Quantifying radium in human bone: a novel application of digital autoradiography

George Tabatadze[1], Jessica E. Linson[2], John D. Brockman[2], and Sergey Y. Tolmachev[1]

[1]United States Transuranium and Uranium Registries, Washington State University, Richland, WA;
[2]University of Missouri, Columbia, MO

An ionizing radiation quantum imaging detector (iQID) is employed at the United States Transuranium and Uranium Registries as a non-destructive technique for visualizing the micro-distribution of alpha-emitting radionuclides in human tissues. This study examines the potential of iQID imaging not only for spatial mapping but also for quantifying activity concentrations of ^{226}Ra in bone samples. Two plastic-embedded bone sections, one from the middle shaft of the left femur and one from the body of the seventh thoracic vertebra, were selected from a historical case of a female radium dial painter. She had worked as a dial painter for six years, and her ^{226}Ra intake was subsequently estimated at 58.9 MBq. She passed away at the age of 24 from diphtheria and nasopharyngeal bronchopneumonia. Cortical and trabecular bone regions were segmented, and a computational model was developed to simulate sample-specific geometric efficiencies, enabling quantitative activity concentration estimates based on alpha particle emissions detected by the iQID. The same bone sections were acid-digested and analyzed by inductively coupled plasma mass spectrometry. ^{226}Ra activity concentrations were measured at 80.8 ± 9.2 Bq/g for the femur and 63.7 ± 17.0 Bq/g for the vertebra, providing a basis for assessing the reliability of the imaging-based estimates. This study highlights the potential of an iQID as a non-destructive technique capable of both resolving spatial heterogeneity and supporting quantitative assessments of alpha-emitting radionuclides. Such capabilities offer promising applications in internal dosimetry and retrospective dose assessment.

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