

K-edge Subtraction Imaging of Barium and Strontium in Bone

Understanding the extent and pattern of elemental accumulation in the skeleton is important from diagnostic, therapeutic, and toxicological perspectives. In this project, we investigated skeletal uptake of barium and strontium (both from the same group as calcium in table of elements) in two different age groups, growing and skeletally mature, in healthy rats. Animals were dosed orally for 4 weeks with equal molar concentrations of either strontium chloride or barium chloride or combined. The distribution of trace elements was imaged in 3D using synchrotron K-edge subtraction micro-CT at $13.5\mu\text{m}$ voxel size and 2D Electron Probe Micro Analysis. Both elements were primarily deposited in the areas of active bone turnover such as growth plates and trabecular bone. Barium and strontium concentration in the bones of juvenile rats were 2.3 times higher (figure 1), while serum levels were 1.4 and 1.5 times lower than adults. In all treatment and age groups strontium was preferred to barium (in terms of incorporated amount in bone) even though equal molar concentrations were dosed. This study displayed spatial co-localization of barium and strontium in bone for the first time. Barium and strontium can be used as surrogates for calcium to study the pathological changes in animal models and to study the effects of pharmaceuticals on bone micro-architecture and bone remodeling in high spatial sensitivity and precision.

Figure 1. The panel shows accumulation of barium in the tibia of a juvenile (left) and an adult rat (right). Bones are rendered in grey and barium concentration is represented in colour on top of the grey render. Bone forming regions are more prevalent in the juvenile rat.

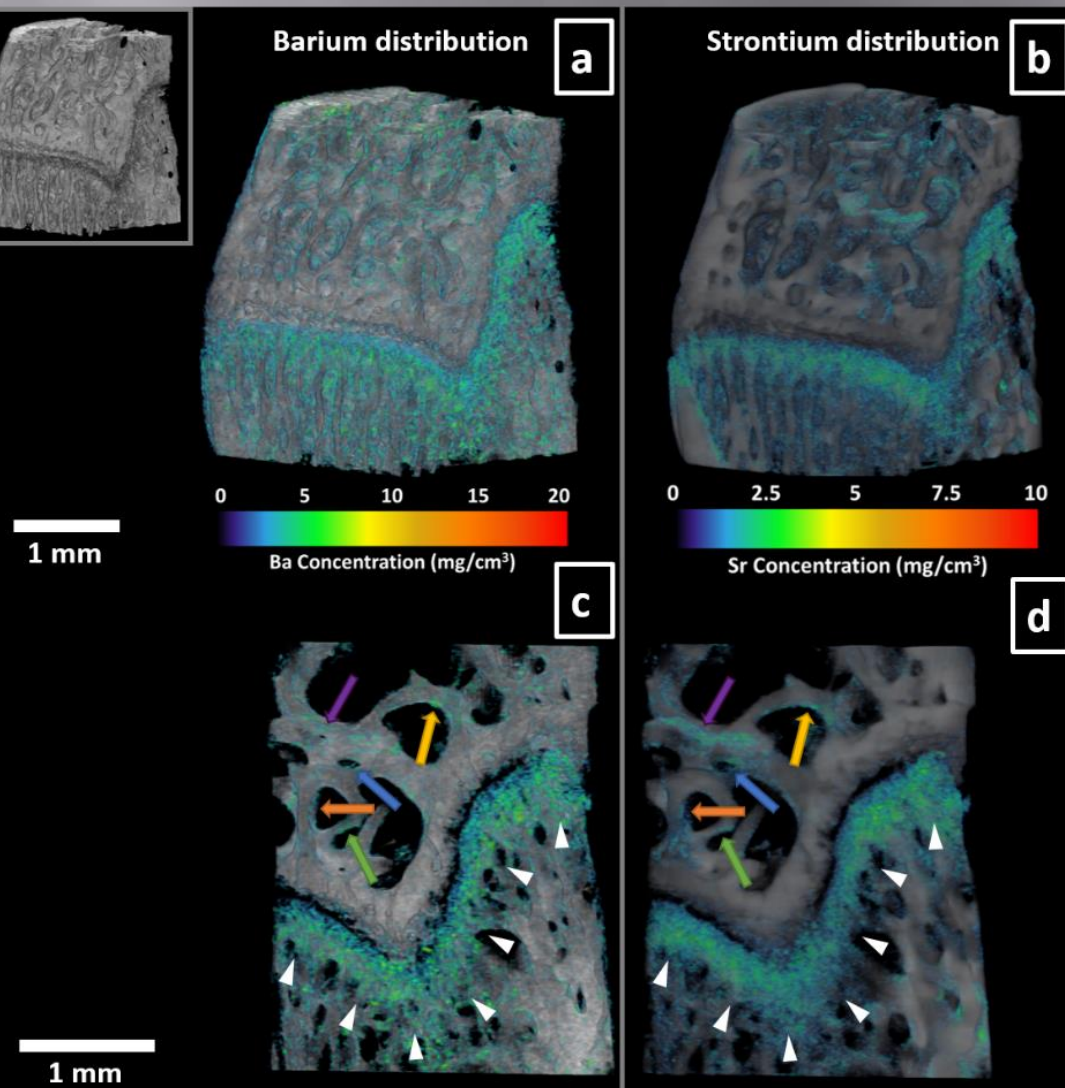


Figure 2. Figs 2a, c show barium distribution in the tibia of a co-dosed adult animal, while figs 2b, d show the strontium distribution in the same sample. The bottom panels are a stack of 20 CT slices for better visualization of finer details. The colored arrows indicate co-localization of barium and strontium in the same regions. The white arrowheads indicate accumulation of barium and strontium in the growth plate. The inset shows a plain 3D model of the respective bone.