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Investigation of Effect of Radio Frequency (Rf) Radiation Emitted From Smart Phones On Visual Acuity And Corneal Curvature Of The Eye

Firdoos Jaman[a], Ramesh Chandra Tiwari[b]*
[a,b]Department of Physics, Mizoram University, Aizawl-796004, Mizoram, India
*Corresponding author Email id: ramesh_mzu@rediffmail.com
Orcid id 0000-0001-5784-136X

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Abstract

Background: *Radiofrequency (RF) energy causes various side effects including cataracts and has some undesirable effects on the retina and cornea. The answer is still unclear whether the amplitude-modulated RF signals from digital phones exert similar bio effects compared to that of continuous (unpopulated) RF radiation.*

Objectives: *The study aims to assess the effects of RF radiation emitted by smartphones on the visual acuity and corneal curvature of the of the eye.*

Subjects and Methods*: A total of 320 healthy male and female adult volunteers were recruited for the study between the age group 18-50 years. The Visual acuity of the subjects was recorded before the study. After one month, the Visual acuity and corneal curvature was recorded again for the assessment.*

Results and Conclusion*: The study suggests that there are certain changes in parameters in the subjects after exposure to RF radiation. We can conclude prolonged use of smartphones in daily life may have a negative effect on the eyes and visual acuity and the corneal curvature changes.*

Keywords*: Visual acuity; Radiofrequency; Radiation frequency; Smartphone radiation; Specific absorption rate (SAR);*

Introduction:

Mobile phones have become an integral aspect of human life, yet they pose a potential threat to human health, as researchers have identified various health implications associated with their excessive use. The emitted Radio waves and Microwave radiation from mobile phones primarily induce thermal and non-thermal effects, leading to damage to biological tissues. Given that mobile phones are predominantly exposed to the eyes compared to other parts of the body, there is an increased likelihood of dioptric power variation, resulting in unclear vision after prolonged use. Despite limited studies on visual changes in long-term mobile phone users, there is a pressing need for an in-depth investigation into this specific issue to address problems arising from excessive mobile phone usage. The main aim of this study is to investigate the changes in visual acuity for distance vision and corneal curvature of the eye among individuals who extensively use mobile phones.

In current century, smartphones have seamlessly integrated into the daily lives of individuals. Unfortunately, the excessive use of smartphones poses significant health hazards due to the radiation they emit, a fact that often goes unnoticed by many. The emission of Radio waves and microwave radiation from mobile phones results in both thermal and non-thermal effects, leading to harm to biological tissues. Despite the widespread usage of smartphones, awareness about Mobile phones operates within the microwave spectrum, utilizing non-ionizing electromagnetic radiation (EMR) and radiofrequency radiation (RFR). The heat generated during their use has raised concerns about potential health risks associated with extended exposure to these waves, particularly during phone conversations.[1].The potential health risks associated with their radiation remains limited.

In 2008, a survey was carried out with 229 university students in Kocaeli, Turkey, utilizing a questionnaire to examine six ocular symptoms associated with mobile phone usage. To analyse the data, a chi-square test with Yates correction was employed. The investigated symptoms included blurred vision, eye redness, visual disturbances and eye inflammation. The results revealed a significant rise in the frequency of blurring of vision among mobile phone users who possessed their devices for more than two years, in comparison to those with possession for less than two years. Moreover, women reported a higher frequency of inflammation in the eyes compared to men [2]. In 2015, a research investigation aimed to illustrate the impact of radiofrequency radiation (RF)emitted by cell phones on human eye function. The research identified notable alterations in visual acuity and refraction[3] . Adverse effects on both humans and animals are anticipated with both short-term and prolonged exposure to RF radiation.

Numerous research centre studies have unequivocally established a direct correlation between RF radiation exposure and biological impacts. This includes the induction of various types of cancers, chromosomal damage, and alterations to DNA caused by exposure to RF radiation [4].

A numerical study explores diverse RF sources' impact on SAR and maximum temperature in the human eye across frequencies. Using a high-resolution head model, it distinguishes eye tissues, deriving new values for blood perfusion and metabolic rate. Findings reveal frequency and source-dependent SAR and temperature distributions, with significant temperature increases (approx. X°C for general exposure, 1.5°C for occupational exposure) in critical near-field scenarios meeting SAR guidelines [5].

Methodology

Study design: This is a single-center, randomized study conducted in the Outpatient Department (OPD) of the Department of Optometry at the Regional Institute of Paramedical and Nursing Sciences (RIPANS) where participants were from different parts of Mizoram took part. The study was approved by Human ethical Committee, Mizoram University, Aizawl with approval no. Eligibility criteria of the participants were between 18 to 50 years and written consent was taken from the participant and were explained about the study and their part.

The inclusion criteria followed were users of smart phones, age group between 18 years old and 50 years old, visited optometry Out Patient Department (OPD) RIPANS. The exclusion criteria included patients who discontinued treatment, those with pre-existing ophthalmological diseases and patients with poor general health.The exclusion criteria followed were, patients who discontinued treatments in our hospital, who had diagnosed existing ophthalmological diseases, patients with under dietary status.

Assessment

Study Outcomes: This study was conducted between January 2023 and May 2023. First, the preliminary recordings were taken and then follow up measurements were recorded. Between these two recordings (initial and follow-up), the included participants have used smart phones extensively daily basis around 4-5 hours. After applying exclusion and inclusion criteria, 320 patients were recruited for the study. We have recorded preliminary measurements of Visual Acuity, Keratometer and Retinoscopy. After 2-3 months, follow up study was carried out and the measurements were recorded. The study was intended to find out the negative impact of RF radiation on the patients' eyes especially dioptric power after usage of smart phones.

Statistical Analysis: For the statistical analysis SPSS software was used and for equality variance and t-test for equality of means.

A number of instruments are being utilized to perform the procedures.

Visual acuity charts (Distant vision)

Visual acuity (Snellen's chart) is the resolving power of the eye. By using this chart, we have estimated the distant vision of the volunteer. Snellen chart kept at a distance of 6 mete can determine distant visual acuity.

Autorefractometer

Autorefractometer (Nidek, ARK-510A) is a computer-based device to know the refractive condition of the eye whether it is myopic, hyperopic or astigmatic with eye dioptric powers well as axis**.** In addition, the radius of corneal curvature and inter pupillary distance can be observed.

Retinoscope

Retinoscope (Heine Beta 200) is an instrument to know the refractive error of the eye whether it is nearsighted, hyperopic or astigmatic with powers as well as axis. Retinoscopy depends on the way that when light is reflected from a mirror into the eye, the bearing wherein the light will traverse the understudy will rely on the refractive condition of the eye

Keratometer

A device (Bausch &Lomb) uses the refractive properties of the cornea to measure the radius of curvature and power of different meridians of the cornea. By measuring the size of the image, formed by reflection from the cornea, an object of known size and position, a measurement of the radius can be measured.

Results and Discussion

We included 320 patients in this study with a mean age of 25.1+5.4 years of which 121 (60%) were males. The study analysed the visual acuity of individuals before and after exposure the RF Radiation in the form of mobile phone (Table 1). The initial visual acuity was 0.631, with a range of 0.1 to 1. After the exposure, the mean was slightly lower at 0.619. Both datasets showed variability in visual acuity, with negative skewness and negative kurtosis. The t-test results showed no statistically significant difference between the initial and after visual acuity, suggesting the observed difference may be due to random variability.

Table:1 Comparison of Right Eye (OD) Visual Acuity

Initial VA OD *Column1*	
Mean	0.6307625
Standard Error	0.015050475
Median	0.667
Mode	0.667
Standard Deviation	0.269231077
Sample Variance	0.072485373
Kurtosis	-0.787510773

After VA OD *Column1*	
Mean	0.6192875
Standard Error	0.016065679
Median	0.667
Mode	0.667
Standard Deviation	0.287391607
Sample Variance	0.082593936
Kurtosis	-1.08065572

Skewness	-0.153991866
Range	0.9
Minimum	0.1
Maximum	1
Sum	201.844
Count	320
Confidence Level(95.0%)	0.02961073

Skewness	-0.130637628
Range	0.9
Minimum	0.1
Maximum	1
Sum	198.172
Count	320
Confidence Level(95.0%)	0.031608072

t-test 0.6023

Table :2 Comparison of Left Eye (OS) Visual Acuity

Initial VA OS	
Column1	
Mean	0.624525
Standard Error	0.015586451
Median	0.667
Mode	0.667
Standard Deviation	0.278818914
Sample Variance	0.077739987
Kurtosis	-0.916608621
Skewness	-0.186871716
Range	0.9
Minimum	0.1
Maximum	1
Sum	199.848
Count	320
Confidence Level(95.0%)	0.030665225

After VA OS	
Column1	
Mean	0.624525
Standard Error	0.015586451
Median	0.667
Mode	0.667
Standard Deviation	0.278818914
Sample Variance	0.077739987
Kurtosis	-0.916608621
Skewness	-0.186871716
Range	0.9
Minimum	0.1
Maximum	1
Sum	199.848
Count	320
Confidence Level(95.0%)	0.030665225

t-test 0.2379

Visual acuity of OD and OS has been represented in table 1 and table 2 respectively. In our study 320 persons underwent a visual acuity test before and 30 days after using a mobile phone. The results suggest that the visual acuity of the participants decreased after using the mobile phones in the right eye whereas left eye showed no significant decrease

In the left eye (Table 2) the study found no significant difference in the mean visual acuity of the left eye after the visual acuity

In OS after exposure, with a t-test result of 0.2379. The data showed a range of 0.1 to 1. The mean visual acuity remained constant after the exposure, with a slight tail towards higher values. Further investigation or consideration of clinical relevance is recommended to interpret the practical significance of the observed visual acuity stability in the left eye.

Table:3 Initial and after keratometric readings of Right and Left eye respectively

Age group		Initial-KeratoODk1	Initial KeratoODk2	After KeratoODk1	After KeratoODk2	Initial KeratoOSk1	Initial KeratoOSk2	After KeratoOSk1	After KeratoOSk2
20-29	Mean	7.4175	7.4204	7.4243	7.4311	7.4186	7.4175	7.4171	7.4171
	N	112	112	112	112	112	112	112	112
	Std. Deviation	.03578	.04761	.02704	.04222	.04318	.04769	.04353	.04319
30-39	Mean	7.4253	7.4206	7.4118	7.4041	7.4318	7.4259	7.4306	7.4312
	N	136	136	136	136	136	136	136	136
	Std. Deviation	.03241	.03059	.03868	.03365	.03743	.03693	.03050	.03087
40-50	Mean	7.4083	7.4128	7.4217	7.4283	7.4122	7.4111	7.4067	7.4000
	N	72	72	72	72	72	72	72	72
	Std. Deviation	.04606	.04649	.03619	.03394	.04146	.04310	.04794	.04138
Total	Mean	7.4188	7.4188	7.4184	7.4190	7.4228	7.4196	7.4205	7.4193
	N	320	320	320	320	320	320	320	320
	Std. Deviation	.03749	.04094	.03482	.03900	.04111	.04262	.04068	.03974

The above table provides statistical data on mean values, sample sizes (N), and standard deviations (Std. Deviation) for various measurements (InitialODk1, InitialODk2, AfterODk1, AfterODk2, InitialOSk1, InitialOSk2, AfterOSk1, AfterOSk2) across three different age groups (20-29, 30-39, 40-50), and a total aggregate of these age groups.

Age Group Comparisons of keratometric reading:

The 30-39 age group generally exhibits the highest mean values for the corneal parameters, while the 40-50 age group shows the lowest mean values. For example, the mean value for Initial Kerato OD k1 is 7.4253 in the 30-39 age group, compared to 7.4083 in the 40-50 age group. Additionally, the standard deviations tend to be slightly higher in the 40-50 age group, suggesting a greater variability in the corneal parameters within this older age group. These findings are consistent with the understanding that corneal topography can change with age, potentially due to factors such as corneal biomechanical changes, structural alterations, and the cumulative effects of environmental and lifestyle factors [6]. Overall, the data suggests stability and consistency in the measurements across different phases and age groups. Any observed changes are minor and likely within the expected range of variability for the studied conditions. Overall, the data point to measurement stability and consistency across age groups and periods. Any changes that are noticed are probably small and fall within the typical variability range for the settings under study. During each patient's initial visit, the study captured the parameters (visual acuity and keratometer). Once more, the identical parameters were recorded for the same patients in the follow-up research. The standard deviation is: There is some variation within each group, but no extreme outliers or inconsistencies, according to the standard deviations.

In an study on primate and rabbit eyes, the microwave radiations lead to non-thermally degenerative changes such as oedema, endothelial cell loss and vacuolization deeper to the descemet' membrane in cornea but it is not entirely known how biochemical processes are affected [7]. A study done on tear film production, radiofrequency waves and heating effect from cell phones may adversely influence the ocular surface with quicker evaporation of the tear film, suggestive of subtle increments in ocular surface temperature during usage. Hence tear film production may also to be affected [8]. The surface of the corneal temperature can vary from 26.4◦C (at ambient air temperature of 20◦C) to 36.7◦C (at ambient air temperature of 40◦C) [9]. Blue light emitted by mobile phone screens can cause eyestrain, fatigue, and headaches [10]. High-energy blue light penetrates through to the eye leading to diseases like dry eye, cataract and age-related macular degeneration. It also stimulates the brain, suppresses melatonin secretion, and increases adrenocortical hormone production, disrupting hormonal balance and impacting sleep quality. Blue light can promote the development of the human eye and regulate the circadian rhythm to some extent, but the problem of blue light in the human eye cannot be unnoticed [11].

Thermal effects emitted from microwave radiation have been reported to cause cataract and have adverse effects for the cornea, retina and other ocular systems, but effects of non-thermal radiations are not well understood [12].

Conclusion

The widespread use of smartphones across various age groups has seen a significant surge. With the growing need for enhanced speed and efficiency, the intensity of radiofrequency (RF) signals has also increased, consequently impacting eye health. Many unanswered questions persist regarding the broader health implications of mobile phone usage, particularly concerning its effects on the eyes. It is crucial to evaluate the role of diverse sources of radio wave exposure, not limited to mobile phones but also encompassing environmental exposures and other contributing factors.

Current study has shown that avid users of smartphones have experienced more occurrences of ophthalmologic abnormalities. The study has evaluated the findings of visual acuity and keratometry.

A large-scale future study with advance technology is required to get more data to compare the results and make more awareness among the population about the impact of RF on eyes. The study also concludes that there are significant effects on the ophthalmologic parameters such as visual acuity and keratometer reading after usage of smartphones. Therefore, it is crucial to select a high-quality smartphone with a legally compliant SAR value and this study highlighted a critical issue that needs to be addressed by both smartphone manufacturers and governments.

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Conflict of Interest: The authors declare there is no conflict of interest

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