Effect of mobile phone use on hearing status of medical students of tertiary healthcare hospital

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Abstract
The present study was carried out to evaluate the hearing status in chronic mobile phone users and alteration in hearing status depending on years of mobile usage, per day use and longest dialogue duration in a day. This was a cross sectional observational study. Preliminary questionnairewas asked to MBBS students of a medical college and 60 volunteers were selected who were using mobile phones for at least 1 year and not having any other causes of hearing loss. In the study group, dominant ear of the subjects was included and non-dominant ear was considered as a control group. Pure tone Audiometry was done to evaluate the hearing status. Out of 60 subjects, in 76.66% subjects, right ear was dominant and in 23.33% of subjects, left ear was dominant for mobile use 52 (86.66%) dominant ears had normal hearing and 8 (13.33%) had hearing loss in high frequencies (4000 and 8000 Hz). Hearing was normal in non- dominant ear of all subjects. Mean hearing threshold in dominant ear was 10.54 $\pm$ 5.75 dB while in non-dominant ear, it was 6.67 $\pm$ 3.76 dB. The difference was statistically significant (p value <0.05). Hearing loss in the dominant ear was seen in subjects who were using mobile phones for 1-3 hours per day, with total duration of use > 3years and in those with longest call duration of >30 minutes. Our conclusion is that hearing threshold increases in dominant ear with long term use of mobile phone and hearing loss is more in higher frequencies in such subjects.

Keywords: Audiometry, Dominant ear, Hearing loss, Pure tone.

Introduction
Mobile phones are in use since 1983. It receives and transmits signals using Electromagnetic fields (EMF) in radiofrequency bands through a network of base stations. Currently, most widely used digital mobile phone service is Global System for mobile Communications (GSM) which operates at 900 to 1800 MHz frequency bands.(1) Medical literatures report that mobile phone use may cause lack of concentration, dizziness, discomfort, headache, skin burning sensation. More adverse health problems caused by mobile phones are sleep disturbances, impairment of short-term memory and even significant increase in the frequency of seizures in epileptic children, brain tumour, increased blood pressure. The effect of EMFs leading to cancer is still a subject of debate and research.(2)

The inner ear, is the direct recipient of Electro-Magnetic Radiations (EMR), so it is a commonly affected organ. Use of "hands-free" devices provide a much lower exposure to the radiofrequency fields than that of holding the handset against their head.(3) Listening to music using headphones has become one of the most popular functions of mobile phones apart from making and receiving calls. Usually, high intensity sound is delivered via headphones. Hair cells of organ of corti are sensitive to chronic exposure to loud noise and don't have regenerative properties. Hence, the ear is at risk of exposure to noise from mobile phone as well as to the EMR emitted by the device.

Substantial number of studies have been conducted to evaluate the effect of mobile phones on hearing. There is increased degree of hearing loss with its long-term use than its short-term use. The present study was conducted with the aims and objectives to evaluate the hearing status in chronic mobile phone users and the impact of long-term exposure to mobile phones, to study the effect of total duration use per day and total years of usage of mobile phone on hearing and to compare the hearing status of dominant versus non-dominant ears of mobile phone users.

Material and Methods
It was a cross-sectional, observational study. It was carried out in the department of ENT, tertiary health care institute of central India. Institutional ethics committee approval was achieved. 60 healthy M.B.B.S. students of medical institute were selected, based on the preliminary questionnaire which included, if they use mobile phone or not, what is the average duration of their daily use of mobile phone, what is the maximum duration of a call, what is the total duration of usage (in years), which ear is often used with mobile phone (dominant ear) etc. Those fulfilling inclusion criteria were included in the study. M.B.B.S. students of medical institute using mobile phones for at least a year and ready to participate in the study voluntarily were included in the study. Students with hard of hearing due to tympanic membrane perforation, secretary otitis media, otosclerosis, exposure to loud noise without adequate protection, head injury, and ototoxic drug intake were excluded from the study. Users of bluetooth devices, portable music players and hands-free devices

and the subjects with bilateral hearing loss were also excluded from the study.

Consent of participants was obtained after informing them about the purpose and the procedure of the study. Dominant ear of the subjects was taken as Study Group and non-dominant ear (not used or rarely used with mobile phone) as control group. Detail ENT examination including otoscopic examination and Tuning Fork Tests were done by senior ENT surgeon to rule out any ear disease. Pure tone audiometry was done using "ELKON eda Giga 3" audiometer and frequencies used were 250, 500, 1000, 2000, 4000 and 8000 Hz. Audiologist was not knowing about the dominant ear and non-dominant ear of the subject thus making it a single blind study. Pure tone Audiometry was done by using Carhart and Jerger's technique (5 up and 10 down technique).[4]

Subjects having hearing threshold of 25dB and below were considered as normal hearing and those having hearing threshold above 25dB from the air conduction threshold level, the deafness can be graded into several categories like below.[5]

≤ 25dB – Normal, 26- 40dB – Mild hearing impairment, 41- 60dB – Moderate hearing impairment, 61-70dB – Severe hearing impairment, 71-90dB – Profound hearing impairment, 91dB and above – Total deafness.

The data from case record forms were tabulated in a Microsoft Excel spreadsheet. Chi square test, fischer exact test and student t-test were used for analysis. P values <0.05 was considered statistically significant.

Results

In this study, 60 healthy M.B.B.S students were included. Mean age of study participants was 20.5 years (SD ± 1.14) with agerange of 18 to 23 years. Among these 60 students, females were 42 (70%) and 18 (30%) were males thus females outnumbered males. Almost all participants were using the mobile phone on only one ear (dominant ear). We grouped dominant ear as a study group and non-dominant ear (not used with mobile phone) as control group. Among our subjects, 46 (76.66%) were dominant on right ear and 14 (23.33%) were dominant on left ear.

As shown in Table 1, out of all 60 students, 52 (86.66) had normal hearing level while 8 subjects (13.33%) found to have sensorineural hearing loss in dominant ear. Non-dominant ear in all students had hearing level with in a normal range (0-25 dB). The difference was statistically significant with p value of < 0.05 under fischer exact test.

Table 1: Distribution of subjects according to hearing status in dominant and Nnon-dominant ear (n=60)

Group	Hearing Status		Total
	Normal Hearing N (%)	Hearing Loss N (%)	
Dominant ear	52 (86.66%)	8 (13.33%)	60
Non-dominant ear	60 (100%)	0	60

Fisher exact test, p value= 0.006 (p value < 0.05- statistically significant)

As shown in Table 2, mean hearing threshold of dominant ear was 10.54± 5.75 dB and that of non-dominant ear of mobile users was 6.67 ± 3.76 dB. The difference was statistically significant with p value < 0.05 using t- Test.

Table 2: Comparison of mean hearing threshold in dominant ear and non-dominant ear in mobile phone users

	Dominant ear (N= 60)	Non-dominant ear (N= 60)	t- test	P value*
Mean Hearing Threshold ± SD (in dB)	10.54 ± 5.75	6.67 ± 3.76	4.36	0.0002

*p value < 0.05- Statistically Significant

As shown in Fig. 1, frequency specific mean hearing threshold in dominant and non-dominant ear, in all subjects was found to be within normal limit but Hearing threshold in all frequencies in dominant ear was increased than that of non-dominant ear and this was a statistically significant difference at all frequencies with p value < 0.001under t-test.

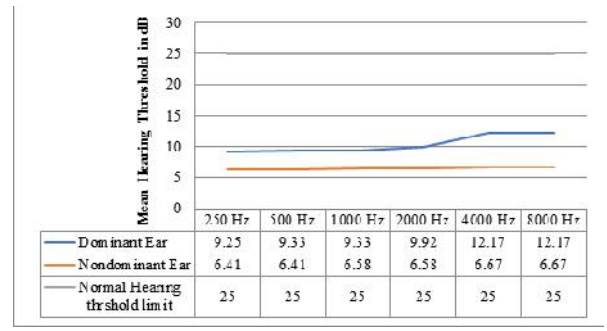

Fig. 1: Frequency specific mean hearing threshold in dominant and non-dominant ears in all subjects

On studying frequency specific hearing threshold in 8 subjects having hearing loss, mean hearing threshold was 31.25 dB (SD ± 2.31) at both 4000 and 8000 Hz indicating mild hearing loss in dominant ear at high frequencies. Mean hearing threshold in lower frequencies was normal. In non-dominant ear, hearing threshold in all frequencies was normal. (Table 3)

Table 3: Frequency specific mean hearing threshold in dominant and non-dominant ears in 8 subjects having hearing loss

Frequency	Mean hearing threshold ± SD (in dB)		P value*
	Dominant ear	Non-dominant ear	
250 Hz	15 ± 3.8	8.75± 2.31	0.0013 (HS)
500 Hz	15 ± 3.8	8.75± 2.31	0.0013 (HS)
1000 Hz	15 ± 3.8	8.75± 2.31	0.0013 (HS)
2000 Hz	16.25 ± 4.43	8.75± 2.31	0.0008 (HS)
4000 Hz	31.25 ± 2.31	9.38 ± 1.77	< 0.0001(HS)
8000 Hz	31.25 ± 2.31	9.38 ± 1.77	< 0.0001(HS)

Paired t- Test used. * p value< 0.05- Statistically significant, HS- Highly significant

Table 4 shows that, out of 60 subjects, maximum subjects i.e. 30 students were using mobile phone for 30-60 minutes per day and 19 subjects were using it for 60 min to 3 hours followed by 11 subjects using it for 15- 30 minutes per day for making or receiving calls. We couldn't find any subject using mobile phone for <15 minutes or > 3hours per day for making or receiving calls.

On studying the relation between total duration of use of mobile per day with hearing loss, we found that, out of 30 subjects with mobile phone usage for 30mins – 1 hour per day, 27 subjects (90%) had normal hearing while 3 subjects (10%) were having mild hearing loss. Out of 19 subjects with mobile phone usage between 1-3 hours per day, 14 subjects (73.68%) had normal hearing while 5 subjects (26.31%) had mild hearing loss. All 11 subjects, using mobile phones between 15-30 minutes per day had normal hearing as shown in Table 4. The difference was statistically insignificant. (fischer exact test p value >0.05)

Table 4: Distribution of subjects according to total duration of usage of mobile phone per day and its relationship with hearing loss in dominant ear (n= 60)

Total duration of usage per Day	No. of Subjects (N=60)	Hearing Status in dominant ear	
		Normal hearing N (%)	Hearing loss N (%)
<15 min	0	0	0
15- 30 min	11	11 (100%)	0
30 min-1 hour	30	27 (90%)	3 (10%)
1- 3 hours	19	14 (73.68%)	5 (26.31%)
> 3 hours	0	0	0
Total	60	52 (86.66%)	8 (13.33%)

For statistical analysis subjects were grouped in < 30 mins mobile usage per day and > 30 mins per day. Fischer Exact Test- p value = 0.35

As shown in Table 5, on studying the relationship of Longest dialogue duration in a day with hearing loss, 1 subject (4.36%) out of 23 was found to have hearing loss whose longest dialogue duration in a day was of 10- 20 minutes. 3 subjects (23.08%) out of 13 had hearing loss with longest dialogue duration on mobile in a day between 20- 30 minutes. 4 (36.36%) out of 7 subjects longest dialogue duration in a day of >30 minutes. With use of Chi square test, there was statistically significant association between dialogue duration and hearing loss (p<0.05).

Table 5: Distribution of subjects according to longest dialogue duration (in min) in a day and its relation with hearing loss in dominant ear (n= 60)

Longest dialogue duration (in min) in a day	No. of Subjects (N=60)	Hearing status in dominant ear	
		Normal hearing N (%)	Hearing loss N (%)
<10 mins	13	13 (100%)	0
10-20 mins	23	22 (95.65%)	1(4.35%)
20-30 mins	13	10 (76.92%)	3 (23.08%)
>30 mins	11	7(63.63%)	4 (36.36%)
Total	60	52 (86.66%)	8 (13.33%)

Chi square test value= 9.72, p value =0.02, statistically significant (p value<0.05- statistically significant)

As shown in Table 6, 3 students, using mobile phones between 1-2 years had no hearing loss. Out of 15 subjects with mobile phone usage for 2-3 years, 1 subject (6.66%) had hearing loss in high frequencies. 7 subjects (16.66%) out of 42 had hearing loss who were using mobile phone for >3 years. On statistical analysis with Fisher Exact test, p value was insignificant (p>0.05).

Table 6: Distribution of subjects according to total duration of usage of mobile phone in years and its relationship with hearing loss in dominant ear (n= 60)

Total duration of usage in years	No. of subjects	Hearing status in dominant ear	
		Normal hearing N (%)	Hearing loss N (%)
<1 year	0	0	0
1-2 years	3	3	0
2-3 years	15	14 (93.33%)	1(6.66%)
>3 years	42	35 (83.33%)	7 (16.66%)
Total	60	52 (86.66%)	8 (13.33%)

For statistical analysis subjects were grouped in < 3 years of mobile usage and > 3 years.
Fischer exact test- p value = 0.47 (Statistically not significant)

It appears that longer duration of dialogue, long usage of mobile per day and long duration of total

usage years of mobiles phones can predispose to hearing loss.

Discussion

There has been a growing concern about possible detrimental effects of use of mobile phone on health. First organ that receives thermal and non-thermal effects of mobile phone is inner ear as it is in close proximity to the ear. The present study was conducted to evaluate the effect of mobile phone on hearing function by means of pure tone audiometry. In a randomized comparative case control study conducted by Prajapati et al,[6] 60 healthy volunteers were included. Mean age of the study group was 26.17 ± 2.65 years and that of the control subjects 26 ± 3.93 years. In the study done by Hegde et al,[7] participants' age ranged from 18 to 30 years and in the study of Velayutham et al,[8] mean age of the volunteers was 27 years with age range between 20- 45 years. In the present study, age range of healthy MBBS students was between 18-23 years and mean age was 20.5 ± 1.14 years. In most of the studies, participants were young adults.

Preferred ear for mobile usage: Velayutham et al[8] in his study found that, in 63% subjects, dominant ear was the right ear and in 22% subjects,left ear was dominant whereas 15% had no preference. In Karthikeyan et al[9] study, in 80% of subjects, right ear was dominant for mobile use and left ear was dominant in 8 % users. In our study, in 76.63% subjects, right ear was dominant for making and receiving calls and left ear was dominant in 23.33%.

Mobile usage and hearing loss: In Shayani Nasab et al[10] study, in both the users and non-users of mobile telephones,Mean pure-tone thresholds (250 to 8000 HZ) were +0.12 ± 5.93 dB and -3 ± 4.73 dB, respectively which was statistically significant difference (*P* value < 0.01). In Prajapati et al[6]study, the mean hearing lossat high frequenciesin both the ears in study group was of 8.47 ± 4.15 dB and in control group, it was 0.33 ± 1.826 dB. This difference was statistically significant. The study done by Velayutham et al[8] showed statistically significant loss in high frequencies in dominant ear as compared to non-dominant ear (p< 0.05) under Chi- square tests. In his study, 62% volunteers had normal hearing while 38% had hearing loss greater than 20 dB in frequencies between 250 and 16000Hz. In Hegde et al[7] study, sensorineural hearing loss was observed in 26.6% of subjects in study group and in 3.3% subjects incontrol group. We found statistically significanthigh frequency hearing loss in dominant ear in 13.33% of all subjects. Mean hearing threshold (250 to 8000 HZ) in all subjectsin dominant ear was 10.54 ± 7.57 dB and that in non-dominant ear was 6.67 ± 3.76 dB. Our findings are consistent with above mentioned studies.

Total years of exposure: In Panda et al[11]study, high frequency hearing loss was found in those subjects who were using the phone for more than 4 years (*P* = 0.04). Patel et al[12] found mild to moderate high frequency hearing loss in 87.5% of subjects using mobile for 2-4 years and moderate high frequency hearing loss in all subjects using mobile phone for>4years. In Shayani Nasab et al[10] study, there was greater threshold increase with the greater use of mobile phones (*P* < 0.05). In Hegde et al[7]study, sensorineural hearing loss was found in 32% of those who have been using mobile phone since 2 years and in 22% of those who have been using it since 3 years, thus indicating that the minimal hearing loss (5-15 dB) noted in the study group was not only dependent onyears of exposure, but also on hours of exposure per day and type of exposure. In the present study, high frequency hearing loss was seen in 6.66% of subjects using mobile phone for 2-3 years and 16.66 % of subjects using mobile phone for >3 years.Subject with mobile usage <2 years had no hearing loss.

Hours of exposure per day: In Hegde et al[7] study, hearing loss of 5 dB was found in 10% of those using mobile phones for 2-3 hours daily, 10 dB hearing loss was seen in 3.3%, and 15 dB in 1.6% in the same group. In those using mobile phones for 3-4 hours daily, hearing loss of 5 dB was seen in 6.6% and 10 dB in 3.3% of subjects. In Patel et al[12] study, mild to moderate high frequency hearing loss was seen in those who were using mobile phone for > 1 hour in comparison to those using it for < 1 hour in a day. Velayatham et al[8] in his study found statistically significant difference in usage time between the no hearing loss group (17.4 ± 13.6 min/ day) and hearing loss present group (40.8 ± 24.2 min/ day). In the study by Callejo and Santamaria,[13] audiometric evaluation was done in 323 healthy volunteers with normal hearing at the beginning of use of mobile phones and 3 years later. Inquiry was done about the period of time per day use and ear in contact with mobile phone. A healthy control group not using mobile phones with normal hearing threshold werealso studied. Audiometric results were similar in cases and controls at the beginning of the study. After follow-up of 3 years, cases showed an increase in hearing threshold between 1 and 5 dB more than controls in speech tones (*P* < 0.001).[13] InOktay and Dasdag[14] study, BERA results showed no difference in hearing status among study and control groups (*P*>0.05). In PTA measurements, hearing threshold in moderate mobile phone users (10-20 minutes per day) and the control subjects (never used cell phones) was similar. However, those who talked approximately 2 hours per day were found to have higher hearing threshold than moderate users and control subjects. In our study, 10 % subjects (3 out of 30 subjects)using mobile phone for 30mins–1 hour per day had mild hearing loss while 26.31% subjects (5 out of 19 subjects) using mobile phone for 1hr-3hrs per day had mild hearing loss. Even if the difference was statistically not significant, increase in duration of mobile usage found to affect more number of subjects.

Longest dialogue duration in a day: Dialogue duration on mobile can also have significant effects on hearing function. But not much work has been done on relation of longest call duration and hearing loss. According to Patel et al[(12)] study, all those having longest dialogue duration of > 45 minutes were found to develop mild to moderate high frequency hearing loss. In our study, there was statistically significant relation between longest dialogue duration in a day and hearing loss.

Conclusion

Our study shows that use of mobile phones for longer duration can predispose to hearing loss. Although Mean Hearing threshold for frequencies 250-8000 Hz was within a normal range in dominant ear of mobile phone users but hearing threshold in dominant ear was more as compared to non-dominant ear and the difference was statistically significant. Mild degree hearing loss was seen in higher frequencies (4000 & 8000 Hz) in dominant ear of mobile phone users. Relationship was found between duration of use of mobile phones and pure tone threshold changes. More the use of mobile phones, more was the threshold change.

Hearing loss due to long term use of mobile phone is serious health hazard which can be easily prevented. We recommend for long term follow up studies in chronic mobile phone users to come to the concrete conclusion.

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