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Study of influence of mobile phone irradiation to tooth enamel EPR spectra

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The contribution of mobile phones influence on electron spin resonance (EPR) spectra formation and electromagnetic noise signal for accuracy of dose estimation on example of tooth enamel samples measurements was investigated for low dose range. The spectra of irradiated tooth enamel samples in doses from 0 to 500 mGy have been measured. The spectra have been processed by mathematical fitting of model spectrum by least square methods. Standard deviation from nominal doses and uncertainty of dose estimation were determined. The noise level has been estimated in spectra by rest sum after model spectra fitting. Enamel samples were measured in 3 conditions: 1) during day from 9-17 o'clock; 2) during day from 9-17 o'clock with mobile phone. After 17 o'clock and in Saturday and Sunday from 9-17 o'clock (this suppose no any noise signal contributed to spectra). It was shown that the biggest uncertainty of dose estimation have been received in day time with mobile phone in on position. Standart deviation is decrising after 5PM with off mobile phone. Noise level in spectra measured after 5PM was less in comparison with spectra measured in day time.

Keywords: EPR dosimetry, tooth enamel, radiation dose, mobile phones

Introduction

Mobile phones use electromagnetic radiation in the microwave range with frequencies between 300MHz (0.3 GHz) and 300 GHz [1]. In this study Code-division multiple access (CDMA) technology mobile phone was used. This uses a digital modulation called spread spectrum which spreads the voice data over a very wide channel in pseudorandom fashion using a user or cell specific pseudo-random code [2].

This research objective is estimation of mobile phone influence to impurity of Electron paramagnetic resonance (EPR) spectra and to sensitivity of the spectrometer. The EPR waveband is stipulated by the frequency or wavelength of a spectrometer's microwave source. EPR experiments often are conducted at X band with microwave frequency of 10 GHz. The factor that determines the sensitivity of a spectrometer is the signal-to-noise ratio. From the literature [3] there is several type of noise signal such as detector noise, klystron noise, amplifier noise and so on, and in this study radiation induced signal (RIS) (standard deviation), background signal and residual sum. These three parameters are responsible for quality of EPR spectra and for sensitivity of spectrometer, which is proportional to the ratio of the signal amplitude to the noise amplitude on the recorder. Also this parameters have been investigated during day time and evening time with and without mobile phone. Mobile phone have positioned near resonator of EPR spectrometer.

Materials and methods

Tooth enamel powder prepared from different teeth was pooled together and split into aliquots of 100 mg. The resulting eight aliquots were irradiated to doses of 0, 100, 200, 300, 500 and 1000 mGy, respectively, from a collimated ^{60}Co source at Hiroshima University [4-7]. The standard uncertainty of the radiation dose is estimated as 3%.

The EPR measurements were carried out at least ten days after irradiation and sample preparation, so that all transient radiation- and mechanical-induced signals have faded out or come to an equilibrium state [8]. All measurements were performed at stabilized room temperature of 21 ^{o}C using an X-band EPR spectrometer JEOL JES-FA100 equipped with a high Q-factor cylindrical TE011 cavity model ES-UCX2, and keeping the spectrum recording parameters similar as previously published [9, 10].

Specially designed computer software [11-13] was used for extraction of the radiation-induced signal (RIS) from the total EPR spectrum and determination of its intensity (or peak-to-peak amplitude). The EPR spectrum of irradiated enamel was divided in the RIS and the background signal (BGS) by applying non-linear least square fitting of the model spectrum describing RIS and BGS in analytical form. The spectrum processing procedure has been applied with description of the BGS by asymmetric narrow component and wide component composed of superposition of Gaussian derivative functions. A fitting window of 3.0 mT width was used, for all the enamel spectra (the left border of the fitting window was -1.0 mT and the right border +2.0 mT relative to the maximum of the BGS) [14-17].

Results and discussion

The spectra of ten samples irradiated in nominal doses of 0, 100, 200, 300 and 500 mGy in pairs were recorded at different time and with and without mobile phone: 1) during day from 9-17 o'clock; 2) during day from 9-17 o'clock with mobile phone. After 17 o'clock and in Saturday and Sunday from 9-17 o'clock (this suppose no any noise signal contributed to spectra). These choices were agreed upon different condition and noise influence during day time and after 17 o'clock, Saturday and Sunday (when load is decreasing). In the figure 1 location of mobile phone on the table are shown. This location can be explaining as usual position during using EPR spectrometer by operator.

As it was mentioned above for study of influence of mobile phone to EPR signal in this study radiation induced signal (RIS) (standard deviation (SD)), background signal and residual sum will be estimated. These parameters were obtained for single measurement and for average of four repeated measurements. In the figure 2 background signal from enamel samples are shown for different time of measurement with and without mobile phone. From this figure for single measurement (figure 2a) lowest background signal was detected after 17 o'clock

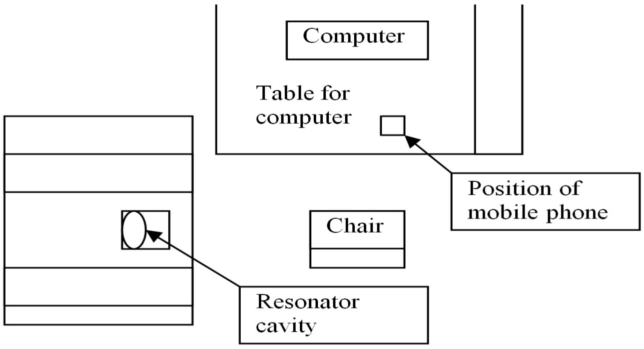

Figure 1. The scheme of position of mobile phone on the desk.

spectra, for day time measurement and for measurements with mobile phone signal almost same and only for 500 mGy dose with mobile phone background signal is higher. For average of four repeated spectra (figure 2b) measurements lower signal was detected for all points (except 300 mGy dose) for measurements after 17 o'clock. Higher background signal for all points with mobile phone measurements (except 100 mGy).

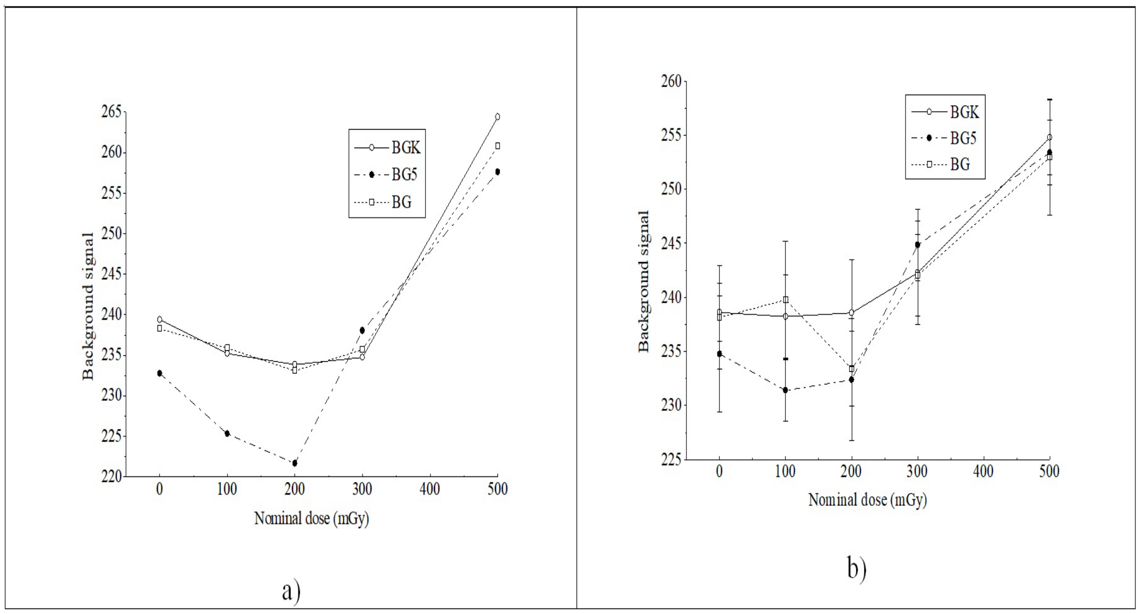

Figure 2. Dependence of background signal from nominal dose (a-for single spectra measurements; b-for average of four repeated spectra measurements; BGK-background signal for measurements conditions with mobile phone; BG5-background signal for measurements conditions after 17 o'clock without mobile phone; BG-background signal for measurements conditions from 9 to 17 o'clock without mobile phone).

Quality of spectra fitting at spectra processing is characterized by the residual signal, derivable by subtraction of the model spectrum from the experimental one. Intensity of this signal is characterized by the rest sum, which is derived from mean-square amplitude of the residual signal. The rest sum numerically characterizes noises in the residual signal and also caused by incomplete correspondence of the model to the experimental spectrum. Dependencies of the rest sum on the accumulation time measured at different dose are shown in figure 3. For single spectra measurements (figure 3a) and for average of four repeated spectra measurements it is impossible strongly to say about high mobile phone influence, because some results for measurements with mobile phone higher than results during day time measurements without mobile phone. And only measurements after 17 o'clock leads to decrease of noise signal.

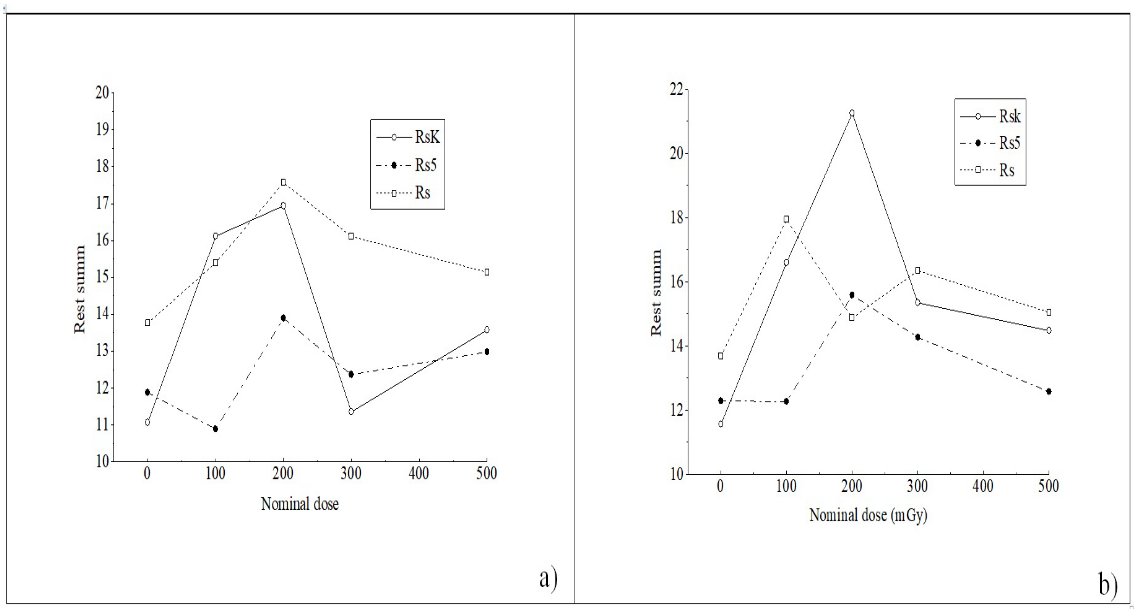

Figure 3. Dependence of rest sum from nominal dose?(a-for single spectra measurements; b-for average of four repeated spectra measurements; RsK-residual signal for measurements conditions with mobile phone; Rs5-residual signal for measurements conditions after 17 o'clock without mobile phone; Rs-residual signal for measurements conditions from 9 to 17 o'clock without mobile phone).

In order to find out the influence to RIS for single spectra measurements (figure 4) and RIS for four repeated spectra measurements (figure 5), the estimation of standard deviation (SD) for measurement conditions after 17 o'clock without mobile phone (figure 4a, 5a); for measurement conditions from 9 to 17 o'clock without mobile phone (figure 4b, 5b); for measurements conditions with mobile phone (figure 4c, 5c). From these figures SD for measurements with mobile phone are higher than measurements without mobile phone and after 17 o'clock.

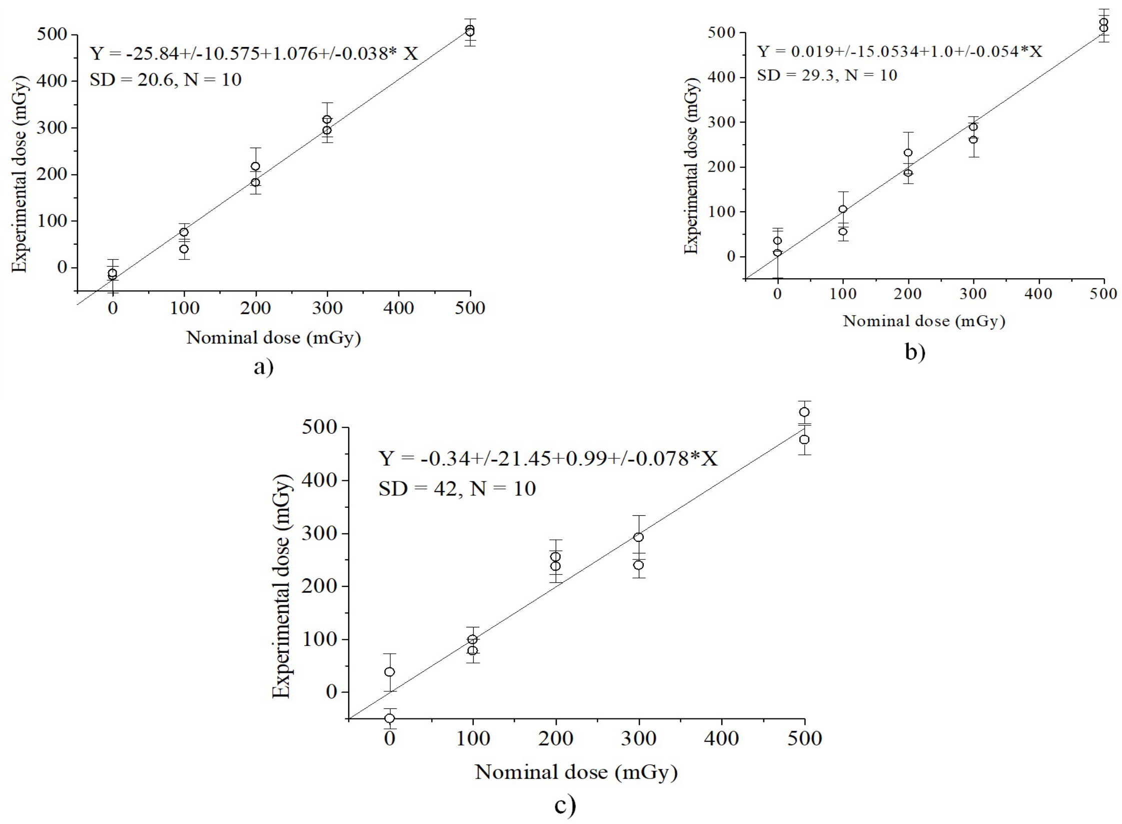

Figure 4. Dependence of Experimental dose from nominal dose for single spectrum measurement (a) - for measurement conditions after 17 o'clock without mobile phone; b)-for measurement conditions from 9 to 17 o'clock without mobile phone; c)-for measurements conditions with mobile phone).

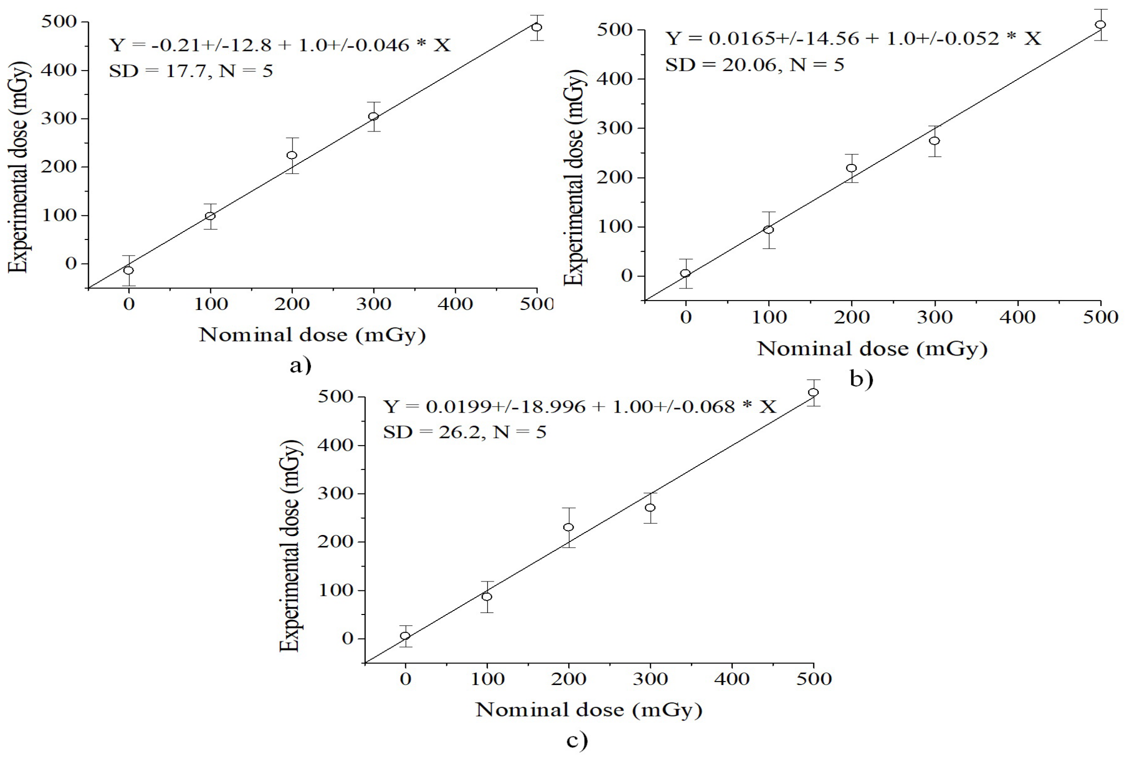

Figure 5. Dependence of Experimental dose from nominal dose for four repeated spectra measurements (a)- for measurement conditions after 17 o'clock without mobile phone; b)-for measurement conditions from 9 to 17 o'clock without mobile phone; c)-for measurements conditions with mobile phone).

Conclusion

The analysis of influences on conditions of EPR measurements for spectrometer JEOL-FA100 has shown that there are several sources affected on quality of EPR spectra and quality of final results as well. The interference of different factors has showed in this investigation. The differences of results are subjected to reduction of noise effects in evening time and it is necessary to take into account for spectra processing procedure.

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