

Effect of Cell Phone Radiations on Orofacial Structures: A Systematic Review

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ABSTRACT

Introduction: The widespread use of cell phone in recent years has raised many questions whether their use is safe to operator who is exposed to Electromagnetic Waves (EMV).

Aim: To find out the effect of cell phone emitted radiations on the orofacial structures.

Materials and Methods: To identify suitable literature, an electronic search was performed using Medline, Pubmed and EBSCO host database in December 2016. The search was focused on effect of cell phone on orofacial structures. Among the literature available in English, the screening of the related

titles and abstracts was done, and only those articles were selected for full text reading that fulfilled the inclusion criteria.

Results: The initial literature search resulted in 360 articles out of which only 24 articles fulfilled the inclusion criteria and were included in this systematic review.

Conclusion: Cell phone emitted radiations had their adverse effect on salivary glands and facial nerves. Studies showed that cell phone emitted radiations had effects on oral mucosal cells and causes changes in salivary flow rate. It was still unclear that cell phone radiations cause tumours of the salivary glands.

Keywords: Non ionizing radiations, Oral cavity, Salivary gland, Tumour

INTRODUCTION

The cell phones have revolutionized the modern world and life without cell phones is unimaginable now. The mobile phone users have increased in large numbers all over the world in the last two decades. The widespread use of cell phones in recent years has raised many questions whether their use is safe to operator who is exposed to non-ionizing EMR in ultra high frequency range of 300-3000MHz [1]. There are two separate prospects which could affect the health due to the exposure of radio frequency field. First prospect is due to prolonged conversations; the mobile phone gets heated up and increases the temperature of the surrounding tissues in contact. The second reason may be non thermal effects due to cumulative effects from both phones and base stations [2]. In 2012, the International Agency for Research on Cancer (IARC) concluded that radiofrequency electromagnetic fields as possibly carcinogenic to humans and classify it as Group 2B agent (Group 2B: The agent is possibly carcinogenic to humans) [3].

Various animals and human studies have shown that radiation emitted by cell phones or base stations have a negative impact on different organs and tissues of the body [4-15].

The frequency of cellular phone used determines the amount of exposure to radiations. The mechanism of radiant energy absorption into the human body dependent upon: (i) the wavelength of the signal and size of the body part; (ii) the radiofrequency signal couples with the tissues; and (iii) resonant absorption of the energy [16]. Investigations have been done to find the different aspects of human health affected by cell phones ranging from mild local warmth to induction of tumour [17].

According to the proximity of mobile phones to the oral cavity and other extraoral structures during the conversation period, did radiations emitted have any serious effect on them? This systematic review was done to find out the effect of cell phone emitted

radiations on the orofacial structures mainly on parotid gland, as this salivary gland is very close to cell phone in use. Effect of cell phone on other salivary glands, oral cavity, dental appliances and dental restorations were also studied.

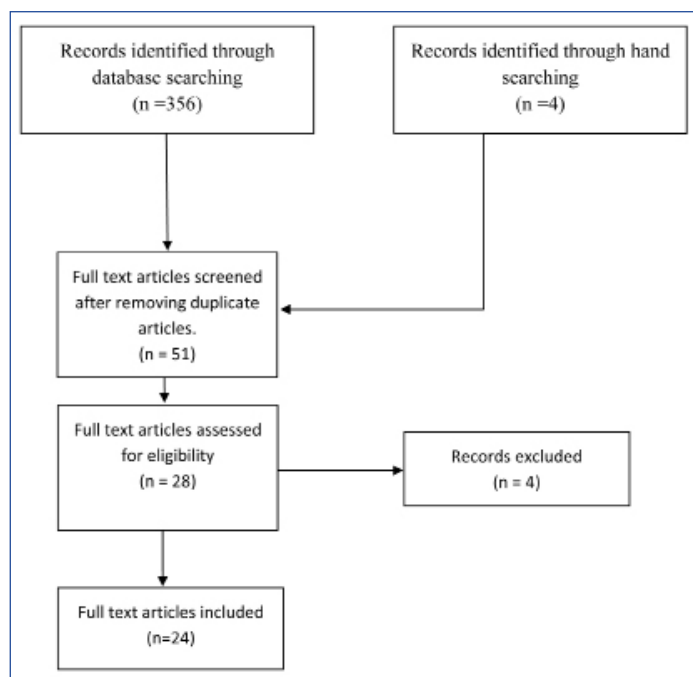
MATERIALS AND METHODS

Search Strategy

A broad search of the dental literature in Medline and Pubmed and EBSCO host database was performed from the year January 2000 to December 2016. A focus was made on peer-reviewed dental journals limited to studies in English. The key words searched were Cell phone, Dental implant, Salivary glands tumours, Oral Cavity, Orofacial Structures, Electromagnetic radiations, Non Ionizing Radiations, Parotid Gland. The search strategy included the combination of the following terms: Cell phone emitted radiations, Mobile phone and health hazards, Mobile phone and dental appliances, Mobile phone and dental restorations, Cell phone radiations and parotid glands, Cell phone radiations and salivary glands, Cell phone radiations and oral cancer, Cell phone radiations and oral health. The references of all the full-text articles were searched manually and electronic search were also performed to select the relevant articles.

Selection Criteria

Flow chart [Table/Fig-1] is provided for the screening of the article. To determine which studies to include in the present systematic review, the following inclusion criteria was applied. Articles related to effect of cell phone on orofacial structures, published in English with both abstract as well as full text articles were included. Review articles and case reports, articles unrelated to the topic of cell phone emitted radiations were excluded.



[Table/Fig-1]: Flow chart presented the screening of articles on cell phone and its effect on orofacial structures, in medline and pubmed database to be included in the review.

The initial literature search resulted in 360 articles out of which 24 articles that fulfilled the inclusion criteria were included in the systematic review [Table/Fig-2] [1,18-40].

RESULTS

The summary and outcome of animal and human studies done on effect of cell phone radiations on orofacial structures, tissues, restorations and appliances were tabulated in [Table/Fig-2].

DISCUSSION

Safety is a major concern for the wireless equipment users mainly, in regard to possible hazards caused by electromagnetic fields. Today, there has been growing concern about the possible adverse health effects due to exposure to radiofrequency radiations from mobile phones. In an animal studies by Aydogan F et al., and Ghoneim FM and Arafat EA et al., there were numerous histopathological changes observed in parotid gland of rats, in both short and relatively long term exposure to radiofrequency radiation [28,29]. Human studies done by Duan Y et al., Lonn S et al., Hardell L et al., and Söderqvist F et al., did not support the hypothesis that there was an increased risk of parotid gland tumours due to mobile phone use [33-35,38]. But contradictory to these studies Sadetzki S et al., found an association between long term cellular phone use and parotid gland tumours. The electromagnetic fields emitted from cellular phones are unlikely to be responsible for the initiation of a tumour, as they do not have sufficient energy to break chemical bonds or damage DNA [36]. A clinical effect could be expected in tumour promotion more rapidly if radiofrequency radiation was due to high level use of cellular phone. Siqueira EC et al., conducted acytokine expression profile in cell phone users and found differences in IL-10 levels in ipsilateral parotids, in comparison to contralateral parotids in subjects using cell phones for more than 10 years. The alterations in cytokine profile in saliva may be due to heating effects of non-ionizing radiation [19].

Khalil AM et al., and De Souza FT et al., found that there was no alteration in parotid salivary flow, protein concentration, or levels of proteins of genes and changes in the salivary oxidant or antioxidant profile due to exposure of parotid glands to cell phone radiations [23,37]. The adverse health effects of cell phone use can be assessed by the antioxidant activity and oxidative stress indices. Bhargava S et al., Hashemipour MS et al., and Goldwein O and

Aframian DJ and found increased salivary flow rate, blood flow rate, and volume of parotid glands in heavy cell phone users [25,26,30]. The radiofrequency radiations of the mobile phones are a type of microwave energy which may be absorbed by the water contained in the adjacent tissues and thus raise their temperature [30]. Extensive exposure to heat due to cell phone increases the capillary blood flow adjacent to the parotid glands and result in an increase of perfusion and increase in the salivary flow rate. Mobile phones had its effect on the autonomic nervous system which causes increase in parasympathetic tone and decrease in sympathetic tone, due to which there is increased salivary flow rate [41]. But contradictory to this Singh K et al., found that there was significantly lesser stimulated salivary secretions in majority of the study subjects [24].

Daroit NB et al., studied cytogenetic abnormalities of oral mucosal cells due to exposure to cell phone emitted EMV. They found that individuals using cell phone for more than 60 minute/week for eight years had increased nuclear abnormalities. The lower lip had a higher amount of binucleated cells and broken eggs (structures associated with gene amplification). Reason for this may be, these sites are near to the cell phone, a source of electromagnetic radiation and also exposed to solar radiations [18]. Similar results were obtained by Souza Lda C et al., [39]. Contradictory results were obtained by Ros-Llor I et al., and Hintzsche H and Stopper H who investigated the effect of mobile phone use on genomic instability of the human oral cavity's mucosa cell [27,40]. There was no significant increase in frequency of micronuclei due to mobile phone use.

Acar GO et al., in their study on rabbits, found that temporary dysfunction of facial nerve occurs due to exposure to mobile phone emitted Radio Frequency Radiation (RFR) [20]. Saghiri MA et al., studied nickel release from the fixed orthodontic appliances of patient's using cell phones [31]. They found that mobile phone use in patients had a time-dependent effect on the concentration of nickel in the saliva. Mortazavi SM et al., studied the release of mercury from dental amalgam restorations in mobile phone users [32]. They found that there was significant release of mercury from dental amalgam restoration due to microwave radiation emitted from mobile phones. Kaya FA et al., in their study on rat found that there was affect on periodontal tissues due to long term exposure to radiofrequency emitted from mobile phones. In few rats vasodilatation and focal areas of bleeding was seen [1]. Dasdag S et al., studied the effect of Radio Frequency (RF) radiation emitted from mobile phones on the enamel micro hardness of rat teeth [22]. There was no alteration in the enamel micro hardness with 900 MHz of RF radiation.

The radiation emitted by mobile phone has both thermal and non thermal effects on biological tissues [42]. The limit of mobile phone use is the Specific Absorption Rate (SAR) of 2 W/kg for the human head. Depending on the different type of mobile phones, the maximum local SAR values ranged between 0.2 and 1.5 W/kg on an average for 10 grams of tissue. The International Commission on Non Ionizing Radiation Protection (ICNIRP) has set frequencies up to 300 GHz as limitations for exposure and it is followed by many countries as their national regulations [43]. At present there are more than 700 million cell phone users around the world and the frequency at which this cell phone operates differs in different countries and continents. The frequency of cell phone decides the exposure to the individuals [44].

The health hazards of cell phone emitted radiations were a matter of serious concern among children and geriatric population. As children have smaller heads, their skull is very thinner and has higher tissue conductivity in comparison to adults [45]. Literature had reported that brains of children of age 5 and 10 when compared to adults' brain, demonstrated the absorbed radiations deeper in the brain [46]. Bone marrow of children absorbs 10 times higher microwave radiation than in adults [47].

Literature had reported higher incidence of genetic damage in elderly individuals due to use of cell phones [48-50]. Bonassi et al.,

Author	Type of Study	Purpose of Study	Study Summary	Outcome
Daroit NB et al., [18]	Human study	Effect of cell phone emitted radiation on oral mucosal cells.	Cells were obtained from cell phone users. The sites were lower lip, border of the tongue, and floor of the mouth	They found that individuals using cell phone for more than 60 minute/week for eight years had increased nuclear abnormalities.
Siqueira EC et al., [19]	Human study	Effect of cell phone use on the parotid glands.	Saliva sample of healthy individuals were examined for cytokine expression profile	There was differences in IL-10 levels in ipsilateral parotids, in comparison to contralateral parotids in subjects using cell phones for more than 10 years
Acar GO et al., [20]	Animal study/ Rabbits	Effect of mobile phones generated heat on facial nerves (FN) and surrounding soft tissue.	A mobile phone was placed for 25 minutes over the ipsilateral ear of the rabbit.	They found that temporary dysfunction of facial nerve occurs due to exposure to mobile phone emitted radiofrequency radiation (RFR).
Shivashankara AR et al., [21]	Human study	The saliva of young individuals using cell phones was analyzed.	Saliva samples were evaluated for amylase, lactate dehydrogenase (LDH), malondialdehyde (MDA) and glutathione (GSH).	Significant changes were observed in salivary enzymes and MDA. More use of cell phone has harmful effect on cell health.
Dasdag S et al., [22]	Animal study/ Wistar Albino Rats	Effect of mobile phones on the micro hardness of enamel of rat teeth.	Rats enamel was exposed to the cell phone emitted radiation for two hours / day for 10 months.	The enamel micro hardness was not changed even with a radiofrequency radiation of 900 MHz.
Khalil AM et al., [23]	Human study	The saliva of cell phone users were examined for oxidant/ antioxidant status.	Saliva samples were collected before using a cell phone and then after 15 minutes and 30 minutes calls.	No changes in salivary oxidant/antioxidant profile was observed on exposure to radio frequency radiation (RFR)
Singh K et al., [24]	Human study	The effect of electromagnetic radiations (EMRs) were studied on unstimulated and stimulated salivary flow rate	Individuals who were residing near the mobile phone towers were taken as the case group and their salivary analysis was done.	Results showed that majority of the subjects had lesser stimulated salivary secretion.
Bhargava S et al., [25]	Human study	The functional and volumetric changes of the parotid glands due to mobile phone use was studied.	Individuals who are using more cell phones were selected and their unstimulated parotid salivary flow rate was measured	There were increased salivary flow rate, blood flow rate, and volume of parotid glands in individuals who were heavy users of mobile phones.
Hashemipour MS et al., [26]	Human study	Studied the effect of radiations on parotid glands of individuals using mobile phone.	Individuals using mobile phones were included in study and their stimulated salivary samples were collected from both the parotid glands.	The concentration of protein and flow rate of saliva from parotid gland was higher on the side to which individuals used the mobile phones predominantly. There was a decrease in concentrations of amylase, lipase, lysozyme, lactoferrin and peroxidase.
Ros-Llor I et al., [27]	Human study	Effect of mobile phones on micronucleus frequency in human exfoliated oral mucosal cells was studied.	Cell samples both from right and left cheek mucosa, from each subject were collected. Cells were screened for nuclear abnormalities, especially micronucleus.	No significant changes were recorded in subjects in relation to their age, gender, body mass index, or smoking status.
Aydogan F et al., [28]	Animal study/ Wistar Albino rats	Studied the short and long term effect of 2100 MHz radiofrequency radiation on the parotid gland of rats.	The study group was exposed to cell phones for six hours/day, for 10 or 40 days.	Histopathological changes were observed in Parotid gland due to exposure to radiofrequency radiation, both in the short and long time period.
Ghoneim FM and Arafat EA. [29]	Animal study/ Albino rats	The parotid gland of rats exposed to mobile phones was studied and also the role of rosemary against radiation was investigated.	Group I (control), Group II (rosemary treated), Group III (exposed to mobile phone) and Group IV (exposed to mobile phone and treated with rosemary).	There were structural changes observed due to electromagnetic radiation of mobile phone. Rosemary has antioxidant property and it could play a protective role against the harmful effect of radiation.
Goldwein O and Aframian DJ. [30]	Human study	Mobile phone induced physiologic changes in the parotid gland was studied.	The stimulated salivary samples from parotid gland of healthy individuals were collected.	Increased salivary rate and decreased secretion of protein was observed from parotid glands adjacent to mobile phone in use.
Saghiri MA et al., [31]	Human study	The level of nickel released in saliva due to exposure to radiofrequency electromagnetic fields emitted by mobile phones was studied.	Saliva samples collected from patients with fixed orthodontic appliances that had not used their cell phones for a week (control group). The time of mobile phone use for the next week was recorded and another saliva sample was taken (experimental group).	The concentration of nickel released in the saliva from orthodontic appliances was dependent on the time for which mobile was used.
Mortazavi SM et al., [32]	Human study	Investigated the release of mercury from amalgam restorations due to use of cell phone.	Subjects restored with dental amalgam and had not used mobile phones previously were investigated.	There was significant release of mercury from dental amalgam restorations due to microwave radiation emitted from mobile phones.
Duan Y et al., [33]	Human study	Investigated the association of epithelial parotid gland malignancy due to use of cellular phone.	Cases treated for parotid malignancy were taken as study group	There was no significant association found of epithelial parotid gland malignancy and frequency of cellular phone.
Kaya FA et al., [1]	Animal study/ Wistar Albino Rats	Investigated the effects of radiofrequency radiation emitted by mobile phone on periodontal tissues and teeth	Rats were exposed to radiations for two hour/day for a period of 10 months.	Vasodilatation and focal areas of bleeding were seen in some rats due to cell phone emitted radiations. It was found that long term radiofrequency exposure of mobile phones affects the periodontal tissues.
Lonn S et al., [34]	Human study	Evaluated the hypothesis that whether long-term mobile phone use increases the risk of parotid gland tumours.	Cases aged 20-69 years diagnosed with parotid gland tumour during 2000-2002 in Denmark and certain parts of Sweden were included in the study.	The data collected do not support the hypothesis that mobile phone use can increase the chances of parotid gland tumours.
Hardell L et al., [35]	Human study	Investigated whether use of cellular or cordless telephone was associated with the risk for salivary gland tumours.	The assessment of cases was done from the six regional cancer registries in Sweden.	The use of cellular or cordless phones was not associated with salivary gland tumours.

Author	Type of Study	Purpose of Study	Study Summary	Outcome
Sadetzski S et al., [36]	Human study	Investigated whether cellular phone use was associated with development of parotid gland tumours (PGTs).	The study included 402 benign and 58 malignant incident cases of PGTs diagnosed in Israel.	An association was found in between cellular phone use and PGTs.
De Souza FT et al., [37]	Human study	Evaluated whether cell phone use alters the expression of gene products related to cellular stress in parotid glands.	Saliva samples were collected from parotid glands of 62 individuals to assess the molecular alterations.	Parotid salivary flow, protein concentration, or levels of proteins of genes was not altered due to exposure of parotid glands to cell phone.
Söderqvist F et al., [38]	Human study	Evaluated whether the use of wireless phones is associated with an increased risk of salivary gland tumour.	Sixty-nine patients with salivary gland tumours were included in the study and 262 randomly recruited subjects were taken as controls.	No association was found which can prove that there was increased risk of salivary gland tumours due to wireless phones use.
Souza Lda C et al., [39]	Human study	Investigation of oral epithelium of mobile phone users was done to analyze the nuclear abnormalities.	Individuals were distributed in three groups according to the mobile phone use: Group I, t > 5 hour; Group II, t > 1 hour and ≤ 5 hour; and Group III, t ≤ 1 hour. (t = time in hours per week)	It was found that the number of broken egg was significantly greater in the individuals in Group I
Hintzsche H and Stopper H. [40]	Human study	Investigated the effect of mobile phone use on genomic instability of mucosal cells of the human's oral cavity.	The study subjects consist of buccal mucosa extracts of 131 individuals. N= 13 Individuals who did not use mobile phones at all, N= 85 individuals using the mobile phone for 3 hour/week N= 33 individuals using the mobile phone for more than 3 hour/week.	The result obtained proved that there was no significant increase of micronuclei due to mobile phone use.

[Table/Fig-2]: Studies on effect of cell phone radiations on orofacial structures [1,18-40].

in their study found age as highly significant for the micronucleus frequency [51]. One of the data from United States from the year 2008 through 2012, presents less than five brain cancer cases for every 100,000 people under the age 65, in comparison to approx 19 cases for every 100,000 people of ages 65 or older [52]. Elderly individuals should be more cautious about their health while using cell phones regularly.

LIMITATION

Limitation of this systematic review is that it includes only articles published in English and articles search was done from only Medline, Pubmed and EBSCO host database. This review focus only on articles related to orofacial structures. To make a generalised statement further research is required to know the effect of cell phone emitted radiations on other body parts in humans.

CONCLUSION

Cell phones increase the temperature of the surrounding tissues and cause facial nerves dysfunction. The salivary flow rate is increased and there is alteration of the cytokine expression profile of the salivary gland in heavy cell phone users. Patient with any metallic appliances or restorations be more cautious as there is leaching of metallic ions or mercury which is very harmful to the individual. Cell phone emitted radiation causes nuclear abnormalities of the oral mucosal cells. Cell phones do not cause tumour of the salivary gland, but since few studies had found adverse effects of cell phone on orofacial structures so uncertainties remain and a continued precautionary approach is recommended until the situation is clarified. Further human and epidemiological studies are required to evaluate long-term effect of cell phone on health of the individual.

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