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An Observational Study to Evaluate Impact of Mobile Phone Usage on Hearing in Central Indian Population

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Abstract

The mobile phone is an essential part of communication in the 21st century. However, the widespread popular use of the mobile phone device has also given rise to cautious apprehensions regarding the health hazards that might originate due to usage of the mobile phones or due to close proximity of the user to the radiofrequencies emitted from the device itself and also from the base stations. To study the impact of mobile phone usage on hearing, this study was conducted in central Indian population, included 120 mobile phone users and non-users each, between the age group of 18-35 years. Objectives of the study was to evaluate the hearing changes in mobile phone users and non-users. To compare and correlate the hearing changes based on the hours of exposure, duration of exposure and type of exposure.

In this study, heating sensation of ears (27%) followed by blocked sensation in ears (16%), tinnitus (10%) and difficulty in hearing (4%) were the main symptoms in the study group at the time of presentation. The study and control groups were found to be comparable with respect to the sex distribution. In group 1, 5% and 3% of cases had minimal sensory-neural hearing loss in the right and left ears respectively, while in group 2, 2% had sensory-neural hearing loss in the left ear only. Sensory-neural hearing loss in the right ear was seen to be statistically significant with a p value < 0.05. None of the subjects in the control group had any symptoms at the time of presentation.

Keywords: mobile phones, radio frequency radiation, Global System for Mobile Communication (GSM) radiation, Microwaves, otoscopy.

Introduction

The mobile phone is a ubiquitous piece in this modern world. Of particular concern to the World Health Organization (WHO) is the fact that, if any adverse health effect is established from mobile phone use, it will be a global concern because developing countries are establishing this technology in preference to the more expensive fixed line systems. Thus, even a small impact on health could have a major public health consequence.

Mobile phones are low power radio devices that transmit and receive radio frequency radiation at frequencies in the microwave range. The skin, inner ear, cochlear nerve and the temporal lobe surface absorb the radiofrequency energy. The extensive use of mobile phones has been accompanied by public debate on the possible adverse effects on human health. The concerns relate to the

emissions of radio frequency (RF) radiation from the mobile phones and the base stations that receive and transmit the signals. There are two direct ways by which health could be affected as a result of exposure to RF radiation [1]. These are thermal (heating) effects caused mainly by holding mobile phones close to the body and also as a result of possible non-thermal effects. The well-liked belief is that adverse health effects can be induced mostly by the heating effect of Global System for Mobile Communication (GSM) radiation. The reported adverse health effects and the extensive portfolio of non-thermal effects that have been published in the scientific literature during the last few years, indicates that the kind of radiation now used in GSM phone can and does affect living organisms in various non-thermal ways. Phones emit a pulsed high-frequency electromagnetic field (PEMF)[2] which may penetrate the scalp and the skull. These electromagnetic fields are known to alter distinct aspects of the brain's electrical response to acoustic stimuli. The extensive exposure to microwave radiation has been found to affect a wide variety of brain functions[3] such as electrical activity, electrochemistry,[4,5] permeability of the blood brain barrier [6] and immune system[7]. Microwaves are known to non-thermally affect the dopamine-opiate system [8,9] of the brain and to increase the permeability of the blood-brain barrier[10]. Exposure to high-density microwaves can cause detrimental effects on the eyes, testis and other tissues and induce significant biologic changes through thermal actions[11]. The temporal region near the phone antenna appeared to be under the most intensive heating. Ultrahigh frequency radiation[12] induces significant changes in local temperature and in physiologic parameters of central nervous and cardiovascular systems. Besides a hypnotic effect[13] with shortening of sleep onset latency, a REM suppressive effect with reduction of duration and percentage of REM sleep was also found. The number of complaints was higher for people using the digital (GSM) system with pulse modulated fields, than for those using the analogue Nordisk Mobile telecommunication [14] (NMT) system. Radiofrequency exposure from mobile phones is concentrated to the tissue closest to the handset, which includes the auditory nerve[15]. The effects on neuronal electrical activity, energy metabolism, genomic responses, neurotransmitter balance, blood-brain barrier permeability, cognitive function, auditory function, sleep, and various brain diseases including brain tumors are of concern. Most of the reported effects are small as long as the radiation intensity remains in the non-thermal range, and none of the research reviewed gives an indication of the mechanisms involved at this range.

Keeping in view the hazards of mobile phones, the present study was designed to investigate the association of use of mobile phones and hearing loss.

Materials and Methods

The prospective study was conducted in the Department of Otorhinolaryngology – Head & Neck Surgery, Sri Shankaracharya Institute of Medical Sciences, Bhilai over a period of 1 year from May 2017 To May 2018. An ethical clearance was obtained from the institutional committee prior the study. The study included 120 mobile phone users and non-users each, between the age group of 18-35 years.

***Inclusion criteria*:** for the study was age group between 18-35 years, >1 year of mobile phone usage, minimum usage of > 1hour/day.

***Exclusion criteria*:** included subjects those with hearing aids/implants, History of CSOM, History of head trauma or head fracture, Family history of hearing defects, People exposed to constant noise pollution/ noisy working environment.

A sample size of 120 cases and control each was selected from the OPD patients, Institutional staff and colleagues

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randomly keeping the inclusion and exclusion criteria in mind.

The study was divided into two groups:

- Group 1 - using mobile phones more than 1 hour/day for more than 1 year
- Group 2 - no usage or using for less than 1 hour for less than 1 yr.

All the candidates were informed in detail regarding the study and their informed consent was taken for their voluntary participation in the study. All candidates were subjected to a detailed history taking with special emphasis on duration, pattern, years of usage and type of mobile phone and hearing loss. Detailed enquiry was made about the onset and progression of hearing loss if any. An enquiry was made into any associated illnesses like diabetes mellitus and systemic hypertension. Any history of childhood ear discharge was asked for. The occupational exposure to loud noise and personal habits like smoking and alcohol was asked for and recorded. Detailed clinical examination was performed including a general systemic examination and thorough examination of the ear using otoscope. The character of the tympanic membrane was observed in detail. The three standard tuning fork tests (Weber's, Rinne's and Absolute Bone Conduction tests) were done. All candidates underwent a pure tone audiometry and all cases with an intact tympanic membrane underwent immittance studies. Pure tone audiograms were assessed for type and percentage of hearing loss.

Instrumentation and materials -A detailed questionnaire for the complaints and examination findings was filled for each patient in a proforma. ENT examination was done by tuning forks – (Gardiner Brown Tuning Forks of 256Hz, 512Hz, and 1024 Hz) and otoscopy done by a Heine Quality pocket otoscope.

For Audiological test battery- A routine Pure Tone Audiogram (0.25 to 8 kHz) was done for all subjects for assessing the air conduction and bone conduction thresholds and the audiogram was plotted. For Tympanometry, the immitance test was done for all subjects using a conventional 226Hz low probe tone frequency. In all cases the middle ear peak pressure, the external auditory canal volume and the peak compliance values were recorded.

Statistical analysis was done using Pearson's Chi-square test and unpaired t-test and p-value of < 0.05 was considered as significant. Categorical variables are expressed as Number of patients and percentage of patients and compared across the 2 groups using Pearson's Chi Square test for Independence of Attributes. Continuous variables are expressed as Mean ± Standard Deviation and compared across the 2 groups using unpaired t test. The statistical software SPSS version 16 has been used for the analysis. An alpha level of 5% has been taken, i.e. if any p value is less than 0.05 it has been considered as significant.

The primary outcome of the study was the presence or absence of hearing loss and the secondary outcomes were the presence of associated symptoms besides hearing loss amongst the subjects of the study group of mobile phone users.

Results

Statistical analysis was done using Pearson's Chi-square test and unpaired t-test and p-value of < 0.05 was considered as significant.

The mean age of the subjects in the study and control group was 23.35 and 22.7 years respectively. The p value was 0.13 which was not statistically significant.

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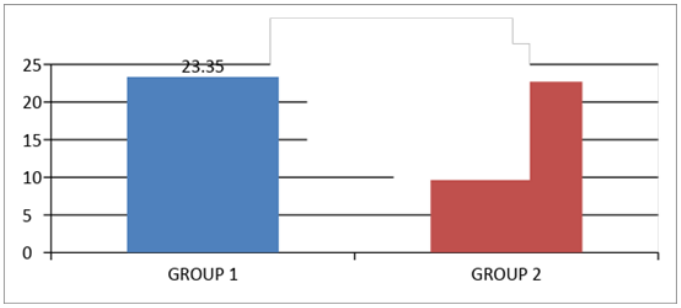
Table 1: Age distribution

	GROUP		P Value	Significance
	GROUP 1	GROUP 2		
	Mean ± Std. Deviation	Mean ± Std. Deviation		
Age (Years)	23.35 ± 2.99	22.7 ± 3.61	0.13	Not Significant

Graph 1: Age distribution

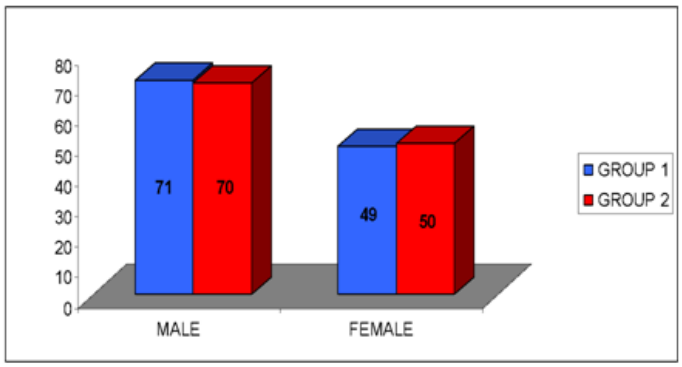


There were 59% males in the study group and 58% males in the control group whereas there were 41% females in the study group and 42% females in the control group.

Table 2: Sex Distribution

	GROUP				
SEX	GROUP 1	GROUP 2	Total	P Value	Significance
MALE	71(59%)	70(58%)	141(59%)	>0.05	Insignificant
FEMALE	49(41%)	50(42%)	99(41%)		
Total	120(100%)	120(100%)	240(100%)		

Graph 2: Sex Distribution

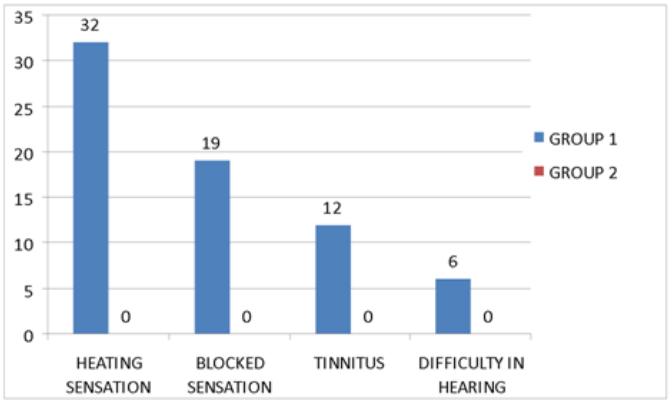


The two groups were found to be comparable with respect to the sex and age distribution. Heating sensation of ears (27%) followed by blocked sensation in ears (16%), tinnitus (10%) and difficulty in hearing (4%) were the main symptoms in the study group at the time of presentation (Table: 3, Figure: 3). None of the subjects in the control group had any symptoms at the time of presentation.

Table 3: Symptoms on Presentation

Symptoms on presentation	Group 1	Group 2	p value
Heating sensation	27%	0%	< 0.001 (significant)
Blocked sensation	16%	0%	< 0.001 (significant)
Tinnitus	10%	0%	< 0.001 (significant)
Difficulty in hearing	4%	0%	0.024 (significant)

Graph 3: Symptoms on Presentation

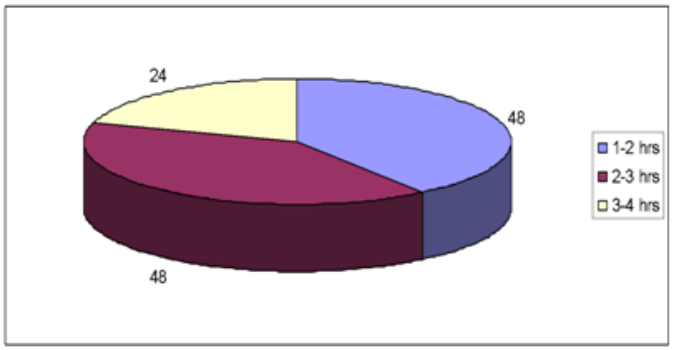


In our study group 48(40%) subjects had 1 – 2 hours of exposure, 48(40%) had 2 – 3 hours and 24(20%) had 3 – 4 hours exposure to mobile phone per day (Figure 4). The p value was found to be < 0.001 which is statistically significant.

Table 4: Number of hours of exposure in the study group

Hours of exposure (per day)	Number of subjects	Percentage
1-2 hours	48	40%
2-3 hours	48	40%
3-4 hours	24	20%

Graph 4 : Hours of Exposure (Group 1).



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In our study group, 6 subjects were detected to have sensory-neural hearing loss out of which 3(6.25%) subjects used mobile phone for 2-3 hours per day and 3(12.5%) subjects used mobile phone for 3-4 hours per day for 2-3years. Mean years of exposure to mobile phones in group 1 was 2.47 years, while that of group 2 was 0.22 years with a p- value < 0.001 which was statistically significant.

Table 5 : Years of Exposure

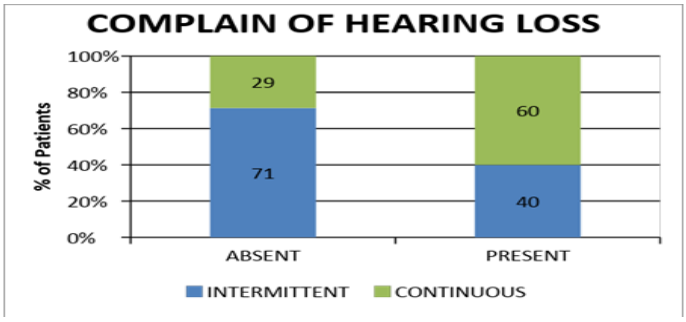
	GROUP		P Value	Significance
	GROUP 1	GROUP 2		
	Mean ± Std. Deviation	Mean ± Std. Deviation		
Years of Exposure	2.47 ± 0.65	0.22 ± 0.26	<0.001	Significant

In our study group, out of 6 subjects who had hearing loss, 3 used mobile phones for 2-3 years and 3 used mobile phones for 3-4 years. Types of exposure noted in the study group were either intermittent or continuous (Figure 5), where continuous exposure was seen to be associated more with the minimal sensory-neural hearing loss noted in the study group, the association of which was compounded by the increasing hours and years of exposure. Exposure was of intermittent type in the control group.

Table 6: Type of Exposure

Type of Exposure	Group		Total	P Value	Significance
	Group 1	Group 2			
Intermittent	84(70%)	120(100%)	204(85)	<0.001	Significant
Continuous	36(30%)	0(0%)	36(15)		
Total	120(100%)	120(100%)	240(100)		

Graph 5: Complain of Hearing Loss Vs Type of Exposure



Sensory-neural hearing loss (SNHL) was seen in 5 % (6 out of 120 subjects) of the study group and 2 % (2 out of 120) in the control group.

Table 7: Type of Deafness (Right Ear)

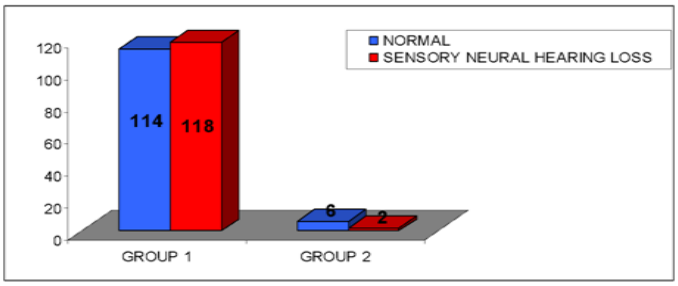
Type of Deafness Right	Group		Total	P Value	Significance
	Group 1	Group 2			
No deafness	114(95%)	120(100%)	234(98%)	0.013	Significant
SNHL	6(5%)	0(0)	6(3%)		
Total	120(100%)	120(100%)	240(100%)		

Table 8: Type of Deafness (Left Ear).

Type of Deafness Left	GROUP		Total	P Value	Significance
	Group 1	Group 2			
No deafness	117(98%)	118(98%)	235(98%)	0.651	Not Significant
SNHL	3(3%)	2(2%)	5(2%)		
Total	120(100%)	120(100%)	240(100%)		

In group 1, 5% and 3% of cases had minimal sensory-neural hearing loss in the right and left ears respectively, while in group 2, 2% had sensory-neural hearing loss in the left ear only. Sensory-neural hearing loss in the right ear was seen to be statistically significant with a p value < 0.05.

Graph 6: Type of Deafness



Hearing Loss

In 5% of the study group hearing loss was noted. Analysis of the data showed that the mean pure tone average in the study group was 13.7 and 14.5 dB for right and left ears respectively which was higher than the control group. This indicates that although the pure tone average was within normal limits for both study and control group yet the hearing thresholds were higher for the study group and the difference in hearing thresholds between study and control group was statistically significant. It was also noted that the increase in hearing threshold observed in the 6 subjects was in the 2kHz, 4kHz and 8kHz frequencies.

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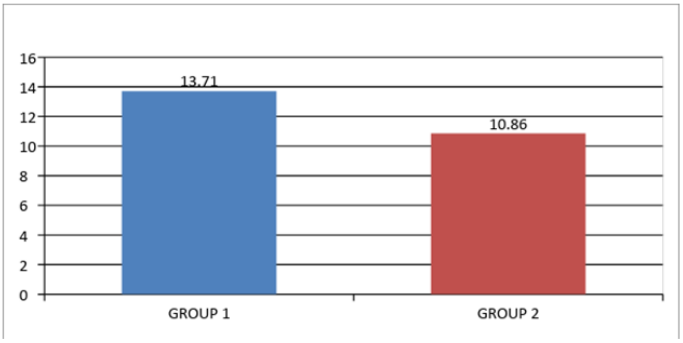
Table 9 : Pure Tone Average Left and Right

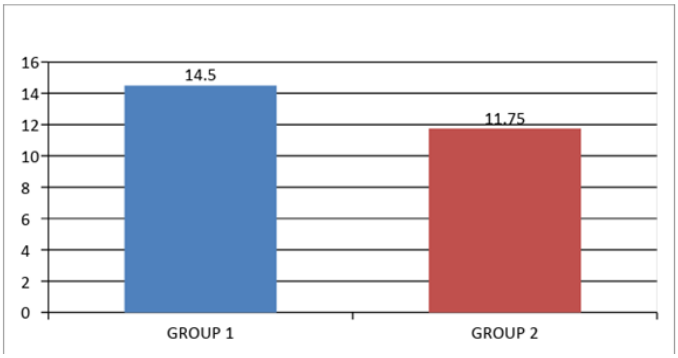
	GROUP	P Value		
	GROUP 1	GROUP 2	Significance	
	Mean ± Std. Deviation	Mean ± Std. Deviation		
Pure Tone Average Right	13.71 ± 5.61	10.86 ± 4.6	<0.001	Significant
Pure Tone Average Left	14.5 ± 5.44	11.75 ± 4.53	<0.001	Significant

Table 10: Hearing Loss

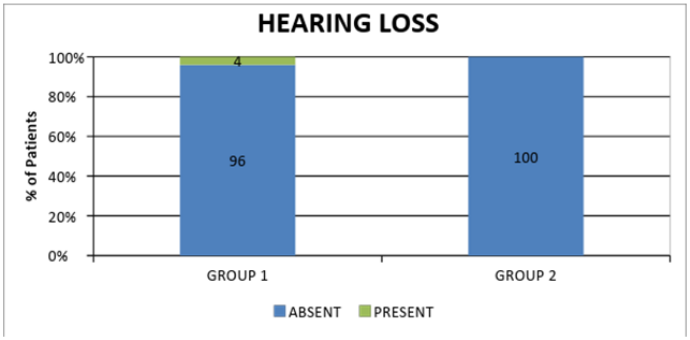
Sensorineural Hearing Loss	GROUP		Total	P Value	Significance
	Group 1	Group 2			
ABSENT	114(96)	120(100)	235(98)	0.024	Significant
PRESENT	6(4)	0(0)	5(2)		
Total	120(100)	120(100)	240(100)		



Graph 7: Pure Tone Average (Right)



Graph 8 : Pure Tone Average (Left)



Graph 9: HEARING LOSS

Discussion

Following observations were found after completion of the study;

The mean age (in years) of the subjects in the study and control group was 23.35 and 22.7 respectively. Male to female ratio in group 1 was 1.45:1 and in group 2 it was 1.4:1. The two groups were statistically insignificant with respect to the sex and age distribution ($p > 0.05$).

Heating sensation of ears (27%) followed by blocked sensation in ears (16%), tinnitus (10%) and difficulty in hearing (4%) were the main symptoms in the study group at the time of presentation. The control group did not present with any symptoms at the time of study. All the mentioned symptoms were found to be statistically significant.

In our study group 48(40%) subjects had 1 – 2 hours of exposure, 48(40%) had 2 – 3 hours and 24(20%) had 3 – 4 hours exposure to mobile phone per day. The p value was found to be < 0.001 which is statistically significant. Six subjects were detected to have sensory-neural hearing loss out of which 3(6.25%) subjects used mobile phone for 2-3 hours per day and 3(12.5%) subjects used mobile phone for 3-4 hours per day for 2-3years.

Mean period of exposure to mobile phones in group 1 was 2.47 years, while that of group 2 was 0.22 years with a p-value < 0.001 which was statistically significant.

Types of exposure noted in the study group were either intermittent or continuous where continuous exposure was seen to be associated more with the minimal sensory-neural hearing loss noted in the study group, the association of which was compounded by the increasing hours and years of exposure. Exposure was of intermittent type in the control group.

Sensory-neural hearing loss (SNHL) was seen in 5 % (6 out of 120 subjects) of the study group which was found to be statistically significant.

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In group 1, 5% and 3% of cases had minimal sensory-neural hearing loss in the right and left ears respectively, while in group 2, 2% had sensory-neural hearing loss in the left ear only. Sensory-neural hearing loss in the right ear was seen to be statistically significant with a p value < 0.05.

Pure tone average in the study group was 13.7 and 14.5 dB for right and left ears respectively which was higher than the control group. This indicates that although the pure tone average was within normal limits for both study and control groups, yet, the hearing thresholds were higher for the study group and the difference in hearing thresholds between study and control group was statistically significant. It was also noted that the increase in hearing threshold observed in the 6 subjects was in the 2kHz, 4kHz and 8kHz frequencies.

In this study, heating sensation of ears (27%) followed by blocked sensation in ears (16%), tinnitus (10%) and difficulty in hearing (4%) were the main symptoms in the study group at the time of presentation. None of the subjects in the control group had any symptoms at the time of presentation. In contrast, in a study conducted by Thamir l-Khlaiwi et al [32], the overall mean percentage for presenting complaints in all groups were headache (21.6%), sleep disturbance (4%), tension (3.9%), fatigue (3%) and dizziness (2.4%). Sultan A Meo SA et al[34] in a study showed about 34.59% of problems were related with impaired hearing, ear ache and/or warmth on the ear, and 5.04% of complaints with the decreased and/or blurred vision.

In our study, 3 of those who have been using mobile phone since 2 years had SNHL (sensory-neural hearing loss) and 3 of those who have been using it since 3 years had SNHL. The minimal hearing loss noted in the study group depended not only on years of exposure, but also on the hours of exposure per day and type of exposure and it was noted that with the increase in hours of exposure per day and years of exposure the incidence of hearing loss also increased. Naresh K. Panda et al [34] found no significant difference was found for high frequency hearing loss, DPOAE (distortion product oto-acoustic emissions), ABR (auditory brain stem response) and MLR in the users. High frequency hearing loss was seen in subjects using the phone for more than 4 years (P= 0.040).

In our study, we also observed that none of the subject in the study group suffered from significant hearing loss (0-25dB hearing loss is taken for all practical purposes as normal). This correlates with the findings of Harry C Davidson H C et al [34]. High or long-term users reported no worse hearing, tinnitus, or balance than low or short-term users. However there were no harmful effects of mobile phone usage on their audio vestibular systems within the range of exposure of the study, in so far as can be detected by the self-report method employed.

Similarly, in a study done by Uwe Sievert et al [35] to investigate the biological effect of the high frequency radiation produced by the Global System for Mobile Communications (GSM) mobile phone on the inner ear with its sensors of the vestibular and auditory systems showed that the electromagnetic fields generated in using the mobile phone do not have an effect on the inner ear and auditory system to the colliculus inferior in the brainstem and on the vestibular receptors in the inner ear and the vestibular system.

Although none in our study group had significant hearing loss, we observed an increase in hearing threshold between 5-15dB in the study group especially in those exposed to mobile phone usage for more than 2 hours/day, more so if the pattern of usage is continuous. This relates to the study done by García Callejo FJ et al[37] he found audiometric curve was similar in cases and controls at the beginning of the study. After this follow-up, cases showed an increase on hearing threshold between 1 and 5 dB HL more than controls in speech tones (p<0.001).

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Our findings were also in agreement with the study done by M Faruk Oktay et al[37] Brainstem evoked response audiometric (BERA) results showed no differences among the groups ($p > 0.05$). In PTA measurements, no differences were observed between moderate mobile phone users (10-20 min. per day) and control subjects. However, detection thresholds in those who talked approximately 2 h per day were found to be higher than those in either moderate users or control subjects. However, detection thresholds in those who talked approximately 2 h per day were found to be higher than those in either moderate users or control subjects. Differences at 4000 Hz for both bone and air conduction for right ears, and 500 Hz, and 4000 Hz bone and air conduction for left ears were significant for mean hearing threshold. This study shows that a higher degree of hearing loss is associated with long-term exposure to electromagnetic (EM) field generated by cellular phones.

A case of sensory-neural hearing loss due to Global System for Mobile Communications mobile was reported in Saudi medical journal in 2007.[39]

While, those in our study with mobile phone usage of less than 2 hour/day showed normal audiometric curves which can be related to study done by Uwe Sievert et al[40] in 12 healthy test persons, with normal hearing. Auditory brain stem reflexes recordings were performed before, during, and after exposure to electromagnetic emissions by standardized mobile phone devices. Two modes of electromagnetic emissions fields were administered: pulsed and continuous. For acoustic stimulation simultaneous to field exposure, special "plug-in" earphones had to be used. There are no adverse effects of mobile phone emissions on the ear function, at least on a short-term range.

Conclusion

To conclude, our study did not show any significant hearing loss in mobile phone users since 0-25dB hearing loss is taken for all practical purposes as normal. But still we observed a minimal hearing loss of 5-15dB in those exposed to mobile phone usage of more than 2 hours per day, the pattern of use being continuous. Also noted was that the threshold was raised for the high frequencies which are not calculated under routine pure tone average. Hence we recommend a long term follow up study in long term mobile users before we can come to a definitive conclusion.

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