Electron paramagnetic resonance dosimetry using synthetic hydroxyapatite

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Study Goal: To confirm the feasibility of radiation dose estimation from intact human teeth, we performed electron paramagnetic resonance (EPR) dosimetry using synthetic hydroxyapatite (HAP) which is the primary component of tooth enamel. For this study, a 1.1-GHz CW EPR spectrometer developed in Hokkaido University was used. Radiation doses were used to determine if there was a linear relationship with radiation of the signal intensities in HAP samples. A blinded test was performed using another HAP sample to estimate its performance.

Abstract: EPR has been known for its capability of quantifying radicals in matter. These radicals include stable radicals formed from the radiation exposure in human teeth, which have been used that facilitate the retrospective dosimetry. EPR dosimetry is based on the measurement of stable radiation-induced radicals in tooth enamel. Hydroxyapatite (HAP) (Ca₁₀(PO₄)₆(OH)₂) contained in tooth enamel is a major probe for dose reconstruction. Molecules CO₂ absorbed on the HAP surface during the formation of enamel in teeth are converted to CO₂-radicals by ionizing radiation. The concentration of radicals increases with the amount of radiation. This implies the possibility of HAP as a useful dosimeter for EPR dosimetry. We tried this tooth radiation dosimetry study using a 1.1-GHz EPR spectrometer in Hokkaido University, Japan. This spectrometer was equipped with a surface coil resonator, which was originally designed for in vivo EPR tooth dosimetry.

HAP (HA, Hydroxyapatite, 289396, Sigma-Aldrich Chemistry) was prepared in disc forms. Prepared HAP discs were split into nine samples. Samples were carefully weighed using an electronic balance to normalize EPR signal intensities.

A clinical linear accelerator (TrueBeam STx, Varian) in Seoul National University Hospital was utilized for x-ray irradiation. HAP samples were irradiated with doses of : 10, 30, 50, 100, 200, 300, 600 cGy. Another HAP sample was prepared with the irradiation of 250 cGy for the performance blind test.

Assessed amplitudes of EPR spectra were matched with the incident absorbed doses to plot a dose-response curve for HAP samples. The dose-response curve showed a linear behavior as generally known.

The absorbed dose measured from a sample prepared for a blind experiment was estimated 267 cGy, which was about 7% different from an expected value of 250 cGy.

Conclusion: X-ray doses were estimated from irradiated HAP samples using 1.1-GHz CW EPR spectrometer. EPR dose-response curve was made using HAP samples. The blind test using 250 cGy sample showed the usual range of variation, indicating the feasibility of EPR dosimetry for triage.

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