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Comparison of Intraocular Pressure Changes Due to Exposure to Mobile Phone Electromagnetics Radiations in Normal and Glaucoma Eye

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Abstract:

PURPOSE: The aim of this study is to investigate the effects of electromagnetic waves (EMWs) emitted by a mobile phone on the intraocular pressure (IOP) in the eyeball.

METHODS: This quasi-experimental study was conducted on 166 eyes from 83 individuals in the 40–70 age range who referred to "Khatam-al-Anbia Hospital, Mashhad, Iran" in 2016. There were two groups of participants, and the first one consisted of 41 participants who had normal eyes, whereas the second one comprised 42 participants who suffered from open-angle glaucoma disease. The IOP in both groups was measured and recorded by a specialist before and after talking 5 min on the cellphone with the help of the Goldman method. Statistical analysis such as paired *t*-test and analysis of variance was performed and all tests are statistically significant at ($P < 0.05$). For this purpose, the SPSS software (version 16) was applied.

RESULTS: IOP in the glaucoma eye (42 eyes) ipsilateral to mobile phone before and after the intervention was 18.64 ± 6.7 and 23.53 ± 6.3, respectively ($P < 0.001$). However, IOP in the control group (41 eyes) ipsilateral to mobile phone before and after the intervention was 12.95 ± 3.5 and 13.39 ± 2.8, respectively ($P = 0.063$). IOP change in the opposite glaucomatous eye to mobile phone in glaucoma group (39 eyes) and normal group (44 eyes) was not significantly different before and after the phone call ($P = 0.065$ and $P = 0.85$, respectively).

CONCLUSION: We found that the acute effects of EMWs emitted from the mobile phones can significantly increase the IOP in glaucoma eye, while such changes were not observed in normal eyes.

Keywords:

Glaucoma, intraocular pressure, mobile phone

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Introduction

Mobile phones are now an inseparable part of a human's life. The widespread use of phones increases human exposure to the electromagnetic waves (EMWs) emitted from them. These devices transmit and receive EMWs through an antenna placed close to a users' head. Mobile phone sometimes causes symptoms such as headache, rash, fatigue, and skin warmness.[1] Changes in the permeability of the blood–brain barrier (BBB), electroencephalographic activity, and blood pressure have also been reported. Long-term use of microwave devices can have a negative impact on biological system, especially on the brain.[1] The eyeball is more vulnerable to the adverse effects of mobile phones due to its anatomy compared to other organs in the head. The closure of the eyeball to the device and its thin bone coverage ease the EMWs

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infiltration. Furthermore, the blood cannot sufficiently scatter the heat generated by the EMWs, due to the poor vascularization of the eyes.

By now, various investigations have been performed to determine the effects of EMWs emitted from the mobile phone on the eye. Some of these effects result from the thermal effects of EMWs such as cataract, corneal edema, endothelial cell loss, lacrimation of eyes, and retinal degeneration.[2] However, the nonthermal effects are not well-established yet.[3] Further reports showed that mobile phones can be responsible for the blurring of vision, inflammatory secretion, and retinal differentiation failure.[4] At present, many studies have focused on the effects of EMWs on the eye, but many aspects of these effects on different eye conditions are still unclear.

The previous reports showed that EMWs increase the vascular permeability, cataract, corneal edema, endothelial cell loss, lacrimation of eyes, and retinal degeneration,[5] permeability of the BBB and also it changes the cerebrospinal fluid secretion, same mechanism may apply to the aqueous humor of the eye, thus increase the intraocular pressure (IOP). On the other hand, in the pathophysiology of glaucoma, it is believed that the increased IOP results in retinal ganglion cell death[6] and aqueous humor plays a key role in developing glaucoma.

Despite the fast growth of mobile phones in today's life, the evidence of its ocular effects is lacking. However, some aspects of the EMWs impact on human visual such as cataract,[5] corneal, and retinal damage has been covered.[5,7] However to date, there is no reliable evidence on the acute effects of the EMWs on the glaucoma patients. Herein, we tested the hypothesis that EMWs emitted from mobile phones can increase the IOP in patients with glaucoma.

Methods

This quasi-experimental study was conducted in Cronbach's alpha sampling method on 166 eyes from 83 individuals (female 43 [51.8%] and male 40 [48.2%]) in the 40–70 age range who were hospitalized in Glaucoma Clinic of Khatam-al-Anbia Hospital located in Mashhad, Iran, during 2016, which is the only specialized Northeastern hospital in Iran. This study is the result of the research (No: 950900) conducted at Mashhad University of Medical Science and all of its steps were approved by the ethics committee of the university.

There were two groups of participants in this study, the first one consisted of 41 participants who had normal eyes randomly selected from patient´s attendants, while the second one comprised 42 participants who suffered from open-angle glaucoma disease randomly selected from glaucoma clinic with high IOP and/or cup to disc ratio and abnormal visual field or retinal nerve fiber layer imaging corresponded to clinical eye exam who have not undergone any specific therapeutic measures yet. Patients who suffered from diseases such as diabetes and high blood pressure and also those who have undergone any kind of eye surgery or received any specific eye medicine have been excluded. After defining the whole method clearly, written consent was obtained from participants, then some of their demographics were recorded.

At the beginning of the study and before exposure to the cell phone, the patients were asked to rest for 20 min without any electronic device and then IOP was measured three times with the Goldmann applanation tonometer (Swiss-made Haag-Streit). In case there was more than 2 mmHg difference between the measured IOPs, we repeated tonometry one more time. Subsequently, all participants were asked to talk on the cellphone (Nokia, N95 model) with a specific absorption (0.79 W/kg) for head and a frequency of 900–1800 MHz for 5-min phone conservation, and after 20 min IOP was measured three times with the same previous device. First, the surface of the eye was anesthetized using tetra Caine drops and placing fluorescein paper in the lower fornix for 3–5 s. After disinfection of the tonometer tip, IOP was measured by an ophthalmologist who was unaware of the intervention. Hence, all IOP measurements before the intervention were done by the same ophthalmologist using the same device and all IOP measurement after the intervention was done another ophthalmologist unaware from intervention and same device in cornea clinic. Since the IOP measurement repeated three times at maximum with lower than two mmHg differences, so were maximum agreement in their IOP measurements. The aqueous humor turnover is about 60 min; therefore, we measured the IOP 20 min after the phone call to evaluate the IOP before the aqueous was completely replaced. Multiple measurements were not performed to avoid the confounding effect of tonometer prism, which may cause iatrogenic changes in IOP.

Measurements were made in both eyes for the hypothesis that the IOP was related to the right or left hand (handheld the cell phone for phone conversation). All measurements of IOP were performed in the sitting position.

Data were analyzed using SPSS V16.0 (SPSS Inc, Chicago, IL, USA). Kolmogorov–Smirnov test was used for the assessment of the normal distribution of data. The mean and standard deviation were reported for normal continues variables and median and interquartile range

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for not normally distributed data. According to the normal distribution of data, independent samples *t*-test or Mann–Whitney U-test was used for comparison between two groups and analysis of variance (ANOVA) test for comparison among more than two groups. Chi-square test was used for categorical data and for the assessment of within-group change of IOP paired *t*-test or Wilcoxon sign-rank test was used. The two-tailed statistical significance level was considered <0.05.

Results

We analyzed 42 normal individuals and 41 individuals with glaucoma. The mean age of the control and glaucoma groups was 55.62 ± 6.0 and 57.47 ± 8.4 years, respectively ($P = 0.09$). Baseline IOP from the ipsilateral eye to the phone was 18.64 ± 6.7 mmHg in the glaucoma patients and 12.95 ± 3.5 mmHg in control groups ($P < 0.001$). The baseline characteristics are presented in Table 1.

According to our results, the IOP of the glaucoma patients significantly increased after 5 min speaking with a mobile phone compared to its baseline status ($P < 0.001$). There was a slight increase in the IOP of the normal eye, which was not statistically significant ($P = 0.056$). Further results are presented in Table 2. Three patients in the glaucoma group had one normal eye. In these cases, we found a dramatic increase in glaucoma eye after exposure to EMWs (mobile phone ipsilateral to glaucomatous eye), while normal eye showed no considerable increase in IOP.

Table 1: Baseline characteristics of patients in the glaucoma and control group

Parameters	Glaucoma (*n*=81 eye)	Control (*n*=85 eye)	*P*
Age (years)*	57.47±8.4	55.62±6.0	0.09
Gender (male)**, *n* (%)	19 (46.34)	21 (50)	0.63
Baseline IOP*			
Ipsilateral eye to mobile phone	18.64±6.7	12.95±3.5	<0.001
Contralateral eye to mobile phone	18.95±5.5	12.35±4.5	<0.001
Cup to disc ratio			
Ipsilateral eye*	0.7±0.15	0.15±0.25	<0.001
Contralateral eye*	0.65±0.1	0.15±0.2	<0.001

*Data were analyzed using independent sample *t*-test, **Data were analyzed with Chi-square test. IOP: Intraocular pressure

Results showed that IOP changes before and after using the handsets between the age groups of 40–50, 51–60, and 61–70 years were 1.853 ± 2.63, 1.47 ± 2.92, and 2.31 ± 2.76, respectively, and the results of ANOVA indicated At 95% confidence level, there has been no significant difference in terms of IOP change index ($P = 0.753$).

Discussion

EMWs emitted from phones reach the central nervous system via ear and eye then put an effect on it.[1] In this study, we compared IOP changes due to exposure to the electromagnetic radiations of the mobile phone in normal and glaucoma eye.

We found that IOP is significantly increased in patients with glaucoma after using a mobile phone, but there were no significant changes in normal eyes. Several reasons can explain this finding. IOP is regulated by the balance between the aqueous humor secretion from the ciliary body its drainage via the trabecular meshwork and uveoscleral outflow pathway. It is believed that the vascular permeability may increase following the BMWs exposure. The increased permeability results in more aqueous humor secretion and ultimately increased IOP. Which increasing pressure has not been observed in healthy people due to the trabecular meshwork normalization while in people who suffer from glaucoma. It is caused by increasing pressure in the eye due to high outflow resistance in the trabecular meshwork. The increased vascular permeability due to EMWs exposure was supported in the previous studies. Schirmacher *et al*. launched and *in vitro* study to evaluate the influence of high-frequency EMWs on the permeability of the BBB. Permeability was measured by using14C-sucrose. Samples were exposed to EMW with a frequency of 1.8 GHz, which is used in mobile phones. Exposure to EMW significantly increased permeability for 14C-sucrose compared to unexposed samples.[8] Similarly, the *in vitro* study of Zhou *et al*. showed increased BBB permeability after exposure to 100 kV/m and 400 kV/m electromagnetic pulse.[9] Other studies reported the same findings.[10] Conversely, 3100 MHz radiation at 55 mW/cm^2 did not change lens opacities, BBB permeability or retinal vascular permeability in rabbits exposed to pulsed.[11]

Table 2: Comparison of the intraocular pressure between the normal and glaucoma eye before and after the effects of electromagnetic waves exposure

	Glaucoma (*n*=81 eyes)		*P**	Control (*n*=85 eyes)		*P***	*P***	*P***
	Before	After		Before	After			
IOP ipsilateral eye to phone	18.64±6.7	23.53±6.3	<0.001	12.95±3.5	13.39±2.8	0.056	<0.001	<0.001
IOP contralateral eye to phone	18.95±5.5	20.43±3.2	0.065	12.85±5.5	12.95±4.75	0.85	<0.001	<0.001

P* is the *P* value of comparing the data in Glaucoma group before and after the intervention using paired *t*-test, *P* is the *P* value of comparing the data in control group before and after the intervention using paired *t*-test, *P**** is the *P* value of comparing the data between glaucoma and control groups before the intervention using independent sample *t*-test, *P***** is the *P* value of comparing the data between glaucoma and control groups after the intervention using independent sample *t*-test. IOP: Intraocular pressure

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We believed that the same mechanism may be applied for the blood–aqueous barrier. It seems that is the exact mechanism of how EMWs affect vascular permeability is yet to be understood, and further molecular researches are mandatory in this field.

We also postulate that the thermal effects of the EMWs could be responsible for the increased IOP in the eyes with glaucoma. Various investigations tried to measure the temperature produced by EMW in the eyeball. Dally *et al*. (1951) used an approximately 75 W source at 8 cm distance from the orbit for 30 min in dogs and rabbits. In the worst case, the mean temperature rise of 1.9°C in the orbit, 3.2°C in the vitreous, and 2.8°C in the aqueous in dogs.[12]

Temperature changes may regulate the secretion, exertion, and flow dynamic of aqueous humor and thus, affects its balance. As the temperature rises in the anterior segment vasodilation and increased metabolic processes in the ciliary body, caused by increased blood flow, resulting in higher secretion. As expected, the opposite mechanism is observed after temperature decreases, due to the activation of the sympathetic system and vasoconstriction. Temperature changes also affect excretion. As mentioned before, metabolic process enhances by increased temperature, which activates the inflammatory pathways and oxidative stress. These reactions lead to increased cellularity of the anterior segment structures and disturb trabecular meshwork drainage.[13,14]

In this research, there is no significant difference in IOP changes for the contralateral eye-to the cellphone. However, in the study of investigating visual evoked potential (VEP) in both eyes-close to and far from the cell phone-a significant difference found by Singh in a way that difference in VEP in various signals for the right eye (the one close to the cellphone) was greater than the left one (far from the cellphone). Singh concluded that the reason for this difference is because of the proximity of the right eye to the cell phone and feeling greater heat and more radiation power as a result of it. This result needs more investigation.[1]

The study suffered from limitations. This study only included the patients with open angle glaucoma; therefore, our results cannot be generalized to all types of glaucoma. This study was set up to determine the effects of EMWs emitted from the mobile phone on the IOP of patients with glaucoma. Our investigation showed that after 5-min phone call, the IOP will significantly increase in glaucoma patients, while there is no dramatic change in the normal eyes. We suggest that glaucoma patients apply mobile phones less often. This study can serve as a basis for future research and evaluating the chronic effects of EMWs.

Conclusion

The results of this quasi-experimental study conducted on glaucoma eye that the acute effects of EMWs emitted from the mobile phones showed significantly increase the IOP, while such changes were not observed in normal eyes.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Singh K. Acute effect of electromagnetic waves emitted from mobile phone on visual evoked potential in adult male: A preliminary study. Indian J Physiol Pharmacol 2016;60:102-7.
2. Kheifets L, Repacholi M, Saunders R, van Deventer E. The sensitivity of children to electromagnetic fields. Pediatrics 2005;116:e303-13.
3. Kabuto M, Nitta H, Yamamoto S, Yamaguchi N, Akiba S, Honda Y, *et al*. Childhood leukemia and magnetic fields in Japan: A case-control study of childhood leukemia and residential power-frequency magnetic fields in Japan. Int J Cancer 2006;119:643-50.
4. Balik HH, Turgut-Balik D, Balikci K, Ozcan IC. Some ocular symptoms and sensations experienced by long term users of mobile phones. Pathol Biol (Paris) 2005;53:88-91.
5. Kues HA, Hirst LW, Lutty GA, D'Anna SA, Dunkelberger GR. Effects of 2.45-GHz microwaves on primate corneal endothelium. Bioelectromagnetics 1985;6:177-88.
6. Richardson W, Duane T, Hines H. Experimental lenticular opacities produced by microwave irradiations. Archives of physical medicine and rehabilitation 1948;29:765-9.
7. Elder JA. Ocular effects of radiofrequency energy. Bioelectromagnetics 2003;Suppl 6:S148-61.
8. Schirmacher A, Winters S, Fischer S, Goeke J, Galla HJ, Kullnick U, *et al*. Electromagnetic fields (1.8 GHz) increase the permeability to sucrose of the blood-brain barrier *in vitro*. Bioelectromagnetics 2000;21:338-45.
9. Zhou JX, Ding GR, Zhang J, Zhou YC, Zhang YJ, Guo GZ. Detrimental effect of electromagnetic pulse exposure on permeability of *in vitro* blood-brain-barrier model. Biomed Environ Sci 2013;26:128-37.
10. Sırav B, Seyhan N. Effects of GSM modulated radio-frequency electromagnetic radiation on permeability of blood-brain barrier in male and female rats. J Chem Neuroanat 2016;75:123-7.
11. Paulsson LE, Hamnerius Y, Hansson HA, Sjöstrand J. Retinal damage experimentally induced by microwave radiation at 55 mW/cm2. Acta Ophthalmol (Copenh) 1979;57:183-97.
12. Dally JR, Wakim KG, Herrick JF, Parkhill EM, Benedict WL. The effects of microwave diathermy on the eye. Am J Phys Med Rehabil 1951;30:178.
13. Saccà SC, Pulliero A, Izzotti A. The dysfunction of the trabecular meshwork during glaucoma course. J Cell Physiol 2015;230:510-25.
14. Saccà SC, Centofanti M, Izzotti A. New proteins as vascular biomarkers in primary open angle glaucomatous aqueous humor. Invest Ophthalmol Vis Sci 2012;53:4242-53.