DOI: 10.7860/JCDR/2022/56667.17035

Original Article

Dentistry Section

Effect of Mobile Phone Radiation on Parotid and Submandibular Salivary Glands-An Ultrasonographic Study

MERCY SRAVANTHI YENDLURU[1], PRIYANKA RANA[2], M CHANDRA SEKHAR[3], G DAVID CHAKRAVARTHI[4], D SURESH[5], P NAGAJYOTHI[6], GANDHAM MEGHANA[7], SONI SOLANKE[8]

ABSTRACT

Introduction: In this era of digitalism, mobile phones have become a cultural accessory. Frequent smartphone usage results in possible adverse effects from low radiofrequency radiation and thermal effect emitted by these devices. One of the major concerns is salivary glands as the mobile phones are held against the side of face in close proximity to these glands.

Aim: To assess the effect of cell phone radiation on the volume, systolic velocity, salivary flow rate of parotid and submandibular gland between the dominant and non dominant side of mobile phone users.

Materials and Methods: A cross-sectional study was conducted in the Department of Oral Medicine and Radiology, Government Dental College and Hospital, Kadapa, Andhra Pradesh, India, from September to November 2021. The sample size of 100 (50 males and 50 females). Inclusion criteria were based on the frequency of mobile phone usage of more than two hours per day. Mobile phone usage was determined based on patient's answer to the questionnaire. Ultrasonography (USG) of both parotid and submandibular gland was done bilaterally to measure the volume of the glands and colour doppler of external carotid artery to measure systolic velocity. Modified Schirmer tear strips were used bilaterally to measure unstimulated salivary flow rate. The data was entered into MS excel and significance was calculated using independent sample t-test.

Results: In parotid gland, mean volume, mean systolic velocity and mean salivary flow rate were of higher value in the dominant side (14.22±2.17 mL; 15.14±3.74 cm/s; 0.37±0.26 mm/5 mins) compared to the non dominant side (13.76±2.14 mL; 14.53±3.39 cm/s; 0.24±0.2 mm/5 mins). In submandibular gland, mean volume, mean systolic velocity and mean salivary flow rate were of higher value in the dominant side (9.60±1.96 mL; 15.70±6.44 cm/s; 0.30±0.22 mm/5 mins) compared to the non dominant side (8.88±2.17 mL; 13.87±4.83 cm/s; 0.26±0.21 mm/5 mins).

Conclusion: The volume, systolic velocity of blood flow, the salivary flow rate, of the parotid gland and submandibular gland were significantly more on the dominant side than the non dominant side of mobile phone usage. The study emphasised that prolonged mobile phone usage causes biological changes in salivary glands and its flow rate.

Keywords: Colour doppler, Salivary flow rate, Systolic velocity

INTRODUCTION

As the world is becoming more and more digital, smartphones have become a common place as well as a cultural accessory. More than six billion people are smartphone users today and this number is expected to rise within a few years. With this, the number and length of phone calls have also increased considerably [1]. Mobile phones works both as receiver and transmitter where it emits heat and Radiofrequency Radiation (RFR) within the frequency range of 800-2200 MHz [1,2]. The RFR can access subcellular structures in this frequency range since the outer membranes of mammalian cells are no longer barriers to electric fields [3].

The salivary glands are one of the concerns as the mobile phones are typically held up against the side of the face where these glands are located. Due to long-term use and proximity to the adjacent tissues, heat and RFR emitted can be absorbed by the tissues resulting in elevated temperature and modified cutaneous blood flow [4,5].

The literature demonstrates the potential health risks associated with mobile phone use. Mobile phones influence the heart rate. The sympathetic tone increase and parasympathetic tone decrease during mobile phone use. This suggests that the electromagnetic field generated may affect the autonomic nervous system by modulating the function of the circulatory system [4]. Multiple studies have examined links of mobile phone use with salivary gland malignancies [6-10]. There are conflicting studies on whether mobile phone emissions (heat and radiation effects) might induce significant physiologic, anatomical, functional, or even carcinogenic alterations in the human body [1,2,11].

The present study was conducted with the aim to evaluate any possible changes in the salivary glands that may happen due to the long-term usage of mobile phones by determining gland volume, its systolic velocity and salivary flow rate and comparing it between dominant and non dominant side of same individuals. Although, studies have been done to know the effect of mobile phone radiation on parotid gland, very little research has been conducted to evaluate the effect of mobile phone usage on submandibular salivary glands [4,6]. This study was conducted keeping in mind that because of the increasing size of mobile phones and dual sim properties of recent mobile phone there is increased radiation due to dual receiver-transmission properties. Only the parotid and submandibular glands were evaluated using Ultrasonography (USG) as they are in easier accessible areas for imaging than the sublingual and minor salivary glands [12].

MATERIALS AND METHODS

A cross-sectional study was conducted in the Department of Oral Medicine and Radiology, Government Dental College and Hospital, Kadapa, Andhra Pradesh, India, from September to November 2021. Ethical clearance was not taken as no therapeutic intervention was undertaken. A total of 100 students who use only smartphones (50 males and 50 females) were selected based on the inclusion and exclusion criteria.

Sample size calculation: All the samples were taken from undergraduates of the dental college based on convenience sampling method. The sample size was calculated based on data from previous similar study using the formula [4]:

$$n = \frac{2\sigma^2 + \left(z_\beta + z_{\alpha/2}\right)^2}{\Delta^2}$$

Inclusion criteria: Individuals who belonged to the age range of 19-29 years, had a history of smartphone usage of more than two years, used smartphone for an average of at least two hours per day and prominently used smartphones on one side were included.

Exclusion criteria: Participants with any history of trauma, systemic disease, salivary gland disorders, metabolic disorders, long-term drug history, adverse habits or drug abuse or recent exposure to medical investigatory radiation, or frequent usage of handsfree devices like microphones or bluetooth devices for voice calls were excluded. The handsfree devices are a confounding factor and its usage has been kept in exclusion criteria as they do not affect the salivary glands.

After taking informed consent, each individual was asked to fill a preformed questionnaire about his/her mobile phone usage habit, followed by a detailed intraoral examination [13]. The questionnaire was devised by the authors based on data from previous study [13]. Intraoral examination was conducted to rule out any trauma, diseases or disorders that could have an effect on salivary flow rate. The questionnaire collected subjective data which was not used for analysis.

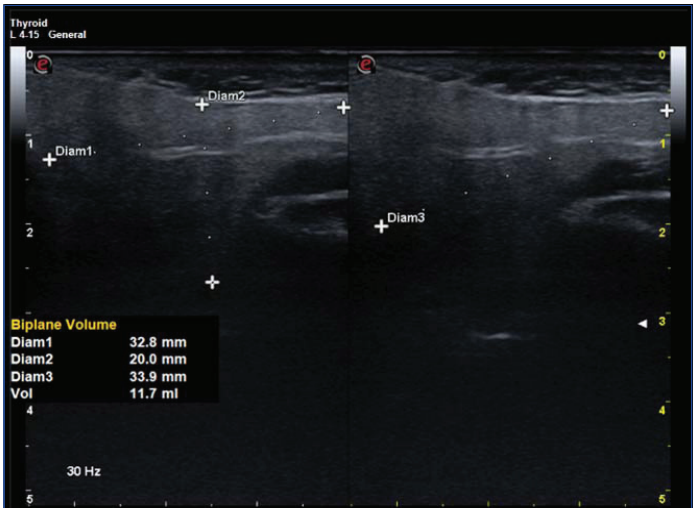
The dominant side was determined as the side more frequently used while talking on the phone and the less frequently used side was considered as the non dominant side.

Ultrasonography (USG) of both superior lobe of parotid gland and submandibular gland was performed bilaterally for all the 100 participants using Toshiba USG machine using a 4 cm imaging linear probe of 5-10 MHz and volume of the glands were recorded in millilitre (mL).

Study Procedure

The patients were examined in a supine position with neck extended and head slightly turned to the side opposite to the gland when examining parotid gland and with a mild tilt of the head upwards when examining the submandibular glands [14].

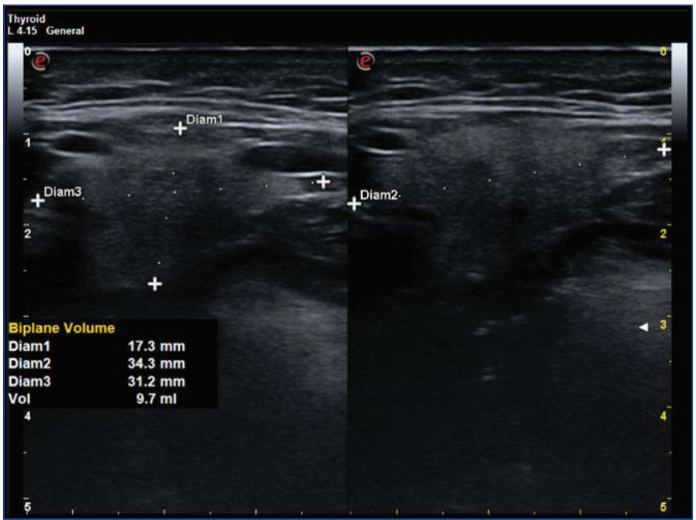
The glands were examined for the echogenicity and the biplane volume of the glands were calculated after measuring the Length (L), antero-posterior length (AP) and width (W) [Table/Fig-1,2]. Colour doppler was used to evaluate the blood flow through the transverse facial artery (branch of superficial temporal artery) to the parotid gland and through the facial artery (branch of external carotid artery) to the submandibular gland [15]. The systolic velocity of blood flow through the glands was measured in cm/sec [Table/Fig-3].



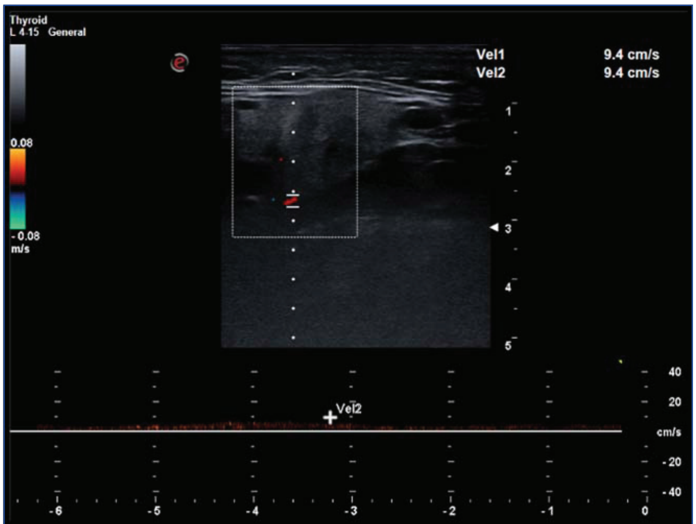
[Table/Fig-1]: Biplane volume of parotid gland.

As the USG process is operator dependent, all the imaging was done on the same machine by the same radiologist who was blinded to dominant side to avoid observer expectancy bias.

The salivary flow rate was measured in between 9-12 AM and all the participants were asked not to brush, eat or drink an hour before the procedure. The Modified Schirmer Test (MST) strip was used to measure the salivary flow rate. The MST is a 4 cm strip of filter paper that is calibrated at 1 mm intervals throughout its length from 5-35 mm. (tear touch- Madhu Instruments Pvt Limited, New Delhi, India) [4].



[Table/Fig-2]: Biplane volume of submandibular gland.



[Table/Fig-3]: Velocity of arterial blood flow of submandibular gland.

The participants were asked to relax for five minutes before the procedure. They were made to sit upright on the dental chair and asked to swallow all the saliva. After proper isolation using cotton pellets, rounded end of the strip was kept at the opening of Stenson's duct for a period of five minutes using tweezers [Table/Fig-4]. The strip was removed and graduated scale on the strip was referred to record the salivary flow rate as mm/5 mins. The same process was then done on the other side and for the wharton's duct at the floor of the mouth beside the lingual frenum for the submandibular glands [Table/Fig-5]. The salivary flow rate measured was unstimulated rather than stimulated as the glands are in their resting phase during most of the day and to record their activity in this phase only [Table/Fig-6].


[Table/Fig-4]: Measurement of salivary flow rate from parotid papilla.
[Table/Fig-5]: Measurement of salivary flow rate from submandibular gland opening.
(Images from left to right)

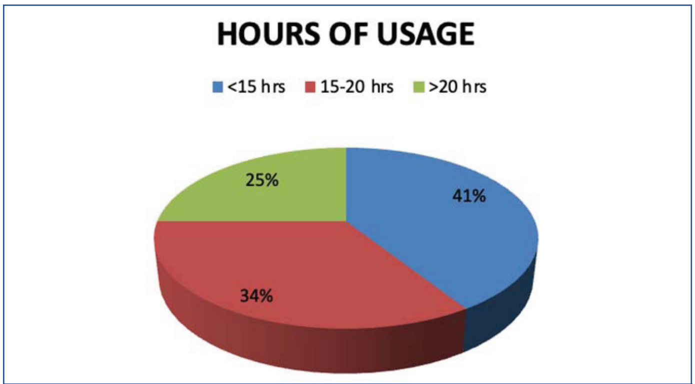
[Table/Fig-6]: Modified schirmer tear test strip.

STATISTICAL ANALYSIS

All the data was recorded and entered into MS excel for statistical analysis and independent sample t-test was used. The level of significance was set at a p-value of less than or equal to 0.05.

RESULTS

A total of 100 volunteers participated in the study (50 male and 50 female) with age range between 19-29 years with mean age being 22.4±1.4 years. Around 49% of these had a history of mobile phone usage of five years or more and 51% have been using it for less than five years but more than three years. The average usage of smartphone by all the participants was 17.73±6.56 hours per week [Table/Fig-7]. Out of the total, 18 (18%) used left side as their dominant side and 82 (82%) used right as their dominant side.



[Table/Fig-7]: A pie chart depicting hours of usage of smartphone per week.

In parotid gland, higher mean volume was recorded on dominant side 14.22±2.17 mL compared to non dominant side (13.76±2.14 mL) but the difference between them was not statistically significant (p>0.05). In parotid gland, higher mean systolic velocity was recorded on dominant side as compared to non dominant side but the difference between them was also not statistically significant p=0.014 [Table/Fig-8].

In submandibular gland, higher mean volume was recorded on dominant side compared to non dominant side and the difference between them was statistically significant (p<0.05). In submandibular gland, higher mean systolic velocity was recorded on dominant side (15.70±6.44 cm/s) compared to non dominant side (13.87±4.83 cm/s) and the difference between them was statistically significant p=0.024.

Gland	Parameter	Side	Obtained values	p-value
Parotid gland	Volume (mL)	Dominant	14.22±2.17	0.131
		Non dominant	13.76±2.14	
	Systolic velocity (cm/s)	Dominant	15.14±3.74	0.228
		Non dominant	14.53±3.39	
	Salivary flow rate (mm/5 mins)	Dominant	0.37±0.26	<0.001*
		Non dominant	0.24±0.2	
Subm-andibular gland	Volume (mL)	Dominant	9.60±1.96	0.014*
		Non dominant	8.88±2.17	
	Systolic velocity (cm/s)	Dominant	15.70±6.44	0.024*
		Non dominant	13.87±4.83	
	Salivary flow rate (mm/5 mins)	Dominant	0.30±0.22	0.198
		Non dominant	0.26±0.21	

[Table/Fig-8]: Parameters of dominant and non dominant sides of parotid and submandibular gland.
*denotes significant difference
Test of significance used: student t-test with level of significance (α=0.05)

In parotid gland, significantly higher mean salivary flow rate was recorded on dominant side as compared to non dominant side (p<0.001). however, non significant higher mean salivary flow rate was recorded on dominant side (0.30±0.22 mm/5 mins) compared to non dominant side (p>0.05) in submandibular gland [Table/Fig-8].

Submandibular volume on the dominant side was found to be a significant factor in predicting the submandibular salivary flow (p<0.01). Submandibular volume can be used to explain up to 41.7% of the variation in predicting submandibular salivary flow. Using linear regression analysis r^2 adjusted value was calculated.

None of the other parameters were found to be significant in predicting the salivary flow rate [Table/Fig-9].

In parotid gland, on the dominant side, both mean volume and systolic velocity were higher in females than males. Similarly, on the non dominant side, females had a higher mean systolic velocity when compared to males, but both were found to be statistically non significant [Table/Fig-10]. In submandibular gland, a higher mean volume was seen in males than females which was statistically significant on the dominant side as well as on the non dominant side. The mean systolic velocity on the both dominant and non dominant sides was also higher in males and was statistically non significant [Table/Fig-10,11].

Salivary flow rate of parotid and submandibular gland had a higher mean in males than females on both dominant and non dominant sides [Table/Fig-10,11].

Side	Gland	Parameter	Constant	β	SE (β)	R2	p-value	95% CI for β	
								Lower bound	Upper bound
Dominant	Parotid	Volume	0.033	0.020	0.024	0.043	0.408	-0.030	0.070
		Systolic velocity	0.266	0.004	0.015	0.004	0.808	-0.028	0.035
	Submandibular	Volume	-0.199	0.049	0.014	0.417	0.004*	0.018	0.080
		Systolic velocity	0.233	0.002	0.005	0.007	0.743	-0.009	0.013
Non dominant	Parotid	Volume	0.247	0.009	0.014	0.005	0.524	-0.019	0.037
		Systolic velocity	0.338	0.002	0.008	0.001	0.768	-0.014	0.019
	Submandibular	Volume	0.116	0.020	0.013	0.028	0.131	-0.006	0.046
		Systolic velocity	0.365	-0.004	0.004	0.009	0.403	-0.012	0.005

[Table/Fig-9]: Predicting salivary flow rate.
*denotes significant difference; Test of significance used: student t-test with level of significance (α=0.05)

Gland	Parameter	Gender	N	Mean	Std Dev	t	p-value
Parotid gland	Volume	Male	50	14.21	2.03	-0.046	0.964
		Female	50	14.23	2.33		
	Systolic velocity	Male	50	14.98	3.09	-0.445	0.657
		Female	50	15.31	4.31		
	Salivary flow rate	Male	50	0.38	0.27	0.484	0.629
		Female	50	0.35	0.24		
Subm-andibular gland	Volume	Male	50	10.19	1.68	3.141	0.002*
		Female	50	9.01	2.06		
	Systolic velocity	Male	50	16.47	7.29	1.205	0.231
		Female	50	14.92	5.42		
	Salivary flow rate	Male	50	0.31	0.24	0.582	0.562
		Female	50	0.29	0.20		

[Table/Fig-10]: Comparison of different parameters between male and female on the dominant side.
*denotes significant difference
Test of significance used: student t-test with level of significance (α=0.05)

Gland	Parameter	Gender	N	Mean	Std dev	t	p-value
Parotid gland	Volume	Male	50	13.88	2.16	0.554	0.581
		Female	50	13.64	2.13		
	Systolic velocity	Male	50	14.25	3.66	-0.826	0.411
		Female	50	14.81	3.12		
	Salivary flow rate	Male	50	0.25	0.21	0.232	0.817
		Female	50	0.24	0.20		
Subma-ndibular gland	Volume	Male	50	9.73	1.88	4.265	<0.001*
		Female	50	8.02	2.13		
	Systolic velocity	Male	50	14.54	5.91	1.391	0.167
		Female	50	13.20	3.37		
	Salivary flow rate	Male	50	0.27	0.19	0.134	0.894
		Female	50	0.26	0.22		

[Table/Fig-11]: Comparison of different parameters between male and female on the non dominant side.
*denotes significant difference
Test of significance used: student t-test with level of significance (α=0.05)

Parameter		Phone Us-age	n	Mean	Std Dev	SE of mean	Mean differ-ence	t	p-value
Parotid gland	Volume	<5 yrs	49	14.58	2.14	0.31	0.697	1.616	0.109
		≥5 yrs	51	13.88	2.17	0.30			
	Velocity	<5 yrs	49	14.57	3.67	0.52	-1.117	-1.503	0.136
		≥5 yrs	51	15.69	3.75	0.53			
Subma-ndibular	Volume	<5 yrs	49	9.81	1.63	0.23	0.410	1.044	0.299
		≥5 yrs	51	9.40	2.24	0.31			
	Velocity	<5 yrs	49	15.48	5.22	0.75	-0.436	-0.337	0.737
		≥5 yrs	51	15.91	7.47	1.05			
Salivary flow rate	Parotid	<5 yrs	49	0.41	0.26	0.04	0.084	1.639	0.104
		≥5 yrs	51	0.32	0.26	0.04			
	Subma-ndibular	<5 yrs	49	0.30	0.23	0.03	-0.001	-0.019	0.987
		≥5 yrs	51	0.30	0.21	0.03			

[Table/Fig-12]: Comparison of salivary parameters according to phone usage tenure: dominant side.
*denotes significant difference
Test of significance used: student t-test with level of significance (α=0.05)

There was an overall increase in salivary gland volume, salivary flow rate and systolic velocity on the side where mobile phone is frequently used and statistically significant difference was found between salivary flow rate and volume of parotid gland on the non dominant side with the subsequent increase in the number of years of usage. [Table/Fig-12,13]. Statistically significant difference was also found between salivary flow rate of parotid gland and volume of parotid and submandibular gland on the dominant side with the subsequent increase in the number of hours of usage [Table/Fig-14]. Statistically significant difference was also found between salivary flow rate of parotid gland and volume of parotid gland on the non dominant side with the subsequent increase in the number of hours of usage [Table/Fig-15].

Parameter		Phone usage	N	Mean	Std Dev	SE of mean	Mean Differ-ence	t	p-value
Parotid gland	Volume	<5 yrs	49	14.21	2.00	0.29	0.885	2.103	0.038*
		≥5 yrs	51	13.33	2.20	0.31			
	Velocity	<5 yrs	49	14.07	3.62	0.52	-0.901	-1.332	0.186
		≥5 yrs	51	14.97	3.14	0.44			
Subma-ndibular	Volume	<5 yrs	49	9.14	1.77	0.25	0.527	1.215	0.227
		≥5 yrs	51	8.62	2.49	0.35			
	Velocity	<5 yrs	49	13.07	3.66	0.52	-1.568	-1.636	0.105
		≥5 yrs	51	14.64	5.67	0.79			
Salivary flow rate	Parotid	<5 yrs	49	0.29	0.23	0.03	0.094	2.366	0.020*
		≥5 yrs	51	0.20	0.16	0.02			
	Subma-ndibular	<5 yrs	49	0.25	0.22	0.03	-0.018	-0.438	0.662
		≥5 yrs	51	0.27	0.20	0.03			

[Table/Fig-13]: Comparison of salivary parameters according to phone usage tenure: non dominant side.
*denotes significant difference
Test of significance used: student t-test with level of significance (α=0.05)

DISCUSSION

The aim of the present study was to find the association between the effect of mobile phone radiation on salivary glands between the dominant and non dominant side of mobile phone users. USG which has been established as the first choice of imaging modality for salivary gland imaging was used as it is non invasive, uses high frequency pulsed ultrasound beam rather than ionising radiation to give high resolution images of superficial structures rather than Computed Tomography (CT) or Magnetic Resonance Imaging (MRI). The colour doppler feature which allows the blood flow to be detected at the same time is an added benefit [16,17].

Furthermore, it is easier to evaluate the parotid and submandibular glands using USG because of the encapsulation than the sublingual and minor salivary glands [12]. Results of similar studies have been tabulated in [Table/Fig-16] [4,18-20].

There are two means in which mobile phone usage can affect the human tissues due to radiofrequency field. One is due to prolonged conversations as the mobile phone heats up leading to increased temperature of the tissue in contact. This increase in temperature can lead to parenchymal changes like expansion which in turn could be the cause of altered volume of salivary glands [18]. This was similar to results of present study where there was increased volume on the dominant side when compared to the non dominant side in both parotid glands as well as submandibular glands. The second way could be the RFR influencing the autonomic nervous system by affecting the circulatory system leading to changes in the heart rate and hence the altered blood flow to the salivary glands [18,21].

Handsfree devices such as earphones, headphones and earpods are a confounding factor and its usage has been kept in exclusion criteria as they do not affect the salivary glands.

There was a difference in mean volume of both the parotid and submandibular salivary glands which could be attributed to the physiological difference in male and female salivary glands.

The present study showed that both the volume and salivary flow rate were seen higher in the parotid gland than the submandibular gland. This could be attributed to the fact that the direct heating effect of mobile phone radiation is seen more on parotid gland than the submandibular gland which could lead to increase in size as well as volume especially on the dominant side [4].

Parameter		Weekly usage	n	Mean	Std Dev	SE of mean	95% CI for mean		F	p-value	Sig. diff between
							Lower bound	Upper bound			
Parotid gland	Volume	1. <15 hrs	41	14.12	1.69	0.26	13.58	14.65	3.435	0.036*	1 vs 2 (p=1.000)
		2. 15-20 hrs	34	13.69	2.49	0.43	12.81	14.56			1 vs 3 (p=0.187)
		3. >20 hrs	25	15.13	2.21	0.44	14.22	16.04			2 vs 3 (p=0.033)
	Velocity	1. <15 hrs	41	15.30	4.49	0.70	13.88	16.72	0.293	0.747	1 vs 2 (p=1.000)
		2. 15-20 hrs	34	15.32	2.66	0.46	14.39	16.25			1 vs 3 (p=1.000)
		3. >20 hrs	25	14.64	3.74	0.75	13.10	16.19			2 vs 3 (p=1.000)
Submandibular	Volume	1. <15 hrs	41	9.15	1.91	0.30	8.55	9.75	5.320	0.006*	1 vs 2 (p=0.007)
		2. 15-20 hrs	34	9.37	2.01	0.35	8.67	10.08			1 vs 3 (p=0.007)
		3. >20 hrs	25	10.65	1.65	0.33	9.97	11.33			2 vs 3 (p=0.035)
	Velocity	1. <15 hrs	41	16.01	7.06	1.10	13.79	18.24	2.042	0.135	1 vs 2 (p=1.000)
		2. 15-20 hrs	34	16.89	7.02	1.20	14.44	19.33			1 vs 3 (p=0.399)
		3. >20 hrs	25	13.56	3.64	0.73	12.06	15.07			2 vs 3 (p=0.152)
Salivary flow rate	Parotid	1. <15 hrs	41	0.34	0.25	0.04	0.26	0.42	6.618	0.002*	1 vs 2 (p=1.000)
		2. 15-20 hrs	34	0.29	0.24	0.04	0.20	0.37			1 vs 3 (p=0.018)
		3. >20 hrs	25	0.51	0.24	0.05	0.41	0.62			2 vs 3 (p=0.002)
	Submandibular	1. <15 hrs	41	0.28	0.21	0.03	0.21	0.34	0.549	0.580	1 vs 2 (p=0.903)
		2. 15-20 hrs	34	0.33	0.22	0.04	0.25	0.41			1 vs 3 (p=1.000)
		3. >20 hrs	25	0.31	0.23	0.05	0.21	0.40			2 vs 3 (p=1.000)

[Table/Fig-14]: Comparison of salivary parameters according to phone usage duration: dominant side.
*denotes significant difference; Test of significance used: One-Way ANOVA followed by Bonferroni Multiple Comparisons test with level of significance (α=0.05)

Parameter		Weekly usage	n	Mean	Std dev	SE of mean	95% CI for Mean		F	p-value	Sig diff between
							Lower bound	Upper bound			
Parotid gland	Volume	1. <15 hrs	41	14.23	2.02	0.31	13.60	14.87	4.985	0.009*	1 vs 2 (p=0.014)
		2. 15-20 hrs	34	12.86	2.41	0.41	12.01	13.70			1 vs 3 (p=1.000)
		3. >20 hrs	25	14.22	1.53	0.31	13.59	14.85			2 vs 3 (p=0.041)
	Velocity	1. <15 hrs	41	14.81	3.56	0.56	13.69	15.94	1.989	0.142	1 vs 2 (p=1.000)
		2. 15-20 hrs	34	15.04	3.36	0.58	13.87	16.21			1 vs 3 (p=0.290)
		3. >20 hrs	25	13.38	3.02	0.60	12.14	14.63			2 vs 3 (p=0.194)
Submandibular	Volume	1. <15 hrs	41	8.60	2.29	0.36	7.87	9.32	2.247	0.111	1 vs 2 (p=1.000)
		2. 15-20 hrs	34	8.63	2.19	0.38	7.87	9.40			1 vs 3 (p=0.160)
		3. >20 hrs	25	9.66	1.81	0.36	8.92	10.41			2 vs 3 (p=0.214)
	Velocity	1. <15 hrs	41	13.47	4.05	0.63	12.19	14.75	1.975	0.144	1 vs 2 (p=0.405)
		2. 15-20 hrs	34	15.14	6.59	1.13	12.84	17.44			1 vs 3 (p=1.000)
		3. >20 hrs	25	12.80	2.34	0.47	11.83	13.76			2 vs 3 (p=0.197)
Salivary flow rate	Parotid	1. <15 hrs	41	0.22	0.20	0.03	0.15	0.28	7.951	0.001*	1 vs 2 (p=1.000)
		2. 15-20 hrs	34	0.19	0.17	0.03	0.13	0.24			1 vs 3 (p=0.004)
		3. >20 hrs	25	0.37	0.20	0.04	0.29	0.46			2 vs 3 (p=0.001)
	Submandibular	1. <15 hrs	41	0.24	0.20	0.03	0.18	0.30	0.541	0.584	1 vs 2 (p=0.907)
		2. 15-20 hrs	34	0.29	0.21	0.04	0.22	0.36			1 vs 3 (p=1.000)
		3. >20 hrs	25	0.26	0.23	0.05	0.17	0.35			2 vs 3 (p=1.000)

[Table/Fig-15]: Comparison of salivary parameters according to phone usage duration: non dominant side.
*denotes significant difference; Test of significance used: One-Way ANOVA followed by Bonferroni Multiple Comparisons test with level of significance (α=0.05)

Monfrecola G et al., also described that cell phone radiations can change cutaneous blood flow and cause increase in skin perfusion when the gadget is placed near to the skin [5]. Similar results were seen in present study where systolic blood velocity was increased on dominant side when compared to the non dominant side.

In the present study, there was an overall increase in salivary gland volume, salivary flow rate and systolic velocity on the dominant side and statistically significant difference was found between salivary flow rate and volume of parotid gland on the non dominant side with the subsequent increase in the number of years of usage. Statistically significant difference was also found between salivary flow rate of parotid gland and volume of parotid and submandibular gland on the dominant side with the subsequent increase in the number of hours of usage. Statistically significant difference was also found between salivary flow rate of parotid gland and volume of parotid gland on the non dominant side with the subsequent increase in the number of hours of usage. An increase in the washing out of acids (and sugars) and concentration of bicarbonate buffer and of remineralising ions occurred as a result of stimulation of saliva flow [22].

Mobile phones were classified as group 2B agents, potentially carcinogenic to humans, by the World Health Organisation and the International Association for Research on Cancer on June 1, 2011, and many nations have suggested measures to reduce mobile radiation exposure [3]. Use of handsfree to reduce radiation to the head, keeping the mobile phone away from the body, not using the phone in a car without an external antenna and moderate use of mobile phones for youngsters are just a few examples of such measures.

Sl no.	Author's name and year	Place of study	Number of subjects	Age considered	Parameters assessed	Conclusion
1.	Goldwein O and Aframian DJ (2010) [18]	Jerusalem, Israel	50	19-33 years	Rate of parotid salivary secretion and protein concentration in saliva	Increase in the salivary secretion and protein concentration
2.	Bhargava S et al., (2012) [19]	Maharashtra, India	142	18-30 years	Unstimulated parotid salivary flow rate	Increased salivary flow rate, blood flow rate, and volume of parotid glands.
3.	Ranjitha GE et al., (2017) [4]	Tamil Nadu, India	50	17-27 years	Volume, systolic velocity of blood flow of the external carotid artery, the salivary flow rate, and protein concentration of the parotid gland	Volume, systolic velocity of blood flow of the external carotid artery, the salivary flow rate, and protein concentration of the parotid gland were significantly more on the dominant side.
4.	Pattipati S et al., (2015) [20]	Telangana, India	50	17-27	Parotid salivary secretion rate	Salivary secretion rate was significantly less on the dominant side of mobile phone usage.
5.	Present study	Andhra Pradesh, India	100	19-29	Parotid and submandibular gland volume, systolic velocity, salivary flow rate	Overall increase in salivary gland volume, salivary flow rate and systolic velocity on the side where mobile phone was frequently used.

[Table/Fig-16]: Results of previous literature [4,18-20].

Limitation(s)

The limitations of this study are that the sample size is small and factors like the frequency of phone usage, geographic location, location of towers etc. were not considered.

CONCLUSION(S)

In the present study, there is an overall increase in salivary gland volume, salivary flow rate and systolic velocity on the side where mobile phone was frequently used and statistically significant difference has been found between salivary flow rate and volume with the subsequent increase in the number of hours and years of usage.

More long term studies are needed to be done along with other parameters like oxidative stress and free radicals with keeping in mind the frequency of phone usage, geographic location, location of towers etc.

REFERENCES

[1] Khurana VG, Teo C, Kundi M, Hardell L, Carlberg M. Cell phones and brain tumors: A review including the long-term epidemiologic data. Surg Neurol. 2009; 72(3):205-14.
[2] Johansen C, Boice JD, McLaughlin JK, Olsen JH. Cellular telephones and cancer- A nationwide cohort studies in Denmark. J Natl Cancer Inst. 2001;93(3):203-07.
[3] Awadalla H. Health effects of mobile phone. Webmed Central Public Health 2013;04.
[4] Ranjitha GE, Austin RD, Ramasamy S, Bharathi CS, Angeline D, Sambasivam S. Influence of handheld mobiles on parotid: A cohort study. J Indian Acad Oral Med Radiol. 2017;29(4):254-58.
[5] Monfrecola G, Moffa G, Procaccini EM. Nonionizing electromagnetic radiations, emitted by a cellular phone, modify cutaneous blood flow. Dermatology. 2003;207(1):10-14.
[6] Sadetzki S, Chetrit A, Jarus-Hakak A, Cardis E, Deutch Y, Duvdevani S, et al. Cellular phone use and risk of benign and malignant parotid gland tumors-A nationwide case-control study. Am J Epidemiol. 2008; 167(4):457-67.
[7] Duan Y, Zhang HZ, Bu RF. Correlation between cellular phone use and epithelial parotid gland malignancies. Int J Oral Maxillofac Surg. 2011;40(9):966-72.
[8] Hardell L, Hallquist A, Hansson Mild K, Carlberg M, Gertzén H, Schildt EB, et al. No association between the use of cellular or cordless telephones and salivary gland tumours. Occup Environ Med. 2004;61(8):675-79. Doi: 10.1136/oem.2003.011262. PMID: 15258273; PMCID: PMC1740821.
[9] Auvinen A, Hietanen M, Luukkonen R, Koskela RS. Brain tumors and salivary gland cancers among cellular telephone users. Epidemiology. 2002;13(3):356-59.
[10] De Souza FT, Correia-Silva JF, Ferreira EF, Siqueira EC, Duarte AP, Gomez MV, et al. Cell phone use and parotid salivary gland alterations: no molecular evidence. Cancer Epidemiol Biomarkers Prev. 2014;23(7):1428-31. Doi: 10.1158/1055-9965.EPI-13-1357. Epub 2014 Apr 21. PMID: 24753545.
[11] Bhargavi K, Balachandrud KE, Nageswar P. Mobile phone radiation effects on human health. Int J Comput Eng Res 2013;3(4):196-203.
[12] Fang KM, Wen MH, Hsu WL, Chang CM, Hou PY, Liao LJ. Ultrasonographic and elastographic biometry in adult major salivary glands: A preliminary case-control report. Sci Rep. 2019;9(1):8885.
[13] Samkange-Zeeb F, Berg G, Blettner M. Validation of self-reported cellular phone use. J Expo Anal Environ Epidemiol. 2004;14(3):245-48.
[14] El-Rasheedy, Abdalla, Hassanein , S.Ah, Hafez TARA, Aboel-naga HA. The role of ultrasound in evaluating salivary glands swellings. Egypt J Otolaryngol. 2021;37:101-06.
[15] Carotti M, Salaffi F, Manganelli P, Argalia G. Ultrasonography and colour doppler sonography of salivary glands in primary Sjögren's syndrome. Clin Rheumatol. 2001;20(3):213-19.
[16] Riyaz MA. Diagnostic salivary gland imaging- A Review. Integr J Med Sci. 2021;8:01-03.
[17] Whaites, Eric. Essentials of Dental Radiography and Radiology. Edinburgh: Churchill Livingstone; 2007.
[18] Goldwein O, Aframian DJ. The influence of handheld mobile phones on human parotid gland secretion. Oral Diseases. 2010;16(2):146-50.
[19] Bhargava S, Motwani MB, Patni VM. Effect of handheld mobile phone use on parotid gland salivary flow rate and volume. Oral Surg Oral Med Oral Pathol Oral Radiol. 2012;114(2):200-06.
[20] Pattipati S, Velugubantla RG, Balmuri PK, Pachigolla R, Khaitan T, Ginjupally U. Are we telephoning ourselves to an upcoming danger? J Indian Acad Oral Med Radiol. 2015;27(2):178-82.
[21] Kodavanji B, Mantur VS, Kumar NA, Pai SR. A pilot study on long term effects of mobile phone usage on heart rate variability in healthy young adult males. J Clin Diagn Res. 2012;6:346-49.
[22] de Almeida Pdel V, Grégio AM, Machado MA, de Lima AA, Azevedo LR. Saliva composition and functions: A comprehensive review. J Contemp Dent Pract. 2008;9(3):72-80.

PARTICULARS OF CONTRIBUTORS:
1. Assistant Professor, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Kadapa, Andhra Pradesh, India.
2. Postgraduate, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Kadapa, Andhra Pradesh, India.
3. Professor and Head, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Kadapa, Andhra Pradesh, India.
4. Assistant Professor, Department of Radiology, Government Dental College and Hospital, Kadapa, Andhra Pradesh, India.
5. Assistant Professor, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Kadapa, Andhra Pradesh, India.
6. Senior Lecturer, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Kadapa, Andhra Pradesh, India.
7. Postgraduate, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Kadapa, Andhra Pradesh, India.
8. Postgraduate, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Kadapa, Andhra Pradesh, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Priyanka Rana,
Postgraduate, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Kadapa, Andhra Pradesh, India.
E-mail: priyankarana65@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Apr 01, 2022
- Manual Googling: Jul 21, 2022
- iThenticate Software: Jul 23, 2022 (16%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? No
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: Mar 26, 2022
Date of Peer Review: Apr 25, 2022
Date of Acceptance: Jul 25, 2022
Date of Publishing: Oct 01, 2022