Original Article

# Occupational exposure of dentists to electromagnetic fields produced by magnetostrictive cavitrons alters the serum cortisol level

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## Abstract

**Objectives**: Some studies indicate that dentistry is one of the job categories with high potential exposure to elevated levels of extremely low frequency magnetic fields. In spite of this, information on occupational exposure of dentists to these fields is scarce. Studies on other common sources of electromagnetic fields (EMFs) such as mobile base stations have shown alterations in the cortisol level following exposure of humans to these sources. The aim of this study is to compare the level of cortisol among dentists and dentistry students who are being occupationally exposed to EMFs emitted by magnetostrictive cavitrons (case group) and among their counterparts who are not being exposed to these fields (control group). **Materials and Methods**: In this case–control study, blood samples were collected from 41 dentists and dentistry students, 21 of whom were exposed to EMFs emitted by cavitrons as the case group and 20 who were not exposed as the control group, twice; i.e. before work (at 8:30–9:30 a.m.) and after work (11:30–12:30 a.m.). The samples were coded and the serum cortisol level was investigated using the ELISA method (Cortisol AccuBind ELISA Kits). **Results**: The serum cortisol level of dentists and dental students in the morning (before starting the work) in the control group was 189.15 ± 110.70 (mean ± SD) whereas it was 157.77 ± 112.03 in those who were occupationally exposed to EMFs produced by the use of cavitrons. This difference was not statistically significant ($P$ = 0.373). In contrast, the serum cortisol level of the participants in the noon (after stopping the work) in the control group was 136.25 ± 67.91 (mean ± SD) while it was 88.58 ± 52.83 in those who were occupationally exposed to EMFs produced by the use of cavitrons. This time, the observed difference was statistically significant ($P$ = 0.016). In this light, while the difference between serum cortisol levels of dentists and dental students in the morning and after stopping the work was not statistically significant ($P$ = 0.06), in the EMF-exposed group the cortisol level decreased significantly from 157.77 ± 112.03 in the morning to 88.58 ± 52.83 in the noon ($P$ = 0.001). **Conclusions**: As far as we know, this is the first study that evaluated the effect of occupational exposure of dentists to EMFs on their serum cortisol level. The EMFs produced by magnetostrictive cavitrons can decrease the serum cortisol level in dentists. As cortisol plays an important role in blood pressure regulation, cardiovascular, and immune system function, a low cortisol level may threaten health. More studies are needed to clearly understand the effects of EMFs emitted by magnetostrictive cavitron on the level of stress hormones. As some studies have shown that exposure to EMFs has no effect on the cortisol level, whereas other studies reported either an increase or a decrease in the cortisol level, it can be concluded that the effects of exposure to EMFs may occur only at specific absorbed energies or energy absorption rates (usually known as window) similar to that exists in the case of exposure to the low doses of ionizing radiations.

**Key words:** Cortisol, cavitrons, dentists, dentistry nurses, electromagnetic fields

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## INTRODUCTION

Electromagnetic fields (EMFs) are caused by electrical currents. Common household current is alternating current (AC), going through 50 or 60 reversal cycles each second. These reversal cycles create electric and magnetic fields at the same frequency. Overhead power lines are commonly used for power transmission. The fields created by power

lines are power frequency fields. EMFs have different intensities and are produced continuously or brief in duration.

Scaling is a term used for removal of plaque and calculus and scalers or cavitrons are dental devices used to remove calculus and plaque from the exposed supragingival surface. In fact, ultrasonic scalers are electronic generators that transmit high-frequency vibrations from 25 to 40 kHz to a hand piece that is used to remove deposits from the surface of a tooth. Magnetostrictive ultrasonic scalers and piezo scalers are among the main types of cavitrons.

Magnetostrictive materials have long been used for the production of ultrasonic frequency vibrations. Laminated nickel-based ultrasonic dental-scalers are among the main uses. In magnetostrictive ultrasonic scalers, which are common in the United States, a magnetostrictive transducer is used to convert electrical energy to mechanical energy at varying frequencies. On the other hand, in Europe and Asia, piezo ultrasonic scalers are popular which produce vibrations by oscillations of a quartz (piezoelectric) crystal in the hand piece. A major advantage of magnetostrictive ultrasonic scaler is that in most types, tips are interchangeable, while in piezo ultrasonic scalers, tips are typically manufacturer-specific. However, magnetostrictive ultrasonic scalers produce more intense magnetic fields.

Regarding the endocrine system, the bioeffects of EMFs on pineal gland, [1, 2] pituitary gland,[3-5] adrenal gland,[3] and thyroid gland[6-9] as well as of the endocrine pancreas,[10] testicles[11-14] and ovaries[4, 15] to EMFs have been investigated. Cortisol is among the most important hormones which are related to blood pressure regulation, metabolism, immune system and stimulatory and inflammatory reactions. Cortisol, a steroid hormone that is secreted by the cortex of the adrenal glands, is normally released in response to events and circumstances such as fasting,[16] food intake,[17-19] exercising,[20, 21] awakening,[22] and psychosocial stressors[23] which cause the body to release cortisol. Due to wide and systemic effects of cortisol, it plays important roles in controlling the vital processes and preserving the homeostasis. The secretion of cortisol is in a highly irregular manner, with peak secretion levels in the early morning. Cortisol also has a critical role in energy regulation and mobilization[24] by choosing the appropriate type and quantity of carbohydrate, fat or protein that body needs. In addition, cortisol has a significant role in the regulation of the immune system. A low cortisol level may lead to allergic reaction to an individual's external environment, as well as an allergic reaction to one's own body. Decreased cortisol levels are usually associated with the activation of certain autoimmune conditions such as rheumatoid arthritis,[25] Sjogren's syndrome,[26] or lupus.[26] The immune system with this response increases the susceptibility of each individual to infections.

We have previously studied the health effects of the exposure of humans to common EMF sources.[27, 28] Some studies indicate that dentistry is among job categories with high potential exposure to elevated levels of extremely low frequency magnetic fields.[29] In spite of this, information on occupational exposure of dentists to these fields is scarce.[29] Studies on other common sources of EMFs such as mobile base stations have shown alterations in the cortisol level following exposure of humans to these sources.[30, 31]

There is only one published paper that reports the effect of occupational exposure to EMFs on the cortisol level in humans.[32] Considering the lack of data on the bio-effects of EMFs on the cortisol level in humans, the aim of this study was to assess the potential alterations of this hormone after occupational exposure to EMFs produced by magnetostrictive dental scalers. As far as we know, this is the first study that evaluated the effect of occupational exposure of dentists to EMFs on their serum cortisol level.

## MATERIALS AND METHODS

This case–control study was conducted in the school of dentistry of Rafsanjan University of Medical Sciences. Prior to study initiation, the protocol was reviewed and approved by the University Medical Ethics Committee for the Protection of Human Subjects. Participants comprised a convenience sample of 18 dentists and 23 dentistry students; 29 females and 12 males, right-handed, apparently healthy individuals. Age of participants ranged from 20 to 41 (20 to 26 for students and 31 to 41 for dentists). Participants were selected by distributing an invitational letter to second-to-sixth year dentistry students and the faculty members. To assess if interested participants met the inclusion and exclusion criteria of the study, a preliminary screening questionnaire including questions about the health status of the participants and their exposures to common sources of EMFs was completed. Any major health problem or extraordinary exposure to EMF excluded participants from the study. Qualified participants were invited to take part and were given an informed consent form indicating the purpose of the study and its procedures, possible risks, and benefits. Assignment of the participants to either case or control groups was based on random selection. Blood samples were collected from all participants, 21 of whom were exposed to EMFs emitted by cavitrons as the case group and 20 who were

not exposed as the control group, twice; i.e. before work (at 8:30 to 9:30 a.m.) and after work (11:30 to 12:30 a.m.). The samples were coded to avoid any experimenter's bias and the serum cortisol level was investigated using the ELISA method. Blood pressure was measured in all participants and their rest ECG was recorded. Statistical analysis was performed using SPSS 17.0 for Windows.

## RESULTS

The average daily EMF exposure per subject in the occupationally exposed group was 1.21 ± 0.47 (mean ± SD) hours. The serum cortisol level of dentists and dental students in the morning (before starting the work) in the control group was 189.15 ± 110.70 (mean ± SD) nmol/l while it was 157.77 ± 112.03 nmol/l in those who were occupationally exposed to EMFs produced by the use of cavitrons. This difference was not statistically significant ($P$ = 0.373). In contrast, the serum cortisol level of the participants in the noon (after stopping the work) in the control group was 136.25 ± 67.91 (mean ± SD) nmol/l while it was 88.58 ± 52.83 nmol/l in those who were occupationally exposed to EMFs produced by the use of cavitrons. This time, the observed difference was statistically significant ($P$ = 0.016).

In this light, while the difference between serum cortisol levels of dentists and dental students in the morning and after stopping the work, was not statistically significant ($P$ = 0.06), in the EMF-exposed group the cortisol level decreased significantly from 157.77 ± 112.03 nmol/l in the morning to 88.58 ± 52.83 nmol/l in the noon ($P$ = 0.001). These results are summarized in Table 1.

## DISCUSSION

The findings of this study show that EMFs produced by magnetostrictive cavitrons can decrease the serum cortisol level in dentists. The serum cortisol level of dentists and dental students was decreased from 189.15 ± 110.70 (mean ± SD) in the morning (before starting the work) to 136.25 ± 67.91 after stopping the work. This difference was not statistically significant ($P$ = 0.06). On the other hand, in the EMF-exposed group the cortisol level decreased from 157.77 ± 112.03 in the morning to 88.58 ± 52.83 in the noon. In this group the observed difference was statistically significant ($P$ = 0.001), indicating the role of EMFs emitted by magnetostrictive cavitrons on the level of cortisol as stress hormones. As cortisol plays an important role in blood pressure regulation and cardiovascular function, a low cortisol level may cause hypertension and cardiac *dysrhythmia* in stressful situations.

Our results are in line with the findings obtained in a study that as was stated before it is the only published paper that reports the effect of occupational exposure to EMFs on the cortisol level in humans.[32] In this study, the effect of electromagnetic radiation (EMR) on the excretion rates of stress hormones of medical staff in physiotherapy was investigated. Based on the findings of this study, physiotherapists showed significantly increased levels of releasing cortisol, adrenaline, and noradrenaline compared to that of the control group (nurses).

Moving to non-occupational exposures, our results are also in line with the findings obtained in an old study by Mann *et al*., who studied effects on the nocturnal profiles of cortisol, growth hormone (GH), and *luteinizing hormone* (*LH*), as well as melatonin in 22 male subjects.[33] They reported no significant effects on GH or LH levels, but there was a slight, transient elevation of cortisol levels immediately after the onset of RF exposure, suggesting a transient activation of the pituitary adrenal axis.

However, the findings of our study are in contrast with the findings of Braune *et al*. who investigated RF effects on serum levels of cortisol, epinephrine, and norepinephrine in 40 young male subjects in a single blind, randomized crossover study.[34] In this study, a randomized order of exposure to a GSM 900 signal produced over the right side of the head and sham exposures was used. They could not show any effects of RF exposure on the cortisol level. Our results are also in contrast with the findings of Radon *et al*. who investigated the effect of GSM 900 signal on salivary melatonin and cortisol.[35] The radiofrequency signal was emitted by an antenna located 10 cm behind the head of each participant. In double blind trials, each subject underwent a total of 20 randomly allotted 4-h periods of exposure and sham exposure over a 5-month period and saliva samples were taken at regular times on the day of treatment and on wakening the following morning. There

**Table 1: Serum cortisol levels in dentists and dentistry students before and after work**

| Groups | Control individuals, cortisol level (nmol/l) | | Occupationally exposed individuals, cortisol level (nmol/l) | | Significance (independent t-test) |
|---|---|---|---|---|---|
| Status of measurement | Before work | After work | Before work | After work | Between befores, NS ($P$ = 0.373) |
| | 189.15 ± 110.70 | 136.25 ± 67.91 | 157.77 ± 127.76 | 88.58 ± 52.83 | |
| Significance (paired *t*-test) | NS ($P$ = 0.06) | | $P$= 0.001 | | Between afters, $P$ = 0.016 |

NS: Not Significant.

were unable of showing any significant difference in salivary cortisol concentrations between the exposed and sham exposed conditions.

Our data are also in contrast with the findings of a more recent study conducted in France in 2008. Djeridane *et al*. investigated the effect of exposure to 900 MHz GSM radiofrequency radiation on cortisol, testosterone, thyroid-stimulating hormone, growth hormone, prolactin, and adrenocorticotropin levels in 20 healthy male volunteers.[31] All participants were exposed to RF EMFs by using a mobile phone for 2 h/day, 5 days/week, for 4 weeks. They reported that for cortisol, there was a significant decrease of 12%, in the maximum levels when comparing the 2-week exposure periods to the pre-exposure period, but no difference persisted in the postexposure period. Altogether, they concluded that the 900 MHz EMF exposure does not alter the endocrine functions in men.

As the pattern of exposure to EMFs in the above-mentioned nonoccupational studies is quite different with our study, it is not possible to clearly find the origin of the observed differences. More studies are needed to clearly understand the effects of occupational and nonoccupational exposures to EMF on the cortisol level. As some studies have shown that exposure to EMF has no effect on the cortisol level, whereas other studies reported either an increase or a decrease in the cortisol level, it can be concluded that the effects of exposure to EMFs may occur only at specific absorbed energies or energy absorption rates (usually known as window).

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