Elemental Mapping of Strontium in Rat Bones Treated with Strontium Ranelate and Strontium Citrate using 3D Dual Energy X-ray K-edge Subtraction Imaging

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Osteoporosis is a debilitating disease that leads to the loss of bone mass, which is a prevalent health issue in the northern countries such as Canada. Strontium based medications, such as strontium ranelate (Protelos®), have been suggested to have therapeutic effects for the condition. Strontium supplements, such as strontium salts available off-shelf in stores in Canada (e.g., strontium citrate), have been assumed to provide the similar effect as the strontium ranelate. The objective of this study was to compare the distribution of strontium in animal bones following administration of strontium ranelate and strontium citrate.

Skeletally mature (17 wks old) Sprague-Dawley female rats were dosed daily over ten weeks with strontium ranelate (174.3 mg/kg/day elemental Sr, $n = 6$), strontium citrate (235.7 mg/kg/day elemental Sr, $n = 7$), or no strontium (control group, $n = 6$) in a flavoured gelatin vehicle. The strontium citrate group received 35% more elemental Sr; the strontium citrate powder had greater Sr content than previously estimated as revealed by EDS performed on the Sr salts after completion of the study. The right humerus from the forelimb was collected from all animals and strontium distribution was imaged using the 3D Dual Energy X-ray K-edge Subtraction (KES) Imaging at the Canadian Light Source (CLS), Saskatoon, Saskatchewan.

Samples imaged at CLS were defatted in 70% ethanol solution (2 weeks) and air dried (1 week) prior to the measurement. The samples were cut into blocks approximately 2 to 3 mm thick using a diamond wafering blade to allow X-rays to penetrate the samples adequately. Two samples from strontium citrate, four from strontium ranelate, and two from the control groups were scanned at the BMIT BM beamline (source-to-sample distance of 25 m, sample-to-detector distance of 0.2 m). Two sets of data were obtained for each bone in Computed Tomography (CT) mode at 'above' (16.185 KeV) and 'below' (16.085 KeV) the K-edge energy of strontium (16.105 KeV), collecting 1800 projections with rotation step of 0.1^{o} over 180^{o}. The resultant images were reconstructed to obtain cross-sectional slices, then co-registered in 3D and subtracted in order to obtain the strontium distribution maps. Strontium was observed to be largely present in the trabecular regions under the epiphyseal growth plate with concentrations of approximately 5.0 to 15.0 mg/cm^3 in both the Sr-treated groups. The level of strontium in the control bones was below the detection limit.

This work presents the 3D spatial distribution and quantification of strontium in the bones of rats treated with two strontium salts in comparison to the control using dual energy KES imaging. It demonstrated that strontium is efficiently incorporated in the animal bones independently of the strontium salt administered and is accumulated in the same bone region between groups. However, more research is required to fully understand the role of strontium citrate and other strontium salts to treat and/or alleviate osteoporosis.