Systematic Review

Impact of mobile phone radiation on salivary gland: A systematic review

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Abstract

In the recent decades, the use of mobile phone has increased drastically. This has raised many concerns about the potential health risk to the individuals who are exposed to mobile phone emitted radiation. The aim of this systematic review is to find out the impact of mobile phone emitted radiations on salivary gland. An electronic database search was performed to identify the suitable literature using Cochrane, EBSCO host, PubMed, Google Scholar, and Trip database. The literary search was focused on the impact of mobile phone emitted radiation on the salivary gland. Based on inclusion and exclusion criteria, the studies were selected. A total of 31 relevant studies were identified, and 11 articles were taken for the systematic review. The studies concluded that the radiations emitted by the mobile phones have detrimental effects on salivary gland.

Keywords: Mobile phone, nonionizing radiation, salivary gland

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INTRODUCTION

The rapid emergence of mobile technology caused enormous changes in day to day lifestyle of individuals.[1] Mobile phones are the most efficient and convenient way of hand held communication tool which is considered to be the most important form of wireless communication which is essential for work and social life in the emerging fast-paced modern society.[2] It has been predicted that the average annual growth rate of 1.9% of mobile phone users will increase between the time span of 2018 and 2025, where the mobile subscribers will reach to 5.8 billion counting 71% of the world population.[3]

The mobile phone users are often exposed to ultra-high frequency of nonionizing exposure of electromagnetic radiation (EMR) ranges between 300 and 3000MHz. There are two possible ways which could affect the health of the mobile phone users, firstly due to the thermal effects caused by the increase of temperature of nearby tissues during prolonged conversations, second due the consequences of nonthermal effects from the base station and phones itself.[4] In 2012, the International Agency for Research on Cancer categorized the radiofrequency electromagnetic radiation as possibly carcinogenic to humans and classified it as Group 2B agent.[5]

EMR from the mobile phones is localized. The considerable biological side effect is due to continuous exposure and energy absorption by the human body mostly the head and neck regions which are closely associated during the

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usage. These exposures not only affect the phone user but also the neighbors residing in the close proximity to the base station.[6]

A study conducted by Hardell *et al*. indicated an association between mobile phone usage and brain tumor. He also stated that prolonged use of cell phone (>10 years) added to the risk of brain tumor and most commonly in children.[7] Few other studies show the increased incidence of meningioma and gliomas in mobile phone users than in nonmobile phone users.[8]

Salivary gland is an organ which is in close proximity to the mobile phone during usage and parotid gland is the major field of interest. Various studies suggested the incidence of salivary gland dysfunction distinctly increases in the population who majorly use mobile phone for a longer period of time. Contrary to this, various other studies stated no significant association exist between salivary gland disorder and mobile phone radiation exposure.[2,9]

Effects of radiation on the salivary gland and its components gain a particular interest, as the altered salivary composition cause irreversible complications, namely increase risk to oral infections, oral discomfort, and increased susceptibility to dental caries due to oral dryness and distress.[10] The parotid gland receives the major attention as it is located under the skin of the face near to front of the ear. The parotid is more commonly affected by the heat and harmful radiation emitted by the mobile phone during its utilization as it was in direct contact with the mobile devices.[11]

Hence, this systematic review was done to find out the effect of nonionizing radiation emitted by the mobile phone on the salivary gland especially parotid, as this salivary gland is close proximity during mobile phone use.

MATERIALS AND METHODS

This systematic review utilized the methods as per the PRISMA (Preferred Reporting Items for Systematic Reviews and MetaAnalysis) Guidelines, to identify, evaluate, and summarize all relevant research findings. The protocol for systematic review was registered first with PROSPERO (Acknowledgement ID-210723).

Eligibility criteria

The PECO analysis of the articles searched was:

PECO analysis

- **Population:** High talk-time mobile phone users
- **Exposure:** Electromagnetic radiation
- **Comparison:** Low talk-time mobile phone users
- **Outcome:** Parotid gland changes.

Inclusion and exclusion criteria

Inclusion criteria

1. Studies which included the effects of mobile radiation on salivary gland
2. Studies which had assessed the salivary gland changes including the change in salivary gland volume and salivary flow rate were included
3. Cross sectional, case-control, cohort, and comparative studies were only included
4. Studies done in the past 15 years were included. Since the usage increased drastically in the recent decades
5. Studies which was written in the English language were only included.

Exclusion criteria

1. Studies that included other than salivary gland changes due to mobile radiation
2. Qualitative studies, reviews, expert opinion, systematic reviews, meta-analysis, and case studies/series
3. Studies that required translation to the English language.

Literature search strategy

The studies published from 2005 to 2020 were reviewed for literary consideration using the following database such as PubMed, Trip database, Cochrane, Google Scholar, EBSCO host. Boolean search operators "AND" and "OR" were used to link the search terms. The following search strategy was adopted: mobile phone, nonionizing radiation and salivary gland, mobile phone and salivary gland, nonionizing radiation and salivary gland, mobile radiation, and salivary gland. Hand searches of the articles were conducted to ensure additional relevant references but no relevancy had been found.

Data extraction

The data from the studies eligible for the review was extracted manually. It included the variables such as: first author name, year of publication, type of study design, aim, summary and outcome [Table 1].

Risk of bias assessment

The bias assessment of the studies included in the systematic review was done by using Modified Newcastle–Ottawa Scale. The ranking of the studies was given by assigning stars (*) based on the three domains, namely selection, comparability, and outcome. More the stars less the risk of bias. For our convenience, the stars are converted into alphabets. The scores are interpreted as poor (0–4*), fair (5–6*), or good (7–9*). The results of the assessment are displayed in this article [Table 2].

Search results

A total of 31 articles were obtained based on the title from different electronic database, namely PUBMED, TRIPDATABASE, EBSCO, GOOGLE SCHOLAR, and COCHRANE. PUBMED produced 12 articles, 2 articles obtained from TRIPDATABASE, EBSCO produced 1 article, Google Scholar produced 16 articles, and no articles were found in COCHRANE. The full texts of 23 articles were taken for further steps. Among the obtained articles, eight articles were eliminated due to duplication, seven articles eliminated after abstract reading, and three articles eliminated after full-text reading. Finally, on the basis of inclusion and exclusion criteria, 11 articles were selected for the review using PRISMA flowchart [Flow Chart 1].

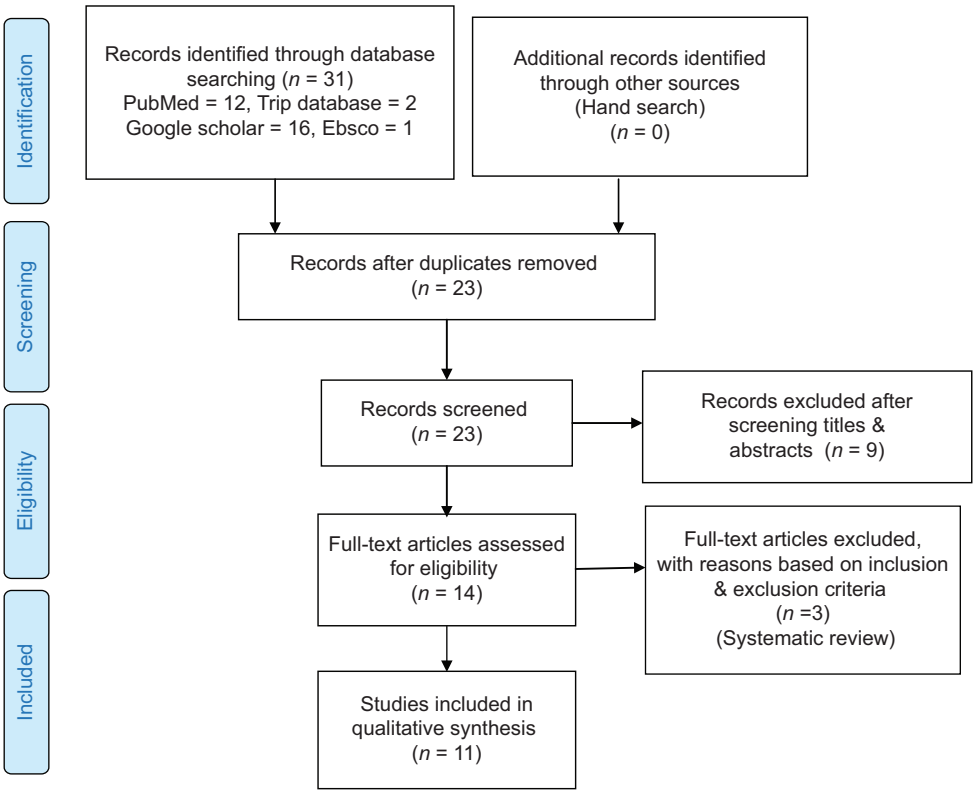
Outcome

The studies taken for this review identified the association of mobile phone use and its effect on the salivary gland in terms of risk of parotid gland tumor, changes in physiological, structural, functional, volumetric parameters of salivary gland and flowrate, and composition of saliva as well.

Table 1: Data extraction

Author	Study design	Aim	Study summary	Outcome
Lonn S *et al*. (2006)	Case-control study	Evaluated the hypothesis that whether long-term mobile phone use increases the risk of parotid gland tumors	Cases aged 20-69 years diagnosed with parotid gland tumor during 2000-2002 from Denmark and some parts of Sweden were included	The study did not supported the hypothesis stating there is no association between mobile phone use and parotid gland tumors
Goldwein O and Aframian DJ (2009)	Cross-sectional study	The aim is to assess the physiological changes of parotid gland induced by mobile phone radiation	Samples of stimulated saliva from parotid gland of healthy controls were collected	Increase in the salivary flow rate was observed with decreased protein secretion from the parotid glands of mobile phone users
Duan Y *et al*. (2011)	Case-control study	Investigated the association between epithelial parotid gland malignancies occurring due to mobile phone use	Parotid gland malignancy treated subjects were taken as cases for the study group	No association was found between the malignancy of parotid gland and mobile phone use
Bhargava S *et al*. (2012)	Cross-sectional study	To assess the functional and volumetric changes of parotid gland due to usage of mobile phone	Subjects with high usage of mobile phone were selected and their salivary flow rate was measured	There was significant increase in the salivary flow rate and volume of the parotid gland in high mobile phone users
Söderqvist F *et al*. (2012)	Case-control study	To evaluate whether the usage of wireless phone is associated with an increased risk of salivary gland tumor	69 subjects with salivary gland tumors were taken as cases and 262 randomly selected individuals were taken as controls	No significant association was found between the use of mobile phone and risk of salivary gland tumor
Hamzany Y *et al*. (2013)	Cross-sectional study	To compare the salivary outcomes such as secretion, oxidative damage indices, flow rate, and composition of saliva between mobile phone users and nonusers	20 subjects using mobile phone for 12.5 mean years and 29.6 h per month were compared with deaf individuals as controls	The study resulted in increase of salivary oxidative stress indices and decrease of salivary flow, protein concentration and amylase activity in mobile phone users
Khadra A *et al*. (2014)	Cross-sectional study	To examine the oxidant/antioxidant status of saliva in mobile phone users	Biochemical status in saliva of 12 male subjects before/after usage of mobile phones for 15 and 30 min were assessed	After 15 min of talking in mobile phone the level of SOD increased, but as talking time increased to 30 min the SOD activity got reduced. Suggesting that the exposure to EMR may exert an oxidative stress on human cells
Hashemipour MS *et al*. (2014)	Cross-sectional study	To study the effect of mobile phone emitted radiation on parotid glands of mobile phone users	Participants using mobile phones were selected for the study and their stimulated salivary samples were collected from both sides of the parotid glands	The protein concentration and salivary flow rate was higher on the dominant side of mobile phone use with decrease in concentrations of amylase, lipase, lysozyme, lactoferrin and peroxidase
Siqueira EC *et al*. (2016)	Cross-sectional study	To find the effect of mobile phone use on the parotid glands	Examination of cytokine expression from the salivary samples of healthy subjects using mobile phone was done	The study resulted in significant difference in the level of interleukin-10 in dominant and nondominant sides of subjects using mobile phones
Singh K *et al*. (2016)	Crosssectional study	To analyze the effect of electromagnetic radiation on stimulated and unstimulated salivary flow rate	Subjects residing near the mobile phone towers were included in the study and their salivary samples were analyzed	The study resulted in decreased secretion of stimulated saliva
Ranjitha GE *et al*. (2017)	Cohort Study	To compare the effect of mobile phone emitted radiation on parotid gland among heavy mobile phone users	50 participants were included in the study. Parotid gland volume, salivary flow rate and concentration of protein in the ipsilateral and contralateral sides of heavy mobile phone users was analyzed	There is a significant difference in the concentration and flow rate of saliva in ipsilateral and contralateral sides of mobile phone use

SOD: Superoxide dismutases, EMR: Electromagnetic radiation



Flow Chart 1: PRISMA 2009 flow chart

Studies done by Goldwein and Aframian 2010,[1] Bhargava *et al*. 2012,[12] Hamzany *et al*. 2013,[13] Abu Khadra *et al*. 2014,[6] Hashemipour *et al*. 2014,[8] Aydogan *et al*. 2015,[14] Siqueira *et al*., 2016,[15] Singh *et al*., 2016,[16] Ghoneim *et al*. 2016,[11] Ranjitha *et al*. 2017[17] showed a difference in salivary flow rate, volumetric, and histopathologic changes of the salivary gland, alteration in protein concentration, and composition of the saliva after exposing to mobile phone radiation.

Whereas the studies by Lonn *et al*. 2006,[9] Duan *et al*. 2011,[2] and Söderqvist *et al*. 2012[18] showed no relationship between salivary gland tumor and mobile phone radiation exposure.

DISCUSSION

Mobile phones receive and transmit radiation at the frequency range between 300 and 3000 MHz. When the human tissues are exposed to radiofrequency electromagnetic waves, the human tissue will absorb some amount of radiation which is called specific absorption rate (SAR), and it is expressed in watts per kilogram (W/kg). The radiation emitted by the mobile phone is one such harmful radiation that was absorbed by the human body and the rate of absorption will differ for the different parts of the body. For instance, studies have reported that about 40% of radiation emitted from the mobile phones were absorbed by head and hand since they were in contact while using the phone.[2]

The prolonged use of mobile phone and its close proximity to the body have raised questions about its possible detrimental effects to the tissues that were near to it during the usage. This indeed gain importance in the assessment of salivary gland and its fluid after EMR exposure and makes it possibly a potential area of research. Meanwhile, saliva secreted from the salivary gland is one of the biological fluid which represents the various forms of biomarker that were secreted by the human tissues on exposing to hazards.[19]

The largest salivary gland of the human body is the parotid gland which is located beneath the skin of the face and the near the front of the ear, its anatomy, continuous and constant contact, with the mobile phone emitted radiation for a longer period of time makes this gland a more vulnerable organ for heat and microwave energies.[2]

In regard to the potential adverse outcome and its effects on the physiologic, structural, functional and carcinogenicity, various contradicting literature do exists, stating two different outcomes. Few studies suggest and state the association exists between mobile phone use and its

Table 2: Risk of bias assessment

	Quality assessment of cross-sectional studies included							
	Selection (1) a/b=1 c/d=0	Selection (2) a=1 b=0	Selection (3) a/b=1 c=0	Selection (4) a=1 b/c=0	Comparability (1) a=1 b=1	Exposure (1) a/b=1 c/d=0	Exposure (2) a=1 b=0	Score
Goldwein O and Aframian DJ (2009)	b	a	a	a	b	a	a	7
Bhargava S *et al.* (2012)	b	b	a	a	b	b	a	6
Hamzany Y *et al.* (2013)	b	b	a	a	b	a	a	6
Khadra A *et al.* (2014)	b	b	a	a	b	a	a	6
Hashemipour MS *et al.*, (2014)	a	b	b	a	b	a	a	6
Siqueira EC *et al.* (2016	b	b	b	a	b	a	a	6
Singh K *et al.* (2016)	b	a	b	a	b	b	a	7
	Assessment of cohort study							
	Selection (1) a/b=1 c/d=0	Selection (2) a=1 b/c=0	Selection (3) a/b=1 c/d=0	Selection (4) a=1 b=0	Comparability (1) a=1 b=1	Outcome (1) a/b=1 c/d=0	Outcome (2) a=1 b=0	Outcome (3) a/b=1 c/d=0	Score
Ranjitha GE *et al.* (2017)	b	a	b	a	a	b	a	a	8
	Assessment of case-control study								
	Selection (1) a=1 b/c=0	Selection (2) a=1 b=0	Selection (3) a=1 b/c=0	Selection (4) a=1 b=0	Comparability (1) a=1 b=1	Outcome (1) a/b=1 c/d/ e=0	Outcome (2) a=1 b=0	Outcome (3) a=1 b/c=0	Score
Lonn S *et al.* (2006)	b	a	a	a	a	b	a	b	6
Duan Y *et al.* (2011)	b	a	b	a	b	b	a	b	5
Söderqvist F *et al.* (2012)	b	a	a	a	a	b	b	a	6

adverse effects such as auditory canal pathology, migraines, headache, brain tumors, and physiologic changes in the salivary glands. On the other hand, few studies deny the above statement.

Growing health hazard on one hand and safety concern on the other creates awareness in the use of wireless equipment's and its concerns in regard to the possible health hazard caused by the electromagnetic radiation on the human body.

Various other studies conducted on the animal model by Aydogan *et al.* in 2015 and Ghoneim and Arafat EA *et al.* in 2016 observed numerous changes in histopathological sections of parotid glands of rats.[14,11] In contrary, human studies done by Hardell L *et al.*, in 2004 Lonn *et al.*, in 2006, Duan *et al.*, in 2011., and Söderqvist *et al.* in 2012 disproved the hypothesis.[7,9,2,18]

A study done by Sadetzki *et al.* found to have an association between parotid tumors and prolonged mobile phone use.[20] Siqueira *et al.* study on cytokine expression profile among the mobile phone users shows elevated interleukin-10 level in ipsilateral parotid in comparison to contralateral parotids in participants using mobile phone users above 10 years. This change in salivary cytokine profile may be due to heating effects of nonionizing radiation.[15]

Hamzany *et al.* in 2013 assessed the salivary secretion and its components, flow rate, and oxidative stress between the mobile and nonmobile phone users. The study result showed increase in the oxidative stress-related indices wherein decrease in flow rate, total albumin, and amylase activity in mobile users.[13] However, in contrary, Khalil *et al.* found that there is no change in the parotid salivary profile such as protein concentration, oxidant, and antioxidant levels in the population who continuously exposed to the mobile phone radiations.[6]

Bhargava *et al.*, Hashemipour *et al.*, and Goldwein and Aframian described that there was a raise in the temperature of the adjacent tissues in direct contact to that of mobile phones due to continuous and prolonged use, the study concluded stating long-term use of mobile phones increases the blood flow in accordance with the salivary flow and also the volume of parotid gland.[1,8,12]

The main reason for the increase in the perfusion and flow rate of the saliva is consider due to the heavy heat exposure transmitted from the mobile phone to the underlying tissues, in turn leads to the increased capillary blood flow affects the parotid gland that is

situated adjacent to it. Another reason for the increased flow rate is an increased parasympathetic tone and reduced sympathetic tone.[7] A study conducted in 2017 by Ranjitha *et al*. also found the increase in salivary flow.[17] However, a study by Singh *et al*. gives a different statement and proves lesser salivary secretion in majority of participants.[16]

Among the 11 studies taken for review, salivary gland changes were found to be highest in the parotid gland in the aspect of salivary flow rate and composition and a positive relation was seen between the radiations emitted by the mobile phone in majority of studies.

CONCLUSION

In conclusion, the results of most of the studies found that the radiation emitted by mobile phones will have adverse effect on the salivary gland. However, few studies have apparently contradict the above statement. However, uncertainties do remain and a continued precautionary approach is recommended, until the situation is clarified. Further human and epidemiological studies are required to evaluate the long-term effect of mobile phone on the health of the individual.

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Conflicts of interest
There are no conflicts of interest.

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