



Brief report

Effect of night work on image quality of optical coherence tomography angiography

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Abstract

Purpose: To assess the effect of night shift work on image quality and artifacts when performing optical coherence tomography angiography (OCT-A).

Methods: In a prospective case series study, twenty nurses underwent OCT-A in two separate sessions: early in the morning before duty shift and at the end of a night shift. Quantitative measurements of horizontal and vertical saccadic, blink, and stretch artifacts and also signal strength of the images were recorded. Moreover, using visual analogue scale of pain (VAS), the perceived pain and discomfort by blue focus light and red scanning laser were recorded.

Results: Vertical and horizontal saccades, blink, and stretch artifacts were significantly higher after the night shift ($P = 0.004$, $P = 0.015$, $P < 0.001$, and $P < 0.001$, respectively). Signal strength was not significantly different between the two measurements ($P = 0.71$). Also, the level of discomfort which was experienced by blue focus light and red scanning laser light was significantly higher after the night shift ($P = 0.009$ and $P = 0.004$, respectively).

Conclusion: Our study suggests that night shift may affect image quality of OCT-A by imposing more artifacts.

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Keywords: Optical coherence tomography angiography; Fatigue; Image quality; Artifacts

Introduction

Optical coherence tomography angiography (OCT-A) is a new technique to evaluate ocular vessels using an en-face OCT device by detecting the intravascular blood flow based on split spectrum amplitude decorrelation angiography.¹ This new imaging modality offers the possibility of imaging the retinal vessels without exposing the patients to the risks of fluorescein

angiography (FA) such as nausea, vomiting, and severe anaphylactic reactions. The OCT-A device repeatedly scans an area of the retina and then evaluates the images to detect changes. The blood flow changes significantly from one image to the other, so by using this technique, the retinal vessels can be visualized at a microvascular level.

OCT-A has proved to be useful in detecting the vascular changes in some retinal diseases such as macular telangiectasia type 2, branch retinal vein occlusion, and choroidal neovascularization secondary to age-related macular degeneration.^{2–4} The images which are obtained by this technique have been shown to have a high resolution.

Unfortunately, like any other imaging technique, OCT-A is prone to imaging artifacts. There are different sources of

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artifacts such as: data processing algorithms, method of data acquisition, some certain ocular properties, pathological changes, and also patients' cooperation during the test.⁵ Accurate fixation to the light is mandatory, and any eye movement will result in poor image quality and image artifacts. Moreover, compared to OCT, OCT-A is inherently slower; this might also decrease the image quality and the patients' cooperation. In this study, we aimed to compare the quality of OCT-A images, which had been taken from healthy subjects, before and after a night work shift.

Methods

This prospective, case series study was performed on healthy cases (with no history of ocular and systemic diseases) adopted from nursing personnel of Farabi Eye Hospital, Tehran University of Medical Sciences, Tehran, Iran. Twenty nurses who volunteered to cooperate in the research project were included. The study and its data acquisitions were approved by the Ethical Committee of Research Deputy of Tehran University of Medical Sciences. Cases were enrolled after providing written informed consent in compliance with the Declaration of Helsinki. OCT-A images were taken after a thorough slit-lamp and funduscopy examination.

After pupillary dilation, OCT-A imaging was performed using an AngioVue device (Optovue, Inc., Fremont, CA), which is based on the Optovue RTVue XR Avanti technology to obtain amplitude decorrelation angiography images: A-scan rate of 70,000 scans per second and wavelength of 840 nm. Split-Spectrum Amplitude-Decorrelation Angiography (SSADA) algorithm and Motion Correction Technology was used to acquire OCT-A images. A 3 × 3 mm scanning area, with a centration on the fovea was considered for each eye. After that, image segmentation and manipulation were carried out, and default preset parameters for segmentation of the capillary bed were used.

Motion artifacts were defined based on the Ghasemi Falavarjani et al.,⁶ and Lauermaann et al. studies⁷:

Stretch artifacts: a stretched image or linear streak at the edge of an en-face image.

Saccadic artifacts: multiple horizontal and vertical saccades which are not adequately corrected by motion correction software (quilting defect).

Blink artifacts: similar to Say et al., a width of more than 10 pixels in one blink line artifact, or the sum of several blink line artifacts in an image, with more than 10 pixels width was considered significant blink artifact in our work.^{7,8}

In order to evaluate the effect of night shift, OCT-A was performed in two separate sessions for each participant: early in the morning before the duty shift and at the end of working a 12-h night shift. To compensate the effect of learning on participants' cooperation, ten of the cases (20 eyes) underwent the first OCT-A after the night shift, and for the others, the first OCT-A was done before their morning duty shift. Vertical and horizontal saccades, blink and stretch artifacts, and signal strength of images were recorded. Also, using the visual analogue scale

of pain (VAS), subjects were asked to define their level of discomfort and perceived pain on a 0-10-point scale during exposure to blue focus light and red scanning laser.

Statistical analysis was performed using SPSS software (IBM SPSS Statistics for Windows, Version 22.0). Student paired *t*-test and Wilcoxon signed ranks-test were used to compare before-after results. Variables were presented as Mean ± SD, and *P*-values less than 0.05 were considered statistically significant.

Results

Twenty healthy cases with mean age of 32 years ± 2.64 (range, 27–45 years) participated in the study. Eighteen subjects (90%) were females. The results showed that the quantitative measured artifacts including vertical saccades, horizontal saccades, blink artifact, and stretch artifacts were significantly lower when OCT-A was performed before the duty shift in comparison with after a night shift (*P* = 0.004, *P* = 0.015, *P* < 0.001 and *P* < 0.001, respectively) (Table 1). However, signal strength was not significantly different between the two measurements (*P* = 0.71). Also, during the test, the level of discomfort experienced by subjects was significantly higher after a night shift either with blue focus light (*P* = 0.009) or red scanning laser (*P* = 0.004) (Table 1).

Discussion

Artifacts are common in OCT-A and may lead to incorrect interpretation of OCT-A images.⁹ Some sources of artifacts are related to image acquisition, processing, segmentation, and display. Moreover, the intrinsic properties of ocular tissue and eye movements are important sources of artifacts.^{9–11} OCT-A is based on the assumption that in a static eye, the only moving objects in the fundus are the red blood cells (RBCs). The motion of RBCs is detected by split spectrum amplitude decorrelation angiography or through an en-face based OCT technique. However, in a living subject, the eye moves, and the major challenge in obtaining the OCT-A images is separating the eye motion which may influence the imaging of erythrocytes' movement within the blood vessels. Moreover, because the device scans the same area multiple times, the OCT-A technique is slower than the OCT.⁹ This means that the patient needs to focus on a fixation light for a longer period of time, which may result in more eye movements and less quality of acquired images. In this study, we sought to investigate the effect of fatigue due to a work shift on the image quality and artifacts of OCT-A images. Our results showed more blink artifact and higher levels of horizontal and vertical saccades after a night work shift. Also, more signal stretch was found in images which had been taken after a night shift.

When performing OCT-A, motion and micro saccades can cause transient change in scans' location.⁹ Although some software such as split spectrum amplitude decorrelation angiography reduce the effect of axial eye motion by reducing the axial resolution, changes in fixation and eye movements

Table 1
Comparison of mean \pm standard deviation (SD) of the measured artifacts and discomfort experienced by the cases between two measurements.

	Early morning (Mean \pm SD)	At the end of night shift (Mean \pm SD)	P-value
Signal strength	78.77 \pm 7.00	78.10 \pm 6.98	0.711
Horizontal saccade	2.02 \pm 2.25	2.32 \pm 1.52	0.015
Vertical saccade	2.62 \pm 1.51	3.97 \pm 2.67	0.004
Blink artifact	0.10 \pm 0.37	0.35 \pm 0.62	<0.001
Stretch artifact	0.02 \pm 0.15	0.20 \pm 0.46	<0.001
Blue focus light discomfort	0.62 \pm 0.97	1.82 \pm 1.99	0.009
Red scanning laser discomfort	0.82 \pm 1.05	2.35 \pm 2.24	0.004

SD: Standard deviation.

are still the major sources of artifacts in OCT-A.⁹ According to our results, it seems that night shift fatigue results in more artifacts by increasing saccadic eye movements and blinking. Also, OCT-A images which were taken after a night shift were prone to more stretch artifacts which deteriorate the image quality.

Image quality influences the OCT-A quantitative measurements and interpretation. Attenuation of signal strength affects the image quality of OCT-A. It can also have an impact on quantitative measurements, such as vessel density estimation. Al-Sheikh et al.,¹² recommended the incorporation of image quality factors and artifacts, when patient information is presented. Signal strength can be affected by media opacity (cataract), defocus (astigmatism, aberration, etc.), aging, and tear film quality.¹³ On the other hand, previous studies show that sleep deprivation impairs the tear film by reduction of tear secretion, tear film stability, and inducing tear hyperosmolarity.^{14–16} Although our results did not show significantly different signal strength before and after a night shift, lower signal strength was found after work shift which can be due to the effect of sleep deprivation and fatigue on quality of tear film. We considered the possible effect of ocular surface diseases and dry eye on image quality and healthy subjects were involved in the study, but reduction of tear film quality after a night shift may affect the image quality in OCT-A measurements and impose more artifacts.

In addition, we evaluated the amount of perceived pain and discomfort, using a VAS scoring system. After a night shift work, in comparison with early in the morning, subjects reported more discomfort with both blue focus light and red scanning laser. Discomfort can be a source of less cooperation, inappropriate fixation, and more blink rates and as a result, more image artifacts. Our study was limited in several ways and there are some issues which should be considered in future studies. Our sample size was small. Future studies with larger sample sizes may confirm our findings. Taking consecutive scans in one session can lead to more accurate results, because artifacts may occur even in consecutive imaging and the results may show different signal strengths in the same subjects.¹⁷ However, artifacts which are linked to fatigue may occur in repeated imaging in one session. On the other hand, repetition can cause the learning effect which might have an improving effect on the results. The effect of fatigue on quantitative assessment of retinal vessels in OCT-A can be investigated in future studies.

Lauermaun et al.⁷ created a motion artifact score (MAS) for OCT-A systems with active eye tracking. MAS can systematically evaluate the motion artifacts. It is also useful to assess the effect of active eye tracking systems on OCT-A image quality. Five major imaging artifacts (blink lines, displacement, stretch artifacts, quilting defect, and vessel doubling) were considered, and MAS was defined from 1 to 4. MAS requires adequate centration of OCT-A image on the fovea. Therefore, in future studies on the effect of subjects' properties on OCT-A image quality, MAS can be useful in better evaluation of motion artifacts and eye tracking techniques.

In brief, we believe that night work should be considered a leading factor to more perceived pain, discomfort, and eye movements during OCT-A. These factors, by imposing more artifacts, can deteriorate the image quality. More spirited patients may experience less discomfort, and the quality of the images may be better. It is suggested to perform OCT-A exams in the morning and after an enough rest.

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