

The influence of handheld mobile phones on flow rate and protein concentration of human parotid saliva - a cross sectional study

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Abstract

BACKGROUND: With the invention of mobile technology in the world, there is a serious issue which is because of emission of electromagnetic waves, specially radiofrequency waves and microwaves through mobile phones. These waves emitted have direct effect on general health of an individual and also on the tissues in close proximity to the mobile phone i.e. parotid gland. Several studies have been conducted in western population regarding effects of handheld mobile on salivary flow rate and protein concentration. But only very few studies have been documented regarding the same in Indian population.

OBJECTIVE: The aim of the present study was to evaluate the parotid salivary flow rate and protein concentration between dominant side (more frequently used side) and non dominant side (less frequently used side) of handheld mobile phone users.

METHODOLOGY: 60 adults (30 males, 30 females and aged between 19-35 years) with a history of using the handheld mobile phones for at least 3 years. The study design was cross sectional study. Unstimulated parotid saliva sample was collected for 5 minutes from dominant and non dominant sides using modified Carlson Crittenden cup, and the salivary flow rate was assessed and protein concentration was estimated.

RESULTS: Significant association was established between the handheld mobile phone (MPH) use and right dominant side where there was increased salivary flow & decreased protein concentration on dominant side. No statistically significant association was found in terms of usage years of MPH and mean daily usage on salivary flow. A decreased protein concentration was found with the increase in the usage years of MPH and mean daily usage.

CONCLUSION: There is an increase in parotid salivary flow rate on the right dominant side and a decreased in protein concentration on the same side. This continuous insult in salivary glands by MPH usage can have detrimental effects on teeth and oral mucosa. Further, exploration by means of large-scale longitudinal studies is warranted.

Keywords: Handheld mobile phone, parotid gland, salivary flow rate, protein concentration.

Introduction

Mobile technology has emerged into our world rapidly and has caused changes in our day to day life activities. The handheld mobile phone operation is based on electromagnetic waves, specially radiofrequency waves and microwaves.¹ The long duration and proximity of mobile phones to human body during use has given rise to concerns of possible adverse effects resulting from absorption of these emissions by the tissues adjacent to area of mobile phone handset use.² Prolonged use of mobile phones not only have thermal effect of elevated temperature on surrounding tissues but also various non thermal effects by interference with highly organized electrical activities at a cellular level.³ Normal unstimulated parotid saliva flow is 0.3-0.5ml/min. The location of parotid gland makes it vulnerable to changes in salivary flow rate resulting from mobile phone heat and radiation.²

Salivary proteins play a role in relation to protection of the teeth against caries and dental erosion. Normal parotid saliva protein concentration is 2.2-4.8gm/dl. Several salivary proteins such as proline rich proteins, cystatins, high molecular weight mucin 1 (MG1), lactoferrin, lysozyme and amylase take part in the formation of acquired pellicle that covers the teeth. Thus, a thick pellicle seems to be more protective against acid challenge on hard dental tissue than thin one in preventing risk of developing dental caries and erosion.⁴

Various studies show a possible association of mobile phone use and parotid gland tumors.⁵ Several studies have been conducted in western population regarding the effects of handheld mobile on salivary flow rate and protein concentration. Only few documented in India regarding the same.^{1, 2}

With this background information, the aim of this study is to evaluate the parotid salivary secretion rate and protein concentration between dominant side (more frequently used side) and non dominant side (less frequently used side) of handheld mobile phone users.

Methodology

In the present cross sectional study, sixty adults (30 males, 30 females and aged between 19-35 years) who visited Department of Oral Medicine & Radiology, Vydehi Institute of Dental Sciences were included. The individuals with a history of using the handheld mobile phones for talking at least 3 years was considered as main protocol of study design, participants using handheld mobile phones beyond 3 years were not considered in the study. The study was approved by Institutional ethical committee, Vydehi Institute of Dental Sciences and Research Centre, Bangalore. Written informed consent from each participant was obtained. The case histories were recorded using a standard case history proforma. Emphasis was laid on the participant's duration of mobile phone use, frequency of usage, preferred side of cellular phone use. The patients with underlying systemic diseases, who were on any medication, chronic alcohol or smoking habits, and with xerostomia, no preferable custom to side holding the handheld mobile phones were excluded from the study. Sampling was randomized cross sectional trial study; with sample size calculation was done using standard deviation and standard error of means. The study was single time sample collection type, which was not a long term cohort study in which follow up is done.

Data collection methodology

Participants were asked to refrain from intake of any food 2 hours before the session.

Unstimulated saliva was collected in morning from all the subjects from both right and left side of the glands. Rationale for using unstimulated saliva rather than stimulated was to examine the parotid glands in their resting state (the state in which the glands are for most part of the day, i.e. unstimulated). The saliva was collected using Modified Carlson Crittenden cup,¹ which was constructed using heat cure acrylic and IV fluid set. (Figure 1) The side of head frequently preferred for mobile phones use was considered to be the

Figure legends:



Figure 1- A- Modified Carlson Crittenden cup for parotid saliva collection, **B-** Positioning of the cup in the mouth, **C-** Centrifugation of saliva samples, **D-** Biuret reagent used for protein concentration in saliva

dominant side, and the side on which use was remarkably less was the non dominant side. The dominant side salivary flow rate was compared with the non dominant side in both groups.

The subjects sat upright in a dental chair and were asked to swallow, after proper isolation and prior to placement of cup, buccal mucosa is dried with gauze and duct orifice was located. After placing the cup over the duct, suction was created using one of IV tube through negative pressure to maintain the cup in its position. Then through other tube, saliva was collected for about 5 minutes and samples were preserved on ice packs at 4°C until further use. Thereafter, samples were centrifuged

at 14000 rpm for 20 min at 4°C and supernatant is collected and protein concentration determined according to Biuret method of protein estimation.⁷ Results were calculated in gm/dl.

Statistical analysis

Mean values, standard deviation (SDM) and standard error of means (s.e.m) were calculated for observations. The data obtained was statistically analyzed using Student's paired & unpaired t-test, Fisher exact test & Pearson correlation test. All the statistical tests were analysed to a significance level of 0.05.

Results

Out of the 60 healthy individuals who participated in the study (30 males and 30 females). Mean age for participation is 23.62 years. Mean usage of MPH was found 6.07 years. Mean usage of MPH was 2.77 hours per day. The use of dominant side of MPH use among the participants was 45 participants (75%) used the right ear more frequently and the remaining the 15 participants used left ear as dominant side. Mean comparison between gender wise usage of MPH was not done.

Salivary flow rate

In subjects whose dominant side was the right, the overall mean unstimulated parotid flow rate measured was higher (mean= 0.20, Table 1) than the flow rate from the left parotid gland (mean= 0.15). There is a statistically significant association between the observations (p- value 0.002). This infers that there is an increase in mean parotid salivary flow rate in right side when compared with the left in participants using right as dominant side.

In subjects whose dominant side was left, the overall unstimulated parotid flow rate measured on left (mean= 0.16) was almost identical to that of the right parotid gland (mean= 0.17). There was no statistical significant association between observations (p-value 0.29). This infers that there is no difference in mean parotid salivary flow rate in right side when compared with the left in participants using left as dominant side.

When the salivary flow ratio between dominant and non dominant sides were considered, there is an overall 1.77-fold increase in salivary secretion rate was found. When the usage years of MPH and mean daily usage of MPH (hrs) with salivary flow rate was correlated (Table 2), weak correlation strength was found between the dominant and non-dominant sides which is not statistically significant.

Protein concentration

In subjects whose dominant side was the right, the protein concentration measured was lower (mean= 2.14, Table 3) than the protein concentration from the left parotid gland (mean= 2.65).

There is a statistically significant association between the observations (p- value ≤ 0.001). This infers that there is a decrease in mean protein concentration in right side when compared with the left in participants using right as dominant side.

In subjects whose dominant side was left, protein concentration measured on left (mean= 2.51) was almost identical to that of the right parotid gland (mean= 2.78). There is no statistical significant association between observations (p-value 0.09). This infers that there is no difference in protein concentration in right side when compared with the left in participants using left as dominant side.

When the protein concentration ratio between dominant and non dominant sides were considered, there is an overall 0.88-fold decrease in protein concentration on right side in participants who used right dominant side.

When the usage years of MPH and protein concentration were correlated (Table 4), negative correlation strength was found between the dominant and non-dominant sides ($r = -0.289$, $p = 0.01$) which is statistically significant.

When the mean daily usage of MPH (hrs) and protein concentration was correlated (Table 4), a negative correlation strength was found between the dominant and non-dominant sides ($r = -0.25$, $P = 0.02$) which is statistically significant. Depending on this, we infer that with increase in usage years of MPH & increase in frequency MPH in hours there is decrease in protein concentration.

Discussion

Human beings are exposed to radiation emitted by the mobile phone device (which operates as a receiver and a transmitter) which has

created a need to investigate possible ill effects of mobile phone use on health of individuals.⁸ The location of parotid gland makes it especially vulnerable to changes resulting from mobile phone heat & radiation.² With this background this study was undertaken to evaluate the parotid salivary flow rate and protein concentration between dominant side (more frequently used side) and non dominant side (less frequently used side) of handheld mobile phone users. The rationale for using the individuals within the age group of 19-35 years was individuals may be free from systemic diseases; this age group may involve usage of long time of mobile usage as a means of communication which may influence on the study.

A significantly increased salivary flow was noticed in the right dominant MPH users compared with the non dominant side. Similar results were obtained by the studies done by Goldwein O et al (2009), where they found there was 2.54 fold increase in the salivary secretion rate between the dominant and non-dominant sides.¹ In a study done by Bhargava S et al (2012), on functional and volume related changes which occur in the parotid glands with mobile phone usage found that in heavy user group there was significantly high salivary flow rate, blood flow rate and increased volume of the parotid glands on the dominant side.² A study conducted by Hamzany Y et al (2013), found there was significant increase in the salivary flow rate in mobile phone users as opposed to those who do not use mobile phone.⁸ The results of our finding of increased salivary flow rate concurred with hypothesis stated by Goldwein O et al (2009), that the enriched capillary bed adjacent to the parotid glands may result in an increase of perfusion because of blood vessel propagation over an extensive time of exposure to heat, leading to an increase in the salivary rate flow.

This increased thermal effect may cause secretory parenchymal tissue expansion, which leads to increased salivary flow from the dominant MPH side (1). In subjects whose dominant side was left, the overall unstimulated

parotid flow rate (mean= 0.16) was almost identical to that of the right parotid gland (mean= 0.17). This could be because in our study right dominant side users were more (n=45) and left dominant side users were comparatively less (n=15). A study with large sample size with more left dominant side users might reveal a significant association.⁹ However refuting studies have been reported by Burlage et al (2005) and de Souza FT et al (2015) where they found no significant difference in the overall mean stimulated parotid flow rate measured in healthy subjects for the left and right parotid glands.^{10,11}

In our study, when the usage years of MPH as well as the daily usage of MPH in hrs and salivary flow rate were correlated, weak correlation strength was found between the dominant and non-dominant sides. Similar results were obtained by the studies done by Goldwein O et al (2009), where weak correlation strength was found between the dominant and non-dominant sides and the numbers of years of MPH use.¹ However studies done by Shivashankara AR et al (2015) and de Souza FT et al (2015), found no significant difference in the salivary flow rate in less mobile users and heavy mobile users.^{8,11} More studies should focus on the effects of MPH use in the long run for analyzing changes in salivary gland function.

A significant decrease in mean protein concentration was observed in right parotid gland in subjects whose dominant side was the right, (mean= 2.14) than the protein concentration from the left parotid gland (mean= 2.65). This is in accordance with the study by Hamzany et al (2013) where decrease in protein concentration on dominant side of MPH usage can be explained based on initiation of oxidative stress from the radio frequency electromagnetic radiation (RF-EMR) on the gland which further causes changes in oxidative metabolism leading to decrease in concentration.⁹ The results of our finding of decreased protein concentration in dominant side is in accordance with a study by Andrzejak et al (2008) where it was found that parasympathetic tone increased while the sympathetic

tone decreased during MPH use,¹² This explains the mechanism for decrease in protein concentration in dominant side MPH users as the heat generated from the mobile phone regulates the sympathetic system which in turn affect the protein concentration. In subjects whose dominant side was left, protein concentration (mean= 2.51) was almost identical to that of the right parotid gland (mean= 2.78). This is in accordance with the study by Shivashankara AR et al (2015) & de Souza FT et al (2015) who found no difference in total protein concentration in high mobile phone users, in comparison to less mobile phone users.^{8,11}

Further in our study, a significant decrease in protein concentration was evident with increase in usage years of MPH and the mean daily usage. This is in agreement with a study by Abu khadra KM (2014) who found that there was negative correlation between calling minutes of mobile per day and protein concentration in parotid salivary glands.¹³ However Goldwein O et al (2009), could find no correlation between number of years of MPH and mean daily usage of MPH and protein concentration.¹ More studies with a larger sample size should focus on the long term effects of MPH use for analyzing changes in salivary proteins.

Tables:

Table 1- Depicts salivary flow rate between right & left dominant sides

Comparison of mean salivary flow rate between 2 dominant sides in study participants using student paired t test											
Dominant Side	Parameter	N	Mean	Standard deviation	Standard error of means	Mean	95% Class interval of the Diff		t	df	P-Value
							Lower	Upper			
Right	Salivary flow rate- Right	45	0.20	0.09	0.01	0.04	0.01	0.07	3.336	44	0.002*
	Salivary flow rate- Left	45	0.15	0.08	0.01						
Left	Salivary flow rate- Right	15	0.17	0.09	0.02	0.01	-0.01	0.04	1.099	14	0.29
	Salivary flow rate- Left	15	0.16	0.08	0.02						

* - Statistically Significant

Table 2: Depicts Correlation between dominant and non-dominant sides users of MPH based on the duration (in years) & frequency (hrs) on salivary flow rate depending on usage

Correlation between usage years of Handheld mobile phone & frequency (hrs) with Salivary flow rate			
Parameter	Values	Usage	Dominant/Non dominant salivary flow rate
Usage	R	1	0.047
	P-value		0.36
	N	60	60
Frequency	R	1	0.055
	P-value		0.338
	N	60	60

Table 3- Depicts protein concentration between right & left dominant sides

Comparison of mean Protein Conctn. between 2 dominant sides in study participants using student paired t test											
Dominant Side	Parameter	N	Mean	Standard deviation	Standard error of means	Mean	95% Class interval of the Diff		t	df	P-Value
							Lower	Upper			
Right	Protein concentration-Right	45	2.14	0.76	0.11	-0.50	-0.66	-0.35	-6.670	44	<0.001*
	Protein concentration-Left	45	2.65	0.44	0.07						
Left	Protein concentration-Right	15	2.78	0.50	0.13	0.27	-0.05	0.58	1.783	14	0.09
	Protein concentration-Left	15	2.51	0.84	0.22						

* Statistically Significant

Table 4- depicts correlation between dominant and non-dominant sides users of Handheld mobile phone based on the duration (years) & frequency (hrs) and protein concentration depending on usage

Correlation between usage years of Handheld mobile phone & frequency (hrs) on Protein Conc			
Parameter	Values	Usage	Dominant/Non dominant protein concentration
Usage	r	1	-0.289
	P-value		0.01*
	N	60	60
Frequency	r	1	-0.257
	P-value		0.02*
	N	60	60

*- Statistically Significant

Conclusion

Based on the findings of the study, we can conclude that there was an increase in salivary flow rate in the right dominant side of MPH usage with decreased in protein concentration on the same side. There was a significant decrease in protein concentration on the dominant side with an increase in the mean daily usage & the years of usage of MPH. This continuous insult on salivary glands by MPH can have detrimental effects on teeth and oral mucosa. As our study period was limited and the samples gathered during this period were less, further prospective longitudinal studies with a large sample size will be fruitful to analyze the morphological and physiological changes in salivary gland parenchyma and protein profiling of the affected glands.

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FUNCTION OF SALIVA

Saliva is a very essential digestive juice. It has got many functions, its absence leads to many inconveniences.

☑ Preparation of food for swallowing

☑ Appreciation of taste

☑ Digestive function

Saliva has got 3 digestive enzymes

1. Salivary amylase (cooked starch to maltose)

2. Maltase (maltose to glucose)

3. Lingual lipase (triglycerides of milk fat to fatty acids and diacylglycerol)

☑ Cleansing action

☑ Protective action/ anticariogenic

☑ Certain enzymes (eg: lysozyme) protects the mouth from bacteria

☑ Antimicrobial property (proteins and lactoferrins)

☑ Antibacterial and antiviral property (IgA)

☑ Role in speech

☑ Excretory function

☑ Regulation of body temperature

☑ Regulation of water balance

☑ Diagnostic function - Bio-components present in saliva serve as a diagnostic aid in certain diseases (like HIV, HPV, HSV, candida)

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Final Year BDS Part I