Original Article

Effect of electromagnetic radiations from mobile phone base stations on general health and salivary function

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Abstract

Objective: Cell phones use electromagnetic, nonionizing radiations in the microwave range, which some believe may be harmful to human health. The present study aimed to determine the effect of electromagnetic radiations (EMRs) on unstimulated/stimulated salivary flow rate and other health-related problems between the general populations residing in proximity to and far away from mobile phone base stations. **Materials and Methods:** A total of four mobile base stations were randomly selected from four zones of Jaipur, Rajasthan, India. Twenty individuals who were residing in proximity to the selected mobile phone towers were taken as the case group and the other 20 individuals (control group) who were living nearly 1 km away in the periphery were selected for salivary analysis. Questions related to sleep disturbances were measured using Pittsburgh Sleep Quality Index (PSQI) and other health problems were included in the questionnaire. Chi-square test was used for statistical analysis. **Results:** It was unveiled that a majority of the subjects who were residing near the mobile base station complained of sleep disturbances, headache, dizziness, irritability, concentration difficulties, and hypertension. A majority of the study subjects had significantly lesser stimulated salivary secretion ($P < 0.01$) as compared to the control subjects. **Conclusions:** The effects of prolonged exposure to EMRs from mobile phone base stations on the health and well-being of the general population cannot be ruled out. Further studies are warranted to evaluate the effect of electromagnetic fields (EMFs) on general health and more specifically on oral health.

Key words: *Base station, electromagnetic radiations, mobile phones, saliva, salivary glands*

INTRODUCTION

The effect of cell phone radiation on human health is the subject of recent interest and studies as a result of the enormous increase in cell phone usage throughout the world. This increased use has raised public concerns and substantial controversy about the potential health effects of the radiofrequency electromagnetic

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field (EMF) emissions of this technology.[1,2] Limited space availability and the lack of strict invigilation by regulatory authorities and local municipal corporations have led to the mounting of mobile towers on residential and office buildings. The World Health Organization (WHO) has recently recommended investigating the effects of exposure to electromagnetic radiations (EMRs) from mobile phone base stations to address public concerns.[3] One well-understood effect of microwave radiation is dielectric heating, in which any dielectric material (such as living tissue) is heated by rotations of polar molecules induced by the EMF. Studies indicate that the population residing near mobile phone base stations complain of nonspecific symptoms of ill-health such as headache and sleep disturbances. Premature cataracts have not been linked with cell phone use, possibly because of the lower power output of cell phones.[4,5] The radiofrequency EMFs from base station leads to impaired cognitive functions including ill effects on general as well as oral health. Saliva modulates the ecosystem within the oral cavity, thus playing a crucial role in maintenance of oral homeostasis.[6] The other functions include lubrication of the bolus, protection and repair of the oral mucosa, buffer capacity, and dental remineralization.[7,8] The quantitative or qualitative alterations in salivary secretion may lead to caries, oral mucositis, candidiasis, oral infections, dysphagia, and halitosis.[9,10] The buffer capacity of saliva depends on bicarbonate concentration.[11] Decreased salivary flow rate tends to increase the risk of caries development.[12]

We have hypothesized that the exposure to biomagnetic radiations from mobile phone base stations could result in intriguing general health problems and salivary gland function. Thus, the objective of our study was to determine the effect of EMRs on unstimulated/stimulated salivary flow rate and other health-related problems in the general population.

MATERIALS AND METHODS

Before conducting the study, ethical approval was obtained from the Institutional Research Review Board of Jaipur Dental College. The present cross-sectional study was conducted at Jaipur, Rajasthan, India between January 2013 and May 2013, The city of Jaipur was divided into north, south, east, and west zones. A total of four mobile base stations from each zone of Jaipur were randomly selected using lottery method with no other base station nearby, operating for at least 8 years as a result of which the newly setup base stations were excluded. The EMRs of the towers were measured prior to selection by the EMR detector device Bravolink DT-1130, Bravolink International Enterprise Limited, Hongkong. The radiation range of the selected towers was 0.55–0.61 W radiation/m^2 that exceeded the normal range of 0.45 W radiation/m^2 and the mean radiation level of the areas at least 1 km away in radius from the selected towers was found to be comparatively lesser (0.34 W radiation/m^2).

Subjects above 18 years of age living in their present house for at least 8 years and a minimum of 8 h a day on an average were included in the study. Medically compromised and uncooperative subjects were excluded. The sample size was calculated based on the findings of the pilot study; assuming effect in 6% of the study participants at 95% confidence level and allowable error of 15%, a minimum of 40 study subjects were required as sample size.

$$\text{Sample size} = \frac{4 \times P \times Q}{L^2}$$

$$\frac{4 \times 6 \times 94}{7.5^2} = 40.10$$

P = Expected proportion of subjects showing effect, ($Q = 1 - P$), L = Allowable error

Thus, a total of 40 individuals were included in the study and were divided into two groups. Group 1 was the case group, which included 20 subjects residing near the selected four mobile phone towers. Group 2 was the control group, which also included 20 individuals residing at least 1 km away in radius from the selected four towers. The subjects included in both the groups were staying in that particular area for a minimum of 8 years, with the assumption of being exposed to these radiations more in the case group as compared to the control group.

The patient's consent was sought for a self-administered questionnaire. The questionnaire was originally developed in English; it was then translated and back-translated and piloted for use in the Hindi-speaking population. The questionnaire was administered prior to the examination. With respect to the contents of the questionnaire, the Kappa coefficient was found to be 0.85. The values revealed a high degree of conformity in observation. The questionnaire included questions about the sociodemographic data, sources of EMF exposure, regular use of mobile telephones, medical history, and questions related to health problems such as sleep disturbances, dizziness, headache, and hypertension. Problems related to

sleep were measured using Pittsburgh Sleep Quality Index (PSQI)[13] and were rated by the participants on a frequency scale ranging from never to more than 3 days a week.

Assessment of salivary parameters was carried out by a single trained investigator and an assistant using GC Saliva-Check Buffer Kit (GC America Inc.) The study of salivary secretion was performed without any stimulus in the morning, and under standard temperature and humidity conditions. All the subjects refrained from eating, drinking, or smoking for a minimum of 2 h before saliva collection.

Testing of resting/unstimulated saliva was performed by visual inspection of the level of hydration, evaluating the saliva consistency and pH measurement. Visual assessment of lower lip labial gland secretion was done by everting the lower lip. Then, labial mucosa was gently blotted with a small piece of gauge and the mucosa was observed under adequate light. Droplets of saliva were formed at the orifices of the minor salivary glands. If droplets appeared after 60 s, it signified low resting flow and if droplets appeared within 60 s, it signified normal resting flow. Salivary consistency was evaluated by visual assessment. Sticky frothy saliva residues signified increased viscosity, frothy bubbly saliva signified decreased viscosity, and watery clear saliva denoted normal viscosity. For recording salivary pH, patients were instructed to expectorate the saliva into the collection cup. Then, pH test strip was placed into the saliva sample for 10 s, and then color change of the strip was observed and compared with the testing chart available with the package.

The testing of stimulated saliva was performed by evaluating the saliva quantity and buffering capacity. Participants were instructed to chew on a piece of wax for 5 min and the saliva was collected into the collection cup and the quantity of saliva was then measured by checking the milliliter marking labeled on the container after 5 min. If <3.5 mL of saliva was produced, it signified very low saliva, 3.5–5 mL signified low saliva, and >5.0 mL of saliva produced corresponded to normal saliva. Buffer test strip was removed from the foil package and placed into the absorbent tissue with the test side up. Using a pipette, sufficient saliva was collected from the collection cup and one drop was dispensed into each one of the three test pads. The strip was turned at 90° and the test pad began to change color immediately. After 2 min, by adding the points according to the final color of each pad the final result was calculated. The following points were assigned against the test pad color at 2 min: Green—4 points, green/blue—3 points, blue—2 points, red/blue—1 point, and red—0 point. When the total buffering ability of the saliva was 0–5, it was interpreted as very low buffering capacity, 6–9 denoted low buffering capacity, and 10–12 signified normal/high buffering capacity.

The data collected were summarized as mean and standard deviation [mean ± standard deviation (SD)]. Chi-square test was used for statistical analysis. All analyses were done using MedCalc version 12.2.1.0 (MedCalc Software Mariakerke, Belgium). For all tests, a *P* value of 0.05 or less was used for statistical significance.

RESULTS

Among the 20 participants in the case group, 55% were males and 45% were females with 40% equal or below 30 years and 60% above 30 years of age. The mean age was 34.50 years. In the control group, out of total 20 subjects 80% were males and 20% were females with 55% equal or below 30 years and 45% above 30 years of age. The mean age was 32.50 years [Table 1].

It was observed that 25% of the study subjects reported with high blood pressure, 10% reported with dizziness, 20% reported with headache, and 40% reported with sleep disturbances, whereas in the control group, only 10% among the 20 participants had high blood pressure, 15% reported headache, and 5% each reported with dizziness, diabetes, and sleep disturbances [Figure 1]. Table 2 shows a comparison between the groups, 40% of the subjects in the case group and 25% of the subjects in the control group had low salivary secretion at resting/unstimulated rate. The findings were nonsignificant with $P > 0.05$. On comparison of saliva

Table 1: Demographic characteristics of subjects by exposure category

Age groups (in years)	Group I (case group) no. (%)			Group II (control group) no. (%)		
	Male	Female	Total	Male	Female	Total
≤30	5 (25.00)	3 (15.00)	8 (40.00)	11 (55.00)	0 (0.00)	11 (55.00)
>30	6 (30.00)	6 (30.00)	12 (60.00)	5 (25.00)	4 (20.00)	9 (45.00)
Total	11 (55.00)	9 (45.00)	20 (100.00)	16 (80.00)	4 (20.00)	20 (100.00)

Mean±SD=34.50±14.40, Mean±SD=32.50±13.98

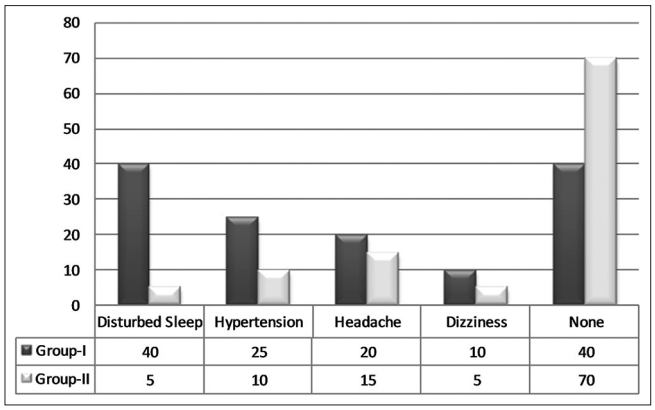

Figure 1: Comparison of self reported symptoms of primary interest for categories of exposure to EMR among case and control groups. Group I: Case group, Group II: Control group

consistency between both the groups, out of the total 20 subjects in the case group, 20% had both frothy bubbly saliva and sticky frothy saliva, whereas in the control group 10% of the subjects had sticky frothy saliva and 5% had frothy bubbly saliva. It was observed that 60% subjects had normal salivary consistency among the case group whereas in the control group, a majority of subjects (85%) had normal salivary consistency. The mean pH of resting/unstimulated saliva among the case group was found to be7.09 ± 0.52 as compared to the control group with 6.80 ± 0.49. No significant difference was found between both the groups with $P > 0.05$.

Table 3 shows that in the case group, 60% of the subjects had low saliva quantity after stimulation, whereas in the control group, 85% had normal saliva quantity and only 15% had low saliva quantity after stimulation. The findings were found to be statistically significant ($P < 0.01$). On comparison of the buffering capacity statistically, significant differences ($P < 0.01$) were found between the groups, as 60% of the subjects in the case group had low buffering capacity in contrast to only 15% among the control group.

DISCUSSION

The results of the present study were in accordance to a questionnaire survey[14] where it was observed that people living in the vicinity of base stations had various complaints mostly of sleep disturbances, irritability, depression, blurred vision, concentration difficulties, nausea, lack of appetite, headache, and vertigo. Also, the results were similar to a study[15] where a majority of the subjects complained of headache and dizziness. It was also observed that there was an influence of confounding variables such as the fear of

Table 2: Comparison of level of dehydration, saliva consistency, and pH in resting/unstimulated saliva among group I (cases) and group II (controls)

Unstimulated saliva						
Level of dehydration	**Group I**		**Group II**		**χ^2**	***P* value***
	No.	**%**	**No.**	**%**		
Low	8	40.0	5	25.00	1.026	>0.05
Normal	12	60.00	15	75.00		
Saliva consistency	**Group I**				**Group II**	
	No.		**%**		**No.**	**%**
Frothy bubbly	4		20.00		1	5.00
Sticky frothy	4		20.00		2	10.00
Normal-watery clear	12		60.00		17	85.00
pH	**Group I**		**Group II**		**P value**	
Mean±SD	7.09±0.52		6.80±0.49		>0.05	

**Calculated by Chi square test (χ^2), P value significant at ≤0.05*

Table 3: Comparison of quantity of saliva and buffering capacity of stimulated saliva among cases (group I) and controls (group II)

Stimulated saliva						
	Group I		**Group II**		**χ^2**	***P* value**
	No.	**%**	**No.**	**%**		
Saliva quantity						
Low	12	60.00	3	15.00	6.827	<0.01*
Normal	8	40.00	17	85.00		
Buffering capacity						
Low	12	60.00	3	15.00	6.827	<0.01*
Normal	8	40.00	17	85.00		

**Calculated by Chi-square test (χ^2), P value significant at ≤0.05*

adverse effects from exposure to high-frequency EMFs from the base station, which may result in self-reported symptoms such as headache and dizziness. But there was no significant effect on the sleep quality of individuals. The findings were in contrast with the present study in which the highest percentage of effect on sleep quality in individuals was observed. The findings of the present study were also similar to the study,[16] which observed that sleep disorders and headache were among the most common health complaints due to electromagnetic hypersensitivity. The results of the present study were in accordance to a cross-sectional study[1] where the participants who were living in the vicinity of a mobile phone base station reported more health complaints than others.

The unstimulated whole saliva represents basal salivary flow rate, which is present in the oral cavity for about 14 h a day. Secretion of stimulated saliva is initiated by physiologic, olfactory, visual, oropharyngeal, and esophageal stimulations produced

before, during, and after eating, present in the oral cavity for up to 2 h. Thus, the study of unstimulated salivary secretion is an accurate method to analyze salivary gland status while stimulated saliva is useful for the study of the functional reserve.[17] In the present study, being an easy and a noninvasive procedure, both unstimulated saliva and stimulated saliva were measured.

The subjects residing near mobile towers had low salivary secretion as compared to the control group. It was also observed that a majority of the control group subjects had normal salivary consistency as compared to the resident group. The buffering capacity of saliva was low in the cases as compared to the controls. The reason might be attributed to radiation effects of the mobile phone base station on salivary glands. Salivary gland dysfunction is caused by damage to the plasma membrane of acinar cells or lack of proper cell renewal because of damage to the DNA of progenitor cells and stem cells.[18] The extent of radiation-induced salivary dysfunction depends on the nature of the salivary glands, the dose of radiation, and the volume of irradiated gland tissue.[19] Research has suggested that radiation influences the salivary secretion and composition.[20]

It was unveiled in the present pilot study that people living in the vicinity of mobile phone base stations had various complaints such as sleep disturbances, headache, dizziness, irritability, concentration difficulties, and hypertension. These findings were similar to a study where a number of respondents mentioned recent health effects but the association with base transmitter stations (BTS) could not be established and the awareness about the possible health hazards from electromagnetic waves of BTS was low among the participants.[21]

The potential health effects cannot be restricted to mobile phone base station frequency bands alone. It can also be attributed to exposure due to other sources of radiofrequency Electromagnetic radiations in daily life such as mobile phones, cordless phones, and wireless local area networks. Additional studies applying a longitudinal design and involving more subjects are warranted to evaluate the effect of EMRs on general health and more specifically to oral health.

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Conflicts of interest

There are no conflicts of interest.

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