Differential Accumulation of Lead in Double-Tidemarks in Articular Cartilage of Osteoarthritic Human Joints

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Long term exposure to increased lead (Pb) concentrations is associated with chronic diseases of the central nervous, the skeletal-hematopoietic, renal and endocrine systems. Approximately 95% of the total burden of Pb is stored in the skeleton. Normal environmental exposure to Pb derives mainly from air, drinking water and food. In a recent study we found that Pb was accumulated up to 18 fold in the tidemark of articular cartilage compared to bone tissue. However, the underlying mechanism remains unclear.

In joints the articular cartilage is tightly bound to bone by about a 100µm wide region of mineralized cartilage. The transition zone between mineralized and non-mineralized cartilage is called tidemark (TM), because of its characteristic histological appearance. Especially, in osteoarthritis associated with damages in the articular cartilage, an initiation of an additional mineralization phase can lead to a second tidemark. Our hypothesis is that the Pb is accumulated after the mineralization front has stopped to advance and the Pb concentration is increasing with time. Thus, if there are two TMs, the inner (older) TM should have the higher and the outer (younger) TM should have lower Pb levels.

Undecalcified tissue from osteoarthritic human joints (patella and hip heads) was examined by quantitative backscattered electron imaging using a pixel resolution of 1 µm to localize the TMs within the cartilage and the subchondral bone region. Areas of interest were analyzed with Synchrotron Radiation induced confocal micro X-ray fluorescence analysis (SR µ-XRF) to determine the distribution of Ca, Zn and Pb in trabecular and cortical bone. Measurements were performed at the FLUO beamline at ANKA and HASYLAB beam L using a beam size of 15x10µm and a depth resolution of 20µm at Au-L\textsubscript{α}, with primary excitation energy of 17keV.

The evaluation of Pb intensities in double TM revealed in average a 2.6 fold higher level in the inner TM compared to the outer TM, whereby the Pb in the outer TM showed a high variation with respect to the inner TM (1.4 to 3.9 fold). The element Zn, which is also accumulated in the TMs did not show differences between inner and outer TM. The data confirm our hypothesis made above. The biochemical composition of the TM seems to be able to selectively accumulate continuously Pb from the interstitial fluid of articular cartilage. In contrast, Zn seems to be a fixed constituent of the TM. The results might be of clinical importance, when during degenerative processes in osteoarthritis the tidemark region is destroyed and accumulated Pb is released again into the body fluid.