Comparison Between Deciduous And Permanent Teeth in Relation to their Utility for EPR Dosimetry

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Introduction

Ionizing radiation generates extremly long lived CO_2 radicals in calcified tissue. The CO_2 concentration rises linearly with dose and can be detected directly by means of EPR spectroscopy (electron paramagnetic resonanc).

For retrospective dose estimation tooth enamel and dentine as well as bone samples may be used as in-vivo-dosimeter. Enamel analysis of permanent teeth has been extensivly reported in the literature [1, 5]. But only few investigations were carried out on deciduous teeth giving results which indicate a twofold decrease in dose response compared with permanent teeth [7]. Our objective is to figure out possible differences concerning chemical composition, background signal and dose response in comparison to permanent teeth for the utility of deciduous teeth as reliable detector material.

Differences in chemical composition

The key differences of enamel from deciduous compared to permanent teeth regarding EPR dosimetry are their lower degree of mineralization and slightly higher water content (Table 1).

Preparation

For accurate isolation of the mineral component of enamel and to avoid mechanically-induced radicals [3] the teeth were stored in saturated KOH for two weeks, washed in distilled water and dried at 50°C for 48 hours. Grain sizes of 300 - 500 µm were used. The samples were exposed to doses of 400 mGy, 1 Gy, 2.5 Gy and 5 Gy from a CO 60 γ - rays source.

Measurement Technique

The EPR spectra were recorded at room temperature with a Bruker ER-420-spectrometer equipped with a standard rectangular resonator operating at approximately 9.9 GHz. The experimental parameters were: 100 kHz modulation frequency, 0.3 mT modulation amplitude, 3.2×10^6 gain factor and 10 mW microwave power.

For EPR dosimetry the relevant quantity is the amplitude of the radiogenic signal. For that determination a new measurement and evaluation routine allows a minimization of the standard error at short accumulation times by multiply measurements [4].

At first a standard signal is measured at a fixed microwave-frequency and a lorentzian curve is fitted. The four magnetic field values of the radiogenic and standard signal extremas are calculated from the fit parameters, the resonance equation and the known g-values at this points. A series of these four signal intensities is measured 1000 times in succession with an internal delay of 50 ms. The number of measurement cycles can be chosen. The mean amplitudes of the radiogenic and the standardized signal are recorded together with the corresponding standard errors.

Results and Discussion

The preliminary results of 10 deciduous tooth samples compared to permanent teeth proved no significant differences in dose response after chemical preparation. The linear regression fit using the least squares method shows a slope of 0.363 and a standard deviation of 0.033 for permanent teeth and 0.366 and 0.024 respectivly for deciduous teeth.

Figure 11: **Background in reference point near to spent fuel temporary storage (empty storage)**

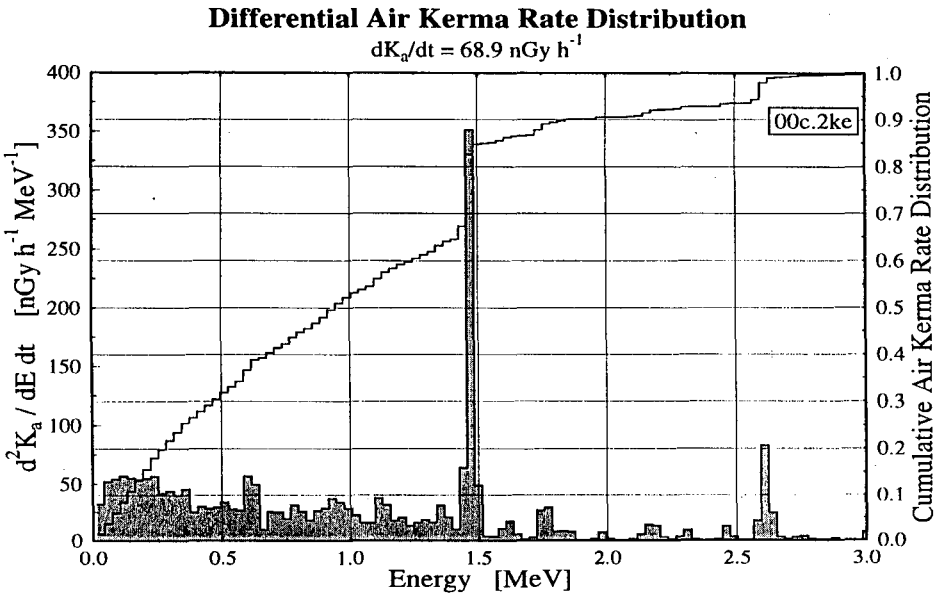
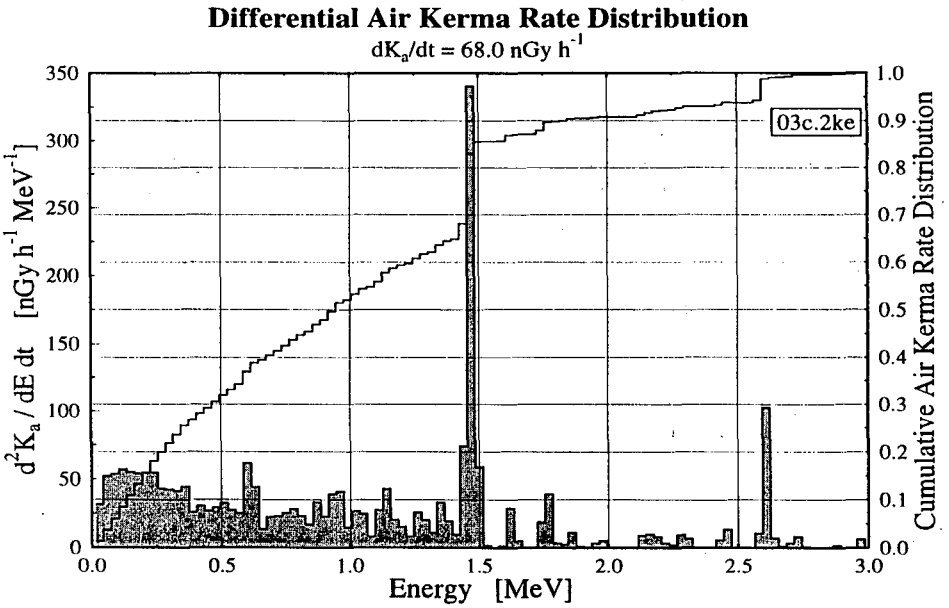


Figure 12: **Background in reference point near to spent fuel temporary storage (with 6 Castor containers)**



For the utility at low doses further unirradiated teeth and their background signals have to be investigated. Especially for this aim using deciduous teeth could be advantagous because of the negligible influence of environmental background dose and the absence of dental X-rays or at least quantitative knowledge thereof. Further work on detection limits, preparation methods and influence of grain sizes is in progress.

References:

1 Aldrich, J.E. and Pass, B., 1988: Determining radiation exposure from nuclear and atomic tests using dental enamel, Health Physics, 54, 469-471

2 Brudevold, F., Söremark, R., 1967: Structural and Chemical Organization of Teeth II, Academic Press

3 Desrosiers, M.F. et al, 1989: Mechanically-induced generation of radicals in tooth enamel, Appl. Radiation Isot., 40, 1195-1197

4 Hormann, V., 1995: Radiogene paramagnetische Zentren in menschlichen Zahnschmelz, master thesis, Bremen

5 Ikeya, M., 1993: New applications of electron spin resonance: Dating, dosimetry and microscopy, World Scientific Publishing , Singapore

6 Mortimer, K.V., 1970: The Relationship of Deciduous Enamel Structure to Dental Disease, Caries Research, 4, 206-223

7 Rodas Duran, J.E. et al, 1985: EPR Dosimetry of Irradiated Human Teeth: ESR Dating and Dosimetry, IONICS, Singapore

Table 1: Chemical composition of enamel of permanent and deciduous teeth in percent dry weight [6,7]

	Permanent teeth / %	Deciduous teeth / %
Mineral	95.4	92.5
ρ Ca	36.8	37.6
ρ P	19.2	17.9
ρ CO_2	2.52	2.47
Organic	0.5 - 2.0	2 - 4
Water	2 - 2.3	2.8

Figure 1: Dose response curves for permanent and deciduous teeth