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Original Article

Clinical Impact of Smartphone with Iris Recognition Scanner on Visual Function in Normal Adults

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Purpose: Smartphone with iris recognition scanner uses using infrared-A wave. The aim of this study was to investigate the impacts of smartphone with iris recognition scanner on the visual function of normal adults.
Methods: Normal, healthy volunteers were divided into 2 groups according to the type of smartphone used: the photo camera and iris recognition scanner groups. Ocular changes were measured before and immediately after ocular exposure (both eyes) for 10 seconds. Ocular examinations, including measurement of visual acuity (logarithm of minimal angle of resolution), refractive error (diopters), grading of the corneal stain score (0 to 5), ocular surface temperature (℃), and pupil diameter (mm) were performed.
Results: A total of 60 volunteers were enrolled in the study. Thirty volunteers each were included in the photo camera and iris recognition scanner groups. The mean age were 38.5 ± 9.3 years and 37.6 ± 6.8 years, respectively. There were no significant changes in the ocular measurements immediately after exposure to the photo camera and iris recognition scanner (p > 0.05 for all).
Conclusions: There were no clinically significant effects on normal adult eyes after exposure to smartphone with iris recognition scanner.
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Key Words: Iris; Recognition; Smartphone; Vision

INTRODUCTION

With the increase in the security requirements for smartphones, there has been extensive application of biometric features, such as iris, fingerprint, or facial image for identification. The iris recognition technique has attracted attention in the past few years due to the unique features, such as ridges, freckles, and complex shapes. Thus they possess a great degree of randomness. Each individual has a unique iris pattern.[1,2] Smartphone developed with the iris recognition system have improved security for data stored in the mobile device.

The iris recognition system analyzes real-time random texture patterns of the iris by illuminating it with near-infrared radiation.[3] Near-infrared radiation offers better resolution and allows the structural patterns of the iris to be imaged with greater contrast.

The infrared radiation is divided into 3 bands: infrared-A (near-IR) between 760 and 1,400 nm, infrared-B (mid-IR) between 1,400 and 3,000 nm, and infrared-C (far-IR) between 3,000 and 10^6 nm.[4] Current iris recognition technology relies on infrared-A radiation.

There has been no study on the clinical effects on normal eyes after exposure to the radiation associated with iris recognition. The purpose of this study was to investigate the clinical impact of the smartphone with iris recognition

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scanner on the visual function in normal, healthy adults.

MATERIALS AND METHODS

Informed consent was obtained from Korean volunteers (20 to 50 years) enrolled in this prospective study. The study protocol was approved by the Korea University Anam Hospital Institutional Review Board and adhered to the tenets of the Declaration of Helsinki. The study was funded under the Samsung Electronics Co., Ltd. (Suwon, Korea). Volunteers with a history of ocular disease including cataract, glaucoma, amblyopia, retinal disease or recent exposure of intensive sunlight within the past 30 days were excluded. Volunteers were randomly divided into two groups according to types of camera used photo camera and iris recognition scanner. We used a smartphone with photo camera (Galaxy S7, Samsung, Seoul, Korea) and another with iris recognition scanner (Galaxy S8 prototype, Samsung) to compare the ocular measurements between the two groups. The image that captured both eyes simultaneously on the screen was obtained at 25 cm from participant's eye. The timer of scanning of iris was set at 10 seconds in the smartphone with iris recognition scanner and the duration of exposure was set at 10 seconds in the smartphone with the photo camera.

All participants underwent ocular measurements including determination of corrected visual acuity, refractive error, corneal stain score, ocular temperature and pupil diameter before and immediately after the photograph was taken. The visual acuity was presented logarithm of minimal angle of resolution (logMAR) and refractive error was calculated as the spherical equivalent (diopter, D). The refractive error was obtained with an autorefractor (RK-F1; Canon, Tokyo, Japan). The degree of corneal stain (0 to 5) was graded with the Oxford scheme using anterior segment photographs.[5] The ocular surface temperature was measured using portable noncontact camera (TG 165, FLIR System Korea, Seoul, Korea). It was measured by one examiner (S.G.H), to avoid inter-examiner variation, in a room without windows. The pupil diameter was measured using a portable pupilometer (NeurOptics® VIP™-200 Pupillometer, NeurOptics, Inc, Irvine, CA, USA) under scotopic, low mesopic and high mesopic conditions. The illumination of the room was maintained at 300 lux. All measurements were performed before and immediately after the exposure. All measurements were taken from the right eyes of all participants.

All statistical analyses were performed using SPSS 21.0 (IBM Corp., Armonk, NY, USA). The independent sample *t*-test and chi-square test were used to compare the measurements between the two groups. The paired *t*-test was used to compare between before and immediately after the exposure. $p < 0.05$ was considered statistically significant.

RESULTS

A total of 60 healthy adults were included in this study. Thirty participants each were included in the photo camera and recognition scanner groups. The mean age was 38.5 ± 9.3 years (range, 21 to 50 years) and 37.6 ± 6.8 years (range, 22 to 49 years) in the photo camera and iris recognition scanner groups, respectively. There were 13 (43.3%) and 14 (46.7%) male participants in the photo camera and iris recognition scanner groups, respectively. The logMAR visual acuity was 0.01 ± 0.09 (range, 0 to 0.1) and 0.01 ± 0.03 (range, 0 to 0.1) in photo camera and iris recognition scanner group, resepctively. The baseline refractive error was -2.6 ± 2.4 D (range, -8.3 to 1.6 D) in the photo camera group and -2.4 ± 2.6 D (range, -9.3 to 0.1 D) in the recognition scanner group. A minus value for the refractive error indicated myopia. The degree of corneal stain was 0.47 ± 0.82 (range, 0 to 3) in the photo camera group and 0.23 ± 0.50 (range, 0 to 2) in the recognition scanner group. The ocular surface temperature was 35.1 ± 0.8℃ (range, 33.3 to 36.4℃) in the photo camera group and 35.3 ± 0.5℃ (range, 34.2 to 36.6℃) in the iris recognition scanner group. The scotopic pupil diameter was 4.6 ± 0.7 mm (range, 2.4 to 5.4 mm) in the photo camera group and 4.8 ± 0.7 mm (range, 3.7 to 7.0 mm) in the iris recognition scanner group. There were not significant differences between the two groups (all, $p > 0.05$). Table 1 shows the details of the demographic data.

The measurements for the photo camera immediately after the exposure were as follows. The refractive error and degree of corneal strain were -2.5 ± 2.4 D (range, -8.5 to 1.3 D) and 0.43 ± 0.72 (range, 0 to 3), respectively. The ocular surface temperature was 35.2 ± 0.7℃ (range, 34.0 to 36.7℃). The scotopic, low mesopic, and high mesopic pupil diameter were 4.7 ± 0.7 mm (range, 2.6 to 5.4 mm), 4.8

± 0.5 mm (range, 2.7 to 5.4 mm) and 4.7 ± 0.9 mm (range, 2.8 to 5.2 mm), respectively. There were no significant changes immediately right after exposure to the smartphone with photo camera (p > 0.05 for all) (Fig. 1).

The measurements for the iris recognition scanner immediately after the exposure were as follows. The refractive error and degree of corneal strain were -2.4 ± 2.6 D (range, -9.6 to 0.3 D) and 0.17 ± 0.46 (range, 0 to 2), respectively. The ocular temperature was 35.3 ± 0.5℃ (range, 34.7 to 36.7℃). The scotopic, low mesopic, and high mesopic pu-

Table 1. Basic demographics

	Photo camera (n = 30)	Iris recognition (n = 30)	*p*-value[*]
Age (years)	38.5 ± 9.3 (21 to 50)	37.6 ± 6.8 (22 to 49)	0.33
Male	13 (43.3)	14 (46.7)	0.71[†]
VA (LogMAR)	0.01 ± 0.09 (0 to 0.1)	0.01 ± 0.03 (0 to 0.1)	0.15
Refractive errors (D)	-2.6 ± 2.4 (-8.3 to 1.6)	-2.4 ± 2.6 (-9.3 to 0.1)	0.65
Corneal stain (°)	0.47 ± 0.82 (0 to 3)	0.23 ± 0.50 (0 to 2)	0.30
Ocular temperature (℃)	35.1 ± 0.8 (33.3 to 36.4)	35.3 ± 0.5 (34.2 to 36.6)	0.59
Pupil diameter (mm)			
Scoptic	4.6 ± 0.7 (2.4 to 5.4)	4.8 ± 0.7 (3.7 to 7.0)	0.13
Low mesopic	4.8 ± 0.7 (2.6 to 5.6)	4.9 ± 0.7 (3.7 to 7.0)	0.19
High mesopic	4.7 ± 0.7 (2.8 to 5.5)	4.8 ± 0.7 (3.6 to 7.0)	0.08

Refractive error is presented as the spherical equivalent. Values are presented as mean ± standard (range) deviation or number (%) unless otherwise indicated.
VA = visual acuity; LogMAR = logarithm of minimal angle of resolution; D = diopters.
[*]Independent sample t-test; [†]chi-square test.

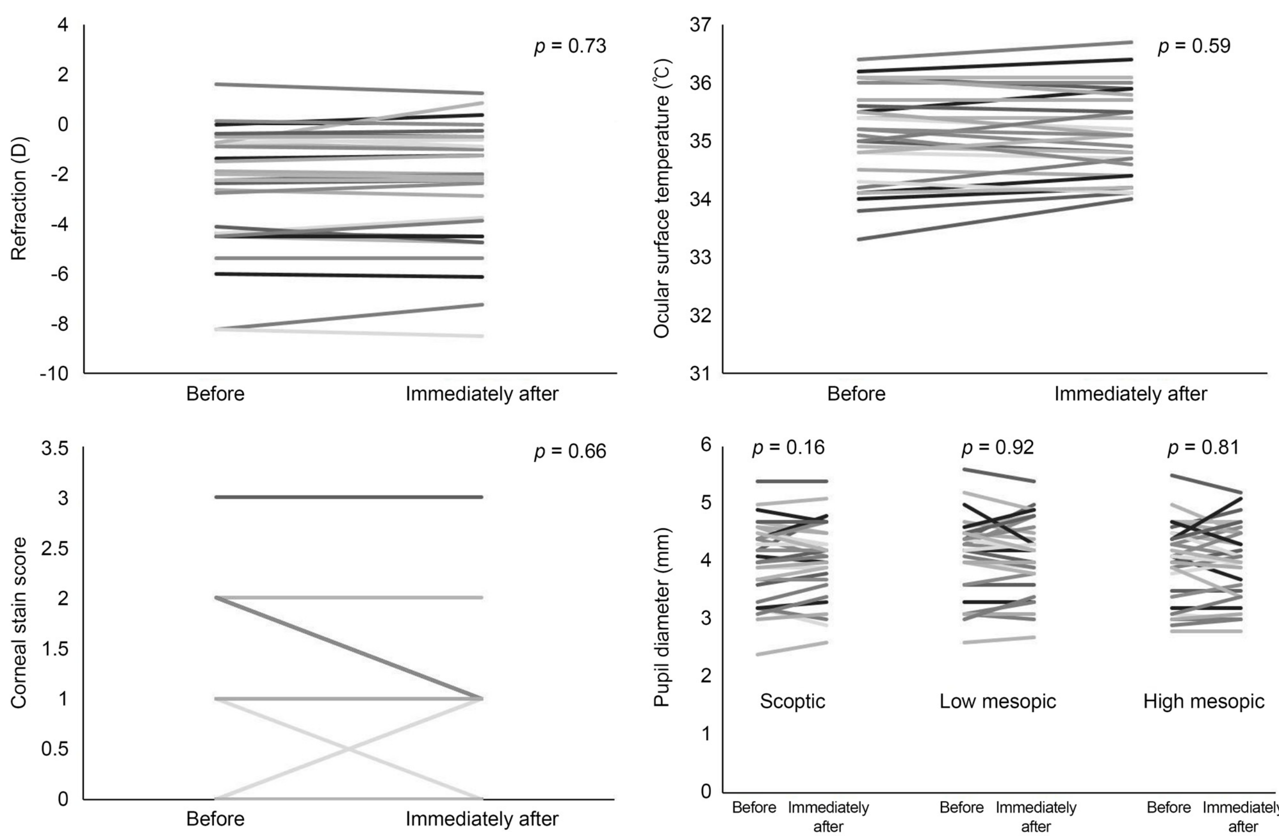

Figure 1. Changes in the ocular measurements after exposure to smartphone with photo camera.

pil diameter were 4.7 ± 0.7 mm (range, 3.5 to 7.1 mm), 4.8 ± 0.7 mm (range, 3.5 to 7.1 mm) and 4.8 ± 0.8 mm (range, 3.4 to 7.1 mm), respectively. There were no significant changes immediately after exposure to the smartphone with iris recognition scanner ($p > 0.05$ for all) (Fig. 2).

DISCUSSION

In this study, there were no clinically significant changes after exposure to the smartphone with iris recognition scanner. This advanced technology in smartphone has been developed and applied for personal security and entertainment. However, the ocular safety of this technology in smartphone has not been established. The authors previously reported the clinical impact of head mounted display in smartphone on the accommodation and binocularity in normal adolescents.[6] We reported that there were no changes in the binocularity after watching a head mounted display.

Infrared radiation induces thermal energy in the ocular tissues as it traverses through the ocular media. Specifically, intense Infrared-A exposure to the eye may cause retinal burns and cataract.[7] Most of the Infrared-A spectrum is absorbed in the anterior segment as it passes through the cornea, iris, and lens.[4] Thus, in this study, we investigated the transient ocular changes after exposure to infrared irradiation from the smartphone iris recognition camera.

We evaluated the degree of corneal stain and ocular surface temperature for quantitative measurements of corneal damage after exposure. In this study, there were no significant changes in the corneal stain score and ocular surface temperature after exposure to smartphone with photo camera and iris recognition scanner ($p > 0.05$ for all).

The intensity of irradiation might be dependent on the pupil diameter.[4] The transmission of irradiation increases with an increase in the pupil diameter. Additionally, accommodation and a decrease of the pupil diameter may be a barrier for the transmission of infrared-A radiation within the eye. However, there were no significant changes in the pupil diameter before and immediately after exposure to the radiation of iris recognition scanner ($p > 0.05$ for all). To

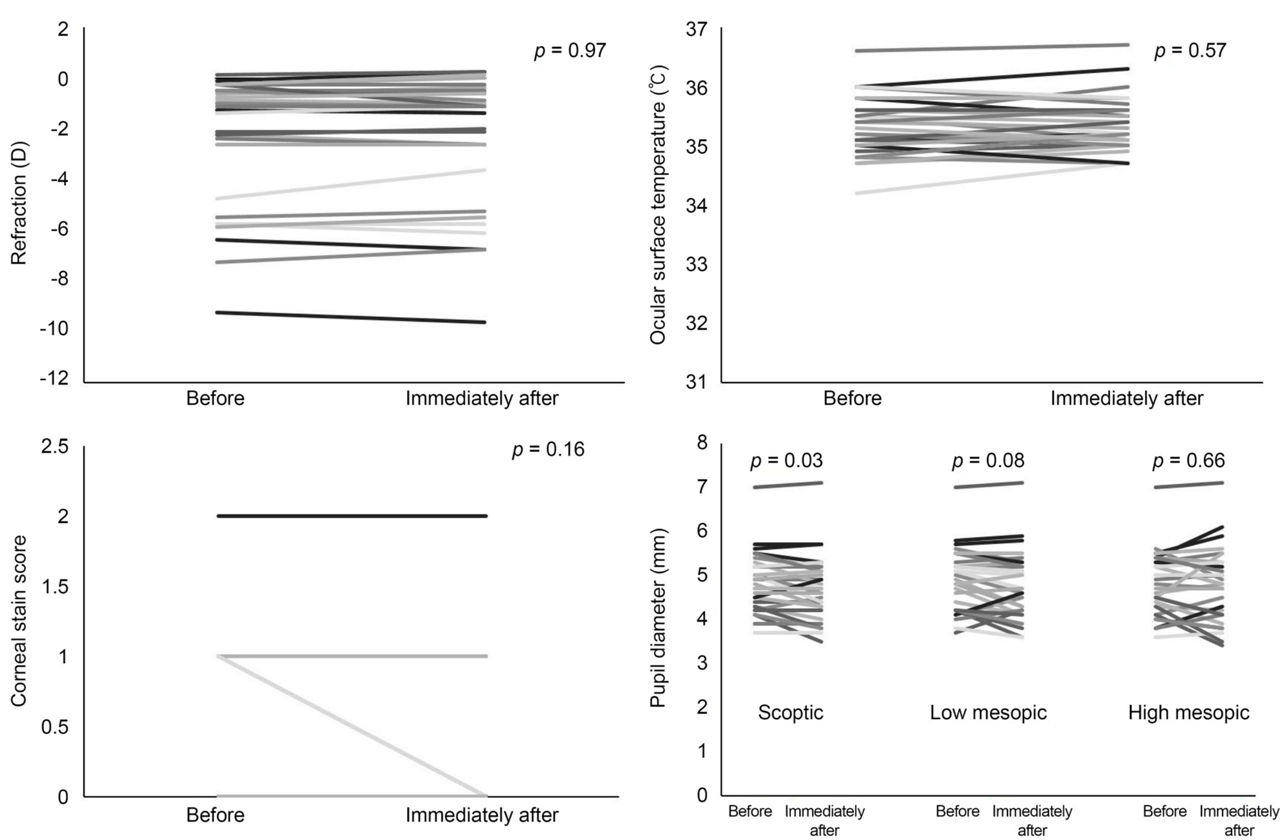

Figure 2. Changes in the ocular measurements after exposure to smartphone with iris recognition scanner.

the best our knowledge, this is the first study to evaluate short-term ocular implications of exposure to smartphone with iris recognition scanner.

This study had some limitations. First, the number of participants included in this study was small. Second, this study was designed to investigate short-term changes after binocular exposure to smartphone with iris recognition scanner. Third, we did not investigate the effect of the eye under extreme conditions, such as long-term use, cumulative effect, and repetitive exposure to IR-A. Further studies are required to investigate the clinical ocular effects of repetitive and long duration use of smartphone with iris recognition camera. Finally, the study sample included normal, healthy adults.

There were no clinically significant effects on normal adult eyes after exposure to smartphone with iris recognition scanner. The ocular safety guidelines for repetitive and chronic use of smartphone with iris recognition scanner require further study.

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