Effect of Long Term 900 MHz Radiofrequency Radiation on Enamel Microhardness of Rat's Teeth

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Abstract

Purpose: Oral tissues are important parts of body that absorbs radiation emitted from mobile phones which is the most popular technological equipment in the world. Because of the limited studies in this field, we aimed to investigate the effect of Radio Frequency (RF) radiation emitted from 900 MHz mobile phones on the enamel micro hardness of rat teeth.

Materials and Methods: The study was carried out on twenty one Wistar Albino adult male rats which were divided into two groups such as control and experiment groups. For the study group (n: 14), rats exposed to the radiation 2 h per day (7 days in a week) for 10 months. For the control group (n: 7), rats were placed into the carousel and the same procedure was applied except that the generator was turned off. At the end of the study, enamel micro hardness of rat's teeth was measured.

Results: The results of this study showed that 900 MHz RF radiation did not alter the enamel micro hardness of rats' teeth ($p>0.05$).

Conclusions: Exposure of 900 MHz RF radiation for 2 hours per day during ten months does not alter enamel micro hardness of rats' teeth. However, further studies are necessary to clarify this topic.

Key Words: Mobile phone, Enamel, Micro hardness, Rat teeth, Radiation

Introduction

Numbers of sources emitted electromagnetic fields especially radiofrequencies are growing rapidly in the world we live today. Radio Frequency (RF) radiation may affect human body by a RF-specific non-thermal action, a thermal action or by a combination of these mechanisms [1]. One of the important areas of radiofrequencies using is wireless communication and one of the most popular using of wireless technologies is mobile phones which are at non-thermal power density levels of RF. Over the past two decades, mobile telecommunication system has been widely used all over the world. Because of too much and intensive using of mobile phones public awareness of the ubiquitous nature of these fields and the growing controversy over their potential effects on living systems have stimulated the research community to define more precisely the physical properties of these fields and to delineate the thresholds for their possible effects on human health and environment [2,3]. However, the WHO/International Agency for Research on Cancer (World Health Organization/IARC) has classified radiofrequency electromagnetic fields as possibly carcinogenic to humans (Group 2B), based on an increased risk for glioma, a malignant type of brain cancer, associated with wireless phone use [4].

The studies on mobile phone exposure and health have been mostly focused on the effects of radiofrequencies on brain [5-7] and reproductive organs [8-11]. However, irradiated organ is not only brain during exposure by mobile phones. One of the important parts of body that absorbs radiation emitted from mobile phones is oral tissue.

Since mobile phone users and also scientists usually do not pay attention to the effect of mobile phone exposure on the oral tissues, the studies related to mobile phone exposure on oral tissues are very limited. For instance, Kaya et al. found that long term radiofrequency exposure emitted from 900 MHz mobile phones affect periodontal tissues [12]. However, Yavuz et al indicated that electromagnetic fields alter some mineral and trace element levels in rat's teeth [3]. Likewise, Adiguzel et al exposed rat heads to long term 900 MHz mobile phone exposure and showed that GSM (Global System for Mobile Communication) -Modulated 900 MHz radiofrequency radiation can be a factor to alter the teeth trace elements' densities [13]. Although it was also suggested 500 μT level of magnetic field strengths may have a certain negative effect on enamel mineralization [14], the studies related to the effect of short or long term mobile phone exposure on teeth biomechanics such as micro hardness still is not existed.

Because of the limited number of studies related to the effects of mobile phone exposure on oral tissues and observed alteration in teeth, more performance is necessary to understand the effects of radiofrequencies on teeth. Therefore, the purpose of this study was to investigate the effect of long term 900 MHz radiofrequency radiation emitted from mobile phones on enamel micro hardness of rat teeth.

Materials and Methods

Subjects and animal care

All animal procedures were in agreement with the Principles of Laboratory Animal Care and the rules of Scientific and Ethics Committee of Dicle University Health Research Center. Twenty one Wistar Albino adult male rats with initial average weight of 267 ± 15g were obtained from the Medical Science Application and Research Center of Dicle University

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(Diyarbakır, Turkey), caged individually and fed with standard pellet food and water. Final average weight of the animals was 363 ± 18g. They were randomly separated into two groups – control (n = 7) and experiment (n = 14) groups and kept on a 14/10 hour light/dark schedule. During the study, the ambient temperature (22°C) and relative humidity (45%) were maintained in the normal range for these animals.

Exposure and measurement of radiation

A generator (GSM Simulator 900PM10 type Everest Comp., Adapazarı, Turkey) which produces 900 MHz band radiofrequency waveform was used in this study to represent the exposure of a typical mobile phone. For the generator used in this study, the carrier frequency was 890–915 MHz, the modulation frequency was 217 Hz and the peak power was 2W. The rats were confined in a Plexiglas carousel, and rat heads in the carousel were exposed to 900 MHz RF exposure emitted from the generator. Experimental setup is illustrated in *Figure 1*. For the experiment group, rats were exposed to RF radiation 2 hours per day for 10 months. For the control group, the rats were placed in the carousel and the same procedure was applied to the rats (2 hours/day/for 10 months), meanwhile, the generator was turned off, i.e. no RF signal was present. Both experiment and control group treatment performed at the same time simultaneously (between 10am-12pm).

Antenna of the generator was placed at the center of a Plexiglas carousel to provide ideal exposure. Distance between antenna and the teeth of the rats was 1 cm. Power Density inside Plexiglas carousel cages was measured by EMR 300 (NARDA, Pfullingen, Germany). Immediately after the last exposure, teeth of the animals were extracted under ketamine anesthesia (Ketalar) (100 mg/kg ketamine hydrochloride, intramuscularly) and kept in sterile saline to measure the micro hardness of enamel surface.

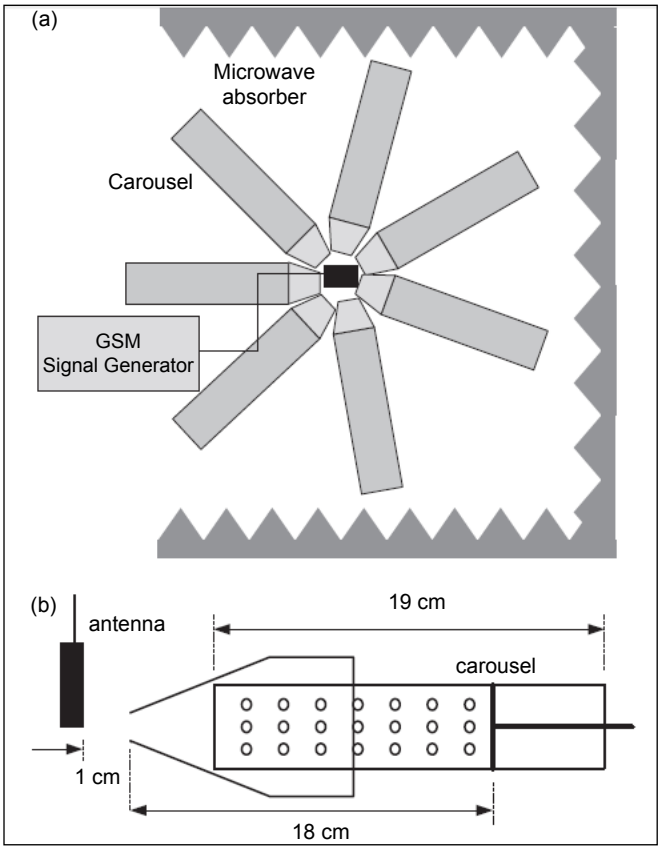

Figure 1. *Experimental setup, (a) top view, (b) side view for one carousel (Tas et al. 2013).*

Specific Absorption Rate (SAR) measurements

In our experimental setup, the electromagnetic field values were measured with an Electric-field probe, while the transmitter was operating, then, these measured values used in the electromagnetic field solver to find the field distribution inside the rat. Simulations were performed using CST Microwave Studio, an electromagnetic field solver based on Finite Integration Technique (FIT). FIT is similar to a Finite Difference Time Domain (FDTD) technique, but it employs discretization on general non-orthogonal grids using integral form of Maxwell's equations rather than differential forms. Charge and energy conservation inherit to Maxwell's equations are preserved with FIT, which leads to very stable numerical results in time-domain. The Voxel (volumetric pixel) rat model, which was formed using computerized tomography, scans of a rat was used in the electromagnetic field simulations. The simulation model consists of electric field distribution inside and around the rat. Simulated field values were consistent with measured electric field data which were obtained with field probe. In SAR calculations, the simulation model consists of electric field distribution inside and around the rat which was 320g weight that corresponds to average weight in the experiment group.

Preparation of specimens for micro hardness testing

A total of 20 incisive rat teeth were used in the analysis; 10 were obtained from control group and 10 were from experiment group. They were individually embedded in acrylic resin (Imicryl, Konya, Turkey) and only the enamel of buccal surfaces was prepared for micro hardness measurements.

The superficial enamel surface of each tooth was flattened and polished with water cooled carborundum discs 1200 grit silicon carbide paper (Buehler Ltd, Lake Bluff, IL, USA), thereby removing about 200 mμ enamel.

Surface micro hardness

Digital Micro-Vickers Hardness Tester (Wilson Wolpert 401 MVD, MA, USA) fitted with a Vickers diamond and a 200N load was used to make indentations in the enamel surface [15]. Five indentations spaced by 100 μm from each other were performed on each tooth surface (3-5 mm). The loaded diamond was allowed to rest on the surface for 15 s.

Statistical analysis

The mean value of five measurements and standard deviations were used to compare the results of control and experiment groups. All analysis was performed by using SPSS 16.0 statistical software (SPSS Inc., Chicago, IL, USA). Mann-Whitney U test was used to analyze the surface micro hardness of rats' teeth in control and experiment groups. Differences were considered statistically significant when calculated p values were less than 0.05.

Results

Whole body (rms) and whole body maximum point SAR were found as 0.0369 (W/kg) and 2.023 W/kg), respectively. Mean micro hardness of teeth in the experiment group [45.5 ± 16.2 VHN (Vickers Hardness Number)**]** was found lower than the control group (49.8 ± 14.4 VHN) and shown in *Figure 2*. The difference between control and experiment groups was

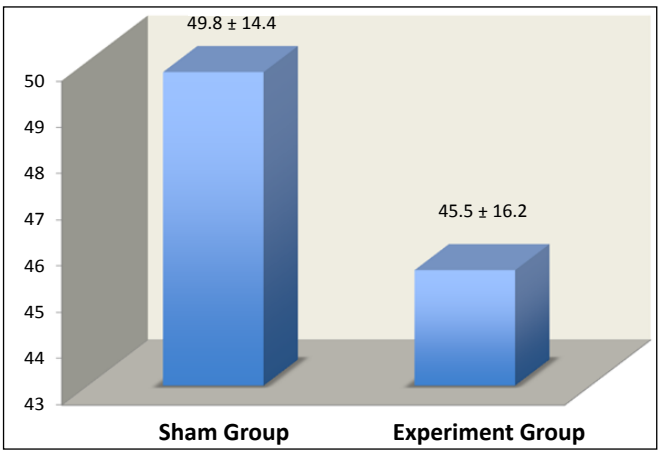

***Figure 2**. Mean microhardness values of sham and experiment groups (there was no statistically significant differences p>0.05).*

not found statistically significant (p>0.05). According to the result of this study, it can be stated that 900 MHz RF radiation did not alter micro hardness of rats' micro hardness of teeth.

Discussion

In the present study the effect of 900 MHz Radio Frequency (RF) radiation emitted from GSM-Modulated mobile phones on the enamel micro hardness of rat teeth was determined and the results showed that long term exposure of 900 MHz radiofrequencies may decrease the enamel micro hardness of rats' teeth. However, the results between experiment and control groups were not found statistically significant (p>0.05)

Enamel is the hardest and most highly mineralized substance of the body which contains inorganic and organic materials and water [16]. Minerals made up of its 96% by weight and the mineral changes in surface layers of enamel are directly related to micro hardness alterations, i.e. remineralization of enamel carious lesions is associated with an increase of enamel surface micro hardness [17].

There are several methods for the measurement of surface alterations of dental enamel, some of them are quantitative. Micro hardness testing permits the measurement of the degree of softening of the surface, since dental enamel can be softened (altering its microhardness) in association with dental wear and/or dental caries [15,18].

The trace elements in teeth also play an important role for dental health since their concentrations are correlated with the presence of dental caries [19-21]. Additionally it was showed that the trace elements of enamel (Ca, Mg, P, Zn) were affected by GSM-Modulated 900 MHz RF radiation and the differences were distinct, especially for Mg and Zn; while the content of Mg trace element decreased, Zn content increased significantly [13]. Hence, they suggested that these chemical alterations may cause different effects such as high caries risk in teeth. Kargul et al. also showed a progressive decrease in the surface hardness of the 100 μT and 500 μT exposure groups and it was suggested the decrease may stem from the alterations of mineral contents of rats' teeth exposed to Extremely Low Frequency Magnetic Field (ELF-MF) [14].

In the previous study, it might be concluded that the contents of some major and trace elements differed significantly in rat's teeth and there was a positive evidence supported the hypothesis that GSM-Modulated 900 MHz radiofrequency radiation was related with changes in these trace elements' amounts but, this was not enough to prove the possibility that GSM-Modulated 900 MHz radiofrequency radiation plays an important etiological role in mineralization [3]. However, there are some studies have been reported that environmental effects such as GSM-Modulated 900 MHz radiofrequency radiation may affect health status in accordance with the altered physiological conditions [22,23]. However, it is stated that small changes of the enamel are reflected in variations of hardness and also it is clinically well known that, the softening of enamel is one of the major criteria used for the identification of carious lesions.

This study is a preliminary study to clarify the effects of 900 MHz RF radiation on the micro hardness of teeth. The results of this study showed that modulated 900 MHz RF radiation decreased micro hardness of rat's teeth. However, difference of micro hardness between exposed and control rats' teeth were not found statistically significant (p>0.05).

For this reason, further studies are needed to reveal the effects of environmental factors on health status and oral tissues more clearly and particular attention should be focused on the teeth of mobile phone users.

Conclusions

The effect of 900 MHz Radio Frequency (RF) radiation emitted from GSM-Modulated mobile phones on the enamel micro hardness of rat teeth was determined. However, the results between experiment and control groups were not found statistically significant (p>0.05).

It can be concluded that long term GSM-Modulated 900 MHz RF radiation may play a role to alter enamel mineralization because of the statistically insignificant decrease observed this study. Therefore results showed that long term exposure of 900 MHz radiofrequencies may decrease the enamel micro hardness of rats' teeth so further studies should be focused on longer exposure duration to clarify this topic.

Declaration of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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