SJIF IMPACT FACTOR (2015): 5.42 CRDEEP Journals
International Journal of Basic and Applied Sciences Omar Solyman Vol. 7 No. 4 ISSN: 2277-1921
International Journal of Basic and Applied Sciences.Vol. 7 No. 4. 2018. Pp. 138-142

Full length Research Paper

Safety of Smartphone Flashlight for Indirect Retinal Photography and Videography

Omar Solyman, MD, FRCS
Research Institute of Ophthalmology, Giza, Egypt.

Article history
Received: 01-12-2018
Revised: 18-12-2018
Accepted: 28-12-2018

Corresponding Author:
Omar Solyman, MD, FRCS
Research Institute of Ophthalmology, Giza, Egypt.

Abstract
Background: Smartphone indirect retinal photography has become a popular everyday ophthalmological practice. This off-label use of smartphone's bright LED flashlight requires a safety study. Safety of only some editions of iPhone smartphones have been studied for this purpose thus far. Aim: This study evaluates the potential photobiological risk of the flash light of Samsung smartphone light emitting diode (LED) flashlight when used in conjunction with indirect ophthalmoscopy condensing lens of different powers for indirect photography and videography of the ocular fundus. Methods: The aim of this study was to assess the spectral profile, weighted retinal irradiance, and thermal exposure rates produced by Samsung Galaxy S4, Samsung Galaxy S5, Samsung Galaxy Grand and Samsung Galaxy note 7 phones during indirect retinal photography. It involved measuring the focused light emitted by the LED flashlight source of the aforementioned four types of Samsung smartphones (Seocho, Seoul, South Korea) when collimated by three indirect ophthalmoscopy condensing lenses of different powers; one at a time. Forty diopter, 30-diopter, and 20-diopter indirect fundoscopy lenses (Volk, Mentor, OH, USA) were used. The set-up of the experiment involved securing the LED light source of the smartphone15 cm in front and centered on the examiner's side of the condensing lens being tested. A spectroradiometer (RPS900-R, International Light Technologies, MA) and Digital lux meter GM1010, (Benetech, Shenzhen, China) were used to measure the spectral profile and the radiant power at a focal length behind the condensing lenses, respectively. Result: The spectrum of the LED light of the four Samsung smartphones falls entirely in the safe light spectrum wavelength with no significant ultraviolet or infrared components. However, the majority of the light of the four smartphones fell in the shortwave length of the spectrum. Irradiance is within the safe limits for examination time with negligible thermal effect. Conclusion: The use of the Samsung smartphones tested in this study appears to be within the safe limits when used indirect fundus photography. The high load of the shortwave component may be concerning with prolonged and repeated examinations.

Key words: *Smartphone, Retinal photography, Indirect ophthalmoscopy*

Introduction

Light can induce damage to the neurosensory retina and the retinal pigment epithelium (RPE) through photothermal, photomechanical, and/or photochemical mechanisms.The particular culprit mechanism depends on the wavelength and exposure duration of the injurious light and the mechanism can be multifactorial and overlapping [1]. Although the eye has different inherent protective mechanisms, these mechanisms can be overcome by hazardouslight exposure resulting in temporary or permanent damage to the retina or the RPE[2]. The use of more powerful modern light sources in both anterior and posterior segment surgery in addition to the increase in surgical complexity requiring longer operative times especially during ophthalmic training have rendered photic injury a real danger for all surgeons [3]. Irreversible thermal damage in the retina typically occurs only after the ambient temperature in the retina is raised by at least 10°C and the ability of light to induce such thermal damage is inversely proportional to its wavelength. The most common clinical example of photothermal damage is retinal photocoagulation.Photomechanical damage results from rapid introduction of energy into the melanosomes of RPE resulting in mechanical compressive or tensile forces. These compressive and tensile forces may result in shock waves that can result in permanent damage to the RPE or photoreceptors. The amount of damage is related to the rate of delivery and amount of energy absorbed. Photochemical damage is thought to result from the exposure of retinal tissue to excessively generated free radicals. Photochemical damage is associated with both long-duration exposure times as well as lower-wavelength (higher-energy) light exposure and is the most common mechanism by which light exposure causes retinal damage[1], [2]. With the recent advances in smartphone cameras, smartphone indirect clinical retinal photographyis becoming a popular medical practice and opens new horizons in telemedicine[4], [5],[6], however there are growing concerns about the safety of smartphone's flash light on the neurosensory retina and RPE[7],[8]. Flash light ofiPhones 4[7], iPhone 6 and iPhone 6S[8] smartphones were found to be within the safe limitsof exposure when used in indirect smartphone fundus photography in two separate studies. While iPhone may be leading the smartphone markets in North America and Western Europe [9], [10], [11], [12]; Android phones particularly Samsung type phones are more popular in Egypt and represented the vast majority of the smartphone market share in Egypt for at least the last 3years[13]. Here in we study the safety of four widely used Samsung smartphones on the retina when used for indirect smartphone retinal photography.

Methods

The aim of this study was to assess the spectral profile, weighted retinal irradiance, and thermal exposure rates produced by Samsung Galaxy S4, Samsung Galaxy S5, Samsung Galaxy Grand and Samsung Galaxy note 7 phones during indirect retinal photography. It involved measuring the focused light emittedby theLED flashlightsource of the aforementioned four types of Samsung smartphones (Seocho, Seoul, South Korea) when collimated bythree different condensing lenses one at a time. Forty diopter, 30-diopter, and 20-diopter indirect fundoscopy lenses (Volk, Mentor, OH, USA) were used. The set-up of the experiment involved securing the LED light source of the smartphone15 cm Infront and centered on the examiner's side of the condensing lens being tested. A spectroradiometer(RPS900-R, International LightTechnologies, MA) and Digital lux meter GM1010, (Benetech, Shenzhen, China) were used to measure the spectral profile and the radiant power at a focal length behind the condensing lenses, respectively. The study was conducted in a light-controlled ophthalmology office with care was taken to make sure that the LED flashlight source of the smartphone, the center of the condensing lens and the sensor of the spectroradiometer/the digital lux meter are along the same axis (Figure-1). In order to minimize background light noise, the light of the ophthalmology office was turned off, the blackout shades were turned down and the smartphone's screen background light was turned to minimum. The phones being tested were maximally charged and the LED flashlight was set at maximumbrightness. Three measurements were taken for each parameter and the average of them was used as a final measurement.

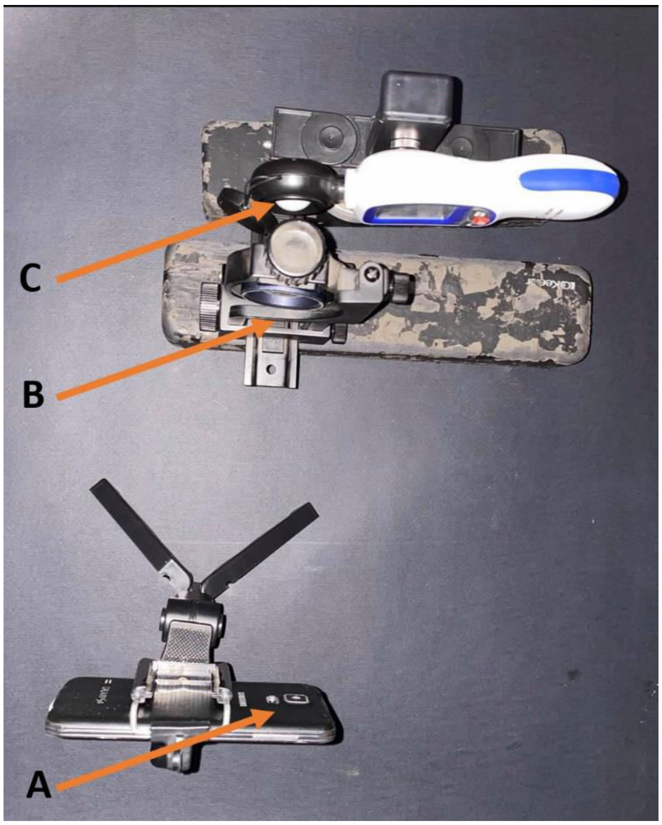

Fig-1: Set up simulating smartphone indirect retinal photography showing A- The LED light source of the smartphone, B- Indirect ophthalmoscopy lens & mount, C- Digital lux meter; all aligned together.

Results

The light spectra of the LEDflashlights are between 400nm and 750 nm (represented in Figure -2) with no significant ultraviolet irradiance or infra-red component. The majority of spectrum fell in the short wavelength blue-green spectrum. The weighted retinal irradiance at the focus of each lens ranged from 0.619 to 1.302 mW/cm^2. More details in table-1. There was no measurable thermal effect after 3 minutes of continuous flashlight exposure from either of the tested smartphones with either of the used lenses.

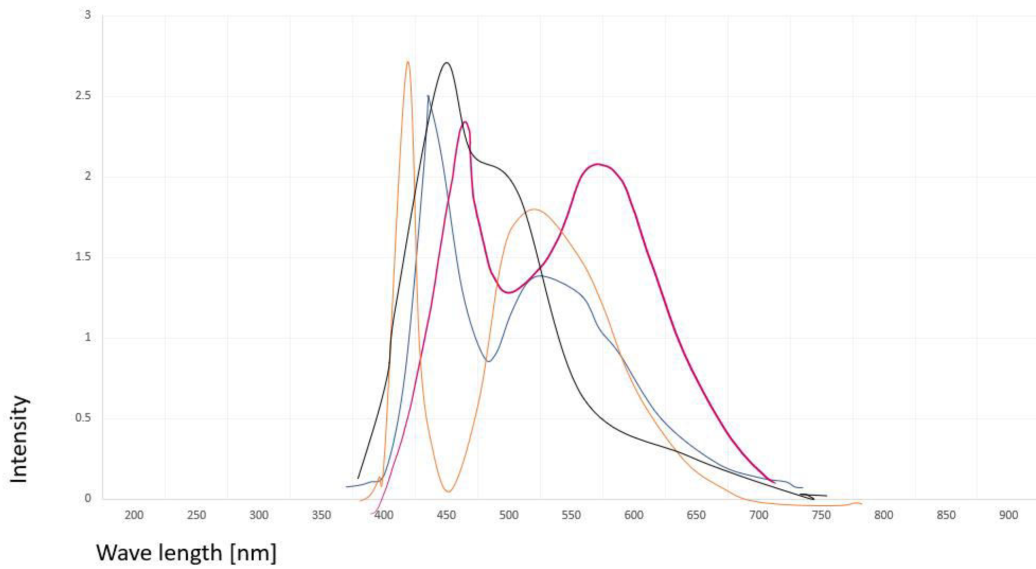

Fig-2: The spectral profile of A- Samsung note-7 (Black), B- Samsung S-4 (Blue), C-Samsung Grand (red) & Samsung S-5 (orange) LED flashlight.

Weighted retinal irradiance

Table1: Weighted retinal irradiance of the four Samsung smartphones using +20, +30 & +40 Volk indirect ophthalmoscopy lenses.

Phone	20 Volk	30 Volk	40 Volk
Note 7	1.192 mW/cm^2	0.723 mW/cm^2	0.824 mW/cm^2
S4	1.281 mW/cm^2	0.8325 mW/cm^2	0.916 mW/cm^2
Grand	1.302 mW/cm^2	0.729 mW/cm^2	1.045 mW/cm^2
S5	1.272 mW/cm^2	0.619 mW/cm^2	0.836 mW/cm^2

Discussion

Studies showed that 98%-100% of physicians in different specialties own smartphoneswith the iPhone representing the leading device in use by physicians in the United States and in the UK. A survey conducted in the United Kingdom showed that 75% of junior doctors own an iPhone. [12],[14], [15], [16]. Smartphone use in clinical practice is gaining growing popularity in different clinical practices including ophthalmology. Indirect retinal photography using the smartphone's camera and LED flashlight allows good quality photography and videography of the retina and the optic disc when used in conjunction with indirect ophthalmoscopy condensing lens. This opens new horizons in terms of clinical training and teleconsultations. Prior studies showed that flashlight of iPhones 4, iPhone 6 and iPhone 6S smartphones to be within safe limits when used in indirect smartphone fundus photography. In Egypt, Android smartphones are more prevalent and Samsung phones lead the market share[13]. Therefore, we conducted this study to evaluate thephotobiological hazard of a sample of Samsung smartphones' flashlight when used for indirect retinal photography.

Although the spectral profile of the 4 tested smartphones in this study fell in the safe spectral wavelength between 400-720 nm with no significant infrared or ultraviolet components (Figure 2), the majority (60-70%) fell in the short wavelength blue light spectrum.A similar finding was observed in prior studies of iPhone 4, 6, and 6S where the blue spectrum consisted the majority of iPhone 6 and 6S[8] and about 70% of iPhone 4.[7]

There is much biological evidence that short wavelength light has serious phototoxicity for the retina and for the retinal pigment epithelial cells.This biological effect of short wavelength blue light has long been a concern for the risk of the development of retinal disorders including age related macular degeneration (AMD) [17],[18]. Several studies demonstrated that cataract surgery in elderly patients, with consequent aphakia or pseudophakia, is associated with an increased risk for AMD This observation was based on the hypothesis of absence of the short wave length blockade by the yellow ageing crystalline lens after cataract extraction**.**[19]**,** [20]**,** [21]**,** [22]**.**

To protect the retina and retinal pigment epithelial cells from the hazards of exposure to short wavelength light after cataract surgery, several types of blue light blocking yellow tinted intraocular lenses have been developed, which absorb a great deal of the short wavelength light[17]. Likewise, yellow tinted indirect ophthalmoscopy lenses were introduced to decrease the load of short wave length blue light focused on the retina during the exam and decrease patient discomfort[23]. Unfortunately, we do not own a yellow tinted indirect ophthalmoscopy lens to study its use in conjunction with smartphone indirect fundus photography at our office. The weighted retinal irradiance at the focus of each lens ranged from 0.619 to 1.302 mW/cm2. More details in table-1.Smartphones are not

considered as a standard ophthalmic instruments, and they fall in Group 2continuous-wave instruments according to the International Organization for Standardization (ISO15004-2.2) classification of ophthalmic instruments. The ISO have set 706 mW/cm2as the limit for Group 2 instruments which they should be at least 1 order of magnitudebelow it to avoid retinal damage [24]Weighted retinal irradiance of the LED flashlight of the four tested smartphones are within safe limits. Weighted retinal irradiance appeared to be slightly higher in 20-diopter more than 40 diopter more than 30 diopter Volk lenses used in this study. This slight difference is likely attributed to a corresponding difference in the diameter of the corresponding lens, rather than an effect of the power of the lens.
In our study, we evaluated the safety of the LED flashlight of 4 different popular Samsung smartphones when used with 3 different indirect ophthalmoscopy collimating lens powers in a set up simulating indirect smartphone retinal photography (Figure-1). Samsung smartphones are the leading brand in the Egyptian smartphone market share for at least the last 3 years[13]. This study shows that the use of LED flashlight of the 4 tested Samsung phones are within safe limits when used in conjunction with an indirect ophthalmoscopy lens for indirect retinal photography. Similar to prior studies of iPhone 4, iPhone 6 and iPhone 6S, the majority of the spectral outcome of the LED flashlight source of the four tested smartphones in this study fell in the short wavelength spectrum (figure-2). This probably results in patient discomfort and is concerning for retinal phototoxicity in case of repeated prolonged exams. We wonder if the use of yellow tinted indirect ophthalmoscopy lens may provide reduction of the blue short wave length light load and probably may increase the patient's comfort and protect the retina and retinal pigment epithelium. Unfortunately, we do not own a yellow tinted indirect ophthalmoscopy lens at our office. Limitations of this study includes that other types of popular smartphones like Huawei, HTC and LG smartphones were not tested. Future prospects include testing the safety of other brands of smartphones and studying the potential protective effect of yellow tinted indirect ophthalmoscopy lenses.

Conclusion

The use of the Samsung smartphones assessed in this study appears to be safe for indirect fundus photography, however the high composition of the blue light component is concerning for photochemical toxicity with prolonged and repeated recordings. A follow up study for the safety of different unstudied smartphones (e.g. Huawei, HTC and LG smartphones) and the potential benefits of the use of yellow tinted indirect ophthalmoscopy lensis recommended.

Disclosure: The author reports no conflicts of interest related to this article

References

[1] R. D. Glickman, "Phototoxicity to the retina: mechanisms of damage," *Int. J. Toxicol.*, vol. 21, no. 6, pp. 473–490, Dec. 2002, doi: 10.1080/10915810290169909.
[2] P. N. Youssef, N. Sheibani, and D. M. Albert, "Retinal light toxicity," *Eye*, vol. 25, no. 1, pp. 1–14, Jan. 2011, doi: 10.1038/eye.2010.149.
[3] W. A. Solley and P. Sternberg, "Retinal phototoxicity," *Int. Ophthalmol.Clin.*, vol. 39, no. 2, pp. 1–12, 1999, doi: 10.1097/00004397-199903920-00002.
[4] A. Russo, F. Morescalchi, C. Costagliola, L. Delcassi, and F. Semeraro, "A Novel Device to Exploit the Smartphone Camera for Fundus Photography," *J. Ophthalmol.*, vol. 2015, p. 823139, 2015, doi: 10.1155/2015/823139.
[5] B. C. Toy *et al.*, "SMARTPHONE-BASED DILATED FUNDUS PHOTOGRAPHY AND NEAR VISUAL ACUITY TESTING AS INEXPENSIVE SCREENING TOOLS TO DETECT REFERRAL WARRANTED DIABETIC EYE DISEASE," *Retina Phila. Pa*, vol. 36, no. 5, pp. 1000–1008, May 2016, doi: 10.1097/IAE.0000000000000955.
[6] N. Panwar *et al.*, "Fundus Photography in the 21st Century--A Review of Recent Technological Advances and Their Implications for Worldwide Healthcare," *Telemed. J. E-Health Off. J. Am. Telemed. Assoc.*, vol. 22, no. 3, pp. 198–208, Mar. 2016, doi: 10.1089/tmj.2015.0068.
[7] D. Y. Kim, F. Delori, and S. Mukai, "Smartphone photography safety," *Ophthalmology*, vol. 119, no. 10, pp. 2200–2201; author reply 2201, Oct. 2012, doi: 10.1016/j.ophtha.2012.05.005.
[8] S. C. Hong, G. Wynn-Williams, and G. Wilson, "Safety of iPhone retinal photography," *J. Med. Eng. Technol.*, vol. 41, no. 3, pp. 165–169, Apr. 2017, doi: 10.1080/03091902.2016.1264491.
[9] B. M. Dala-Ali, M. A. Lloyd, and Y. Al-Abed, "The uses of the iPhone for surgeons," *Surg. J. R. Coll. Surg. Edinb.Irel.*, vol. 9, no. 1, pp. 44–48, Feb. 2011, doi: 10.1016/j.surge.2010.07.014.
[10] J. Chhablani, S. Kaja, and V. A. Shah, "Smartphones in ophthalmology," *Indian J. Ophthalmol.*, vol. 60, no. 2, pp. 127–131, 2012, doi: 10.4103/0301-4738.94054.
[11] A. S. M. Mosa, I. Yoo, and L. Sheets, "A Systematic Review of Healthcare Applications for Smartphones," *BMC Med. Inform. Decis.Mak.*, vol. 12, p. 67, Jul. 2012, doi: 10.1186/1472-6947-12-67.
[12] T. S. El Hadidy, A. E. Alshafei, A. E. Mortell, and E. M. Doherty, "Smartphones in clinical practice: doctors' experience at two Dublin paediatric teaching hospitals," *Ir. J. Med. Sci.*, vol. 187, no. 3, pp. 565–573, Aug. 2018, doi: 10.1007/s11845-017-1713-x.
[13] "Mobile Vendor Market Share Egypt," *StatCounter Global Stats*. https://gs.statcounter.com/vendor-market-share/mobile/egypt (accessed July. 25, 2018).
[14] G. J. Nason *et al.*, "The use of smartphone applications by urology trainees," *Surg. J. R. Coll. Surg. Edinb. Irel.*, vol. 13, no. 5, pp. 263–266, Oct. 2015, doi: 10.1016/j.surge.2014.06.008.
[15] "DOCSS: doctors on-call smartphone study - PubMed." https://pubmed.ncbi.nlm.nih.gov/24338079/ (accessed July. 25, 2018).

[16] K. F. B. Payne, H. Wharrad, and K. Watts, "Smartphone and medical related App use among medical students and junior doctors in the United Kingdom (UK): a regional survey," *BMC Med. Inform. Decis.Mak.*, vol. 12, p. 121, Oct. 2012, doi: 10.1186/1472-6947-12-121.
[17] K. Hayashi and H. Hayashi, "Visual function in patients with yellow tinted intraocular lenses compared with vision in patients with non-tinted intraocular lenses,"*Br. J. Ophthalmol.*, vol. 90, no. 8, pp. 1019–1023, Aug. 2006, doi: 10.1136/bjo.2006.090712.
[18] H. R. Taylor, S. West, B. Muñoz, F. S. Rosenthal, S. B. Bressler, and N. M. Bressler, "The long-term effects of visible light on the eye," *Arch. Ophthalmol. Chic. Ill 1960*, vol. 110, no. 1, pp. 99–104, Jan. 1992, doi: 10.1001/archopht.1992.01080130101035.
[19] R. Klein, B. E. K. Klein, T. Y. Wong, S. C. Tomany, and K. J. Cruickshanks, "The association of cataract and cataract surgery with the long-term incidence of age-related maculopathy: the Beaver Dam eye study," *Arch. Ophthalmol. Chic. Ill 1960*, vol. 120, no. 11, pp. 1551–1558, Nov. 2002, doi: 10.1001/archopht.120.11.1551.
[20] A. Pollack, A. Marcovich, A. Bukelman, and M. Oliver, "Age-related macular degeneration after extracapsular cataract extraction with intraocular lens implantation," *Ophthalmology*, vol. 103, no. 10, pp. 1546–1554, Oct. 1996, doi: 10.1016/s0161-6420(96)30464-8.
[21] J. J. Wang, R. Klein, W. Smith, B. E. K. Klein, S. Tomany, and P. Mitchell, "Cataract surgery and the 5-year incidence of late-stage age-related maculopathy: pooled findings from the Beaver Dam and Blue Mountains eye studies," *Ophthalmology*, vol. 110, no. 10, pp. 1960–1967, Oct. 2003, doi: 10.1016/s0161-6420(03)00816-9.
[22] E. E. Freeman, B. Munoz, S. K. West, J. M. Tielsch, and O. D. Schein, "Is there an association between cataract surgery and age-related macular degeneration? Data from three population-based studies," *Am. J. Ophthalmol.*, vol. 135, no. 6, pp. 849–856, Jun. 2003, doi: 10.1016/s0002-9394(02)02253-5.
[23] M. S. Bradnam, D. M. Montgomery, H. Moseley, and G. N. Dutton, "Quantitative assessment of the blue-light hazard during indirect ophthalmoscopy and the increase in the 'safe' operating period achieved using a yellow lens," *Ophthalmology*, vol. 102, no. 5, pp. 799–804, May 1995, doi: 10.1016/s0161-6420(95)30954-2.
[24] 14:00-17:00, "ISO 15004-2:2007," *ISO*. https://www.iso.org/cms/render/live/en/sites/isoorg/contents/data/standard/03/89/38952.html (accessed July. 25, 2018).