm x 85 µm) as it is available at the SUL-X beamline of the synchrotron radiation source ANKA. Fluorescence radiation was collected with a 7 element Si(Li) detector. The spectra from the standard material showed no significant differences in noise, indicating the suitability of SUL-X.

Though the concentration of Pb in trabecular bone is about 2 orders of magnitude less than in the TM, we could show that the obtained fluorescence intensities at SUL-X are sufficient to perform Pb-L3 XANES in trabecular bone.

The measurements revealed that lead in the tidemark and trabecular bone is bound the same way, although these tissues have a completely different chemical composition.

When comparing the data from the reference materials with the results from the bone samples, the highest correlation was obtained for synthetic Pb-doped carbonated calcium hydroxyapatite. This suggests that in both of these very different tissues (tidemark and trabecular bone) lead is incorporated into carbonated calcium hydroxyapatite.