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Electron Paramagnetic Resonance Biodosimetry in Teeth and Fingernails

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Electron paramagnetic resonance (EPR) biodosimetry is based on the measurement of radiation-induced radicals in human tissues. This physically based type of measurements in tissues provides some useful features, especially for estimating dose with asymmetric exposures. The intensity of the radiation-induced signal is unaffected by biological processes such as stress and reflects only the radiation that impinges directly at the site of measurement (i.e. hands, feet or teeth). Such data can serve as complementary to the dose assessments made based on biological changes that are likely to be affected by physiological stress, injuries and whole body exposure. Tooth enamel has the best EPR dosimetric properties because of the high stability of the radiation induced radicals, which in teeth reside in the hydroxyapatite matrix. During the last decade EPR dosimetry in teeth has made considerable progress towards becoming a routine dosimetric method. It has been applied for dose reconstruction for epidemiological studies of different cohorts, including Hiroshima atomic bomb survivors, Chernobyl clean-up workers and others. In 2002 the International Atomic Energy Agency issued IAEA-TECDOC-1331 that contains a detailed description of the EPR dose reconstruction procedure. International Commission on Radiation Units and Measurements recognized in its Report 68 that EPR dosimetry is the most accurate method of retrospective dosimetry for external gamma exposure. Another important EPR biodosimetry milestone was the completion of four international dose intercomparisions. More than 20 research groups from 14 countries have participated. Most EPR biodosimetry is performed in X-band, which is from 9 to 10 GHz. This band provides a good compromise between sensitivity, sample size, and water content in tooth enamel but requires to have extracted teeth for the dose measurements, making its application for immediate, after-the-fact dosimetry problematic. EPR spectroscopy in other mw bands (both lower and higher than X-band) offers two significant opportunities to overcome this obstacle. The lower frequency of L-band EPR systems (1.2 GHz) makes EPR measurements less perturbed by high water content in a sample and allows in vivo measurements of whole teeth. The higher frequency Q-band (34 GHz) spectrometers require much smaller samples (~2 mg) for the dose measurements which can be obtained by biopsy techniques. Practical utilization of these two opportunities has received a significant development in last years and will be discussed in detail.

Recent studies have also indicated that EPR-based dosimetry in fingernails or toenails can be an effective method for estimating acute exposures in a large number of subjects. Fingernails and toenails contain large amounts of α-keratin and the observed EPR signals appear to be from radiation-induced radicals formed in this component. The use of fingernails and toenails provides an opportunity to measure radiation exposure at four different anatomical sites, complementing the measurements made in teeth.