The Effect of Scleral Lens Wear on Optic Disc Perfusion Measured by Optical Coherence Tomography Angiography (OCTA)

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INTRODUCTION

The benefits of scleral lenses have made them increasingly versatile in eye care. These lenses are often helpful in improving visual acuity and ocular surface disorders in patients who have failed conservative therapies[1]. Although the effect of scleral lens wear on intraocular pressure (IOP)[2,3] has been evaluated in recent years, a clear trend has not been defined. Potential changes in IOP from lens wear are important to consider especially in glaucoma patients or suspects. Optical coherence tomography angiography (OCTA) provides the ability to quantify optic disc perfusion. OCTA generates high-resolution motion-contrast images based on the back-scattering of light from retinal tissue, which allows 3D visualization of the microvasculature and blood flow within seconds. The technique is non-invasive and does not utilize injectable dyes. Volumetric scans can be segmented into specific depths to identify the accurate size and location of diseases[4]. The purpose of this study was to evaluate the effect of scleral lens wear on optic disc perfusion using OCTA.

MATERIALS AND METHODS

Study participant. One emmetropic 35-year-old Asian male, without visually significant eye conditions or history of contact lens wear.

Lens Design. The right eye (OD) was fit with scleral lenses of 2 different diameters (BostonSight PROSE, Needham, MA), one at 18.5 mm and the other at 16.0 mm. All other parameters (base curve, power, center thickness, material) were the same. Corrected visual acuity OD was 20/20 with each lens. The left eye (OS) served as a control and had uncorrected VA of 20/20.

OCTA. 6x6 mm scans of the radial peripapillary capillaries were obtained using the Cirrus HD-OCT 5000 (Carl Zeiss Meditec, Inc.), with AngioPlex OCT Angiography through undilated pupils. On Day 1, both eyes were scanned without lens wear at 8:00 AM and 4:00 PM. On Days 2 and 3, both eyes were scanned at 8:00 AM, 12:00 PM and 4:00 PM. The participant wore the 18.5 mm lens OD on Day 2 and the 16.0 mm lens OD on Day 3. No lens was worn OS for Days 2 and 3 to serve as a control. Quantification software measured vessel area density (VAD), flux, perfusion density (PD), and flux index (FI). Statistical analysis calculated the repeatability estimates of repeated measurements.

OCTA parameters measured:
- **Vessel area density (VAD):** estimated vessel density of both medium vessels and capillaries
- **Flux:** mean flow intensity in the vessel area
- **Perfusion density (PD):** total area of perfused capillary vasculature per unit area of the entire image
- **Flux index (FI):** total area of perfused vasculature per unit area of the entire image

Statistical analysis was performed using SAS 9.4 (Cary, NC) software to calculate the repeatability estimates of repeated measurements. The parameters included:
- **Mean**: average of the raw measurements from the OCTA instrument.
- **Sw:** within-subject standard deviation of the measurements.
- **CRw:** coefficient of repeatability.
- **CVw**: coefficient of variation.

Table 1. Details on dates and times OCTA scans were performed.

Day 1, 8:00 AM	Both eyes scanned without scleral lenses. No lenses were inserted.
Day 1, 4:00 PM	Both eyes scanned without scleral lenses.
Day 2, 8:00 AM	Both eyes scanned without scleral lenses. An 18.5 mm diameter scleral lens was then applied on the right eye. Visual acuity and fit were checked. Scans repeated for right eye. Subject continued to wear scleral lens on right eye.
Day 2, 12:00 PM	Both eyes scanned with scleral lens on right eye only. Subject continued to wear scleral lens on right eye.
Day 2, 4:00 PM	Both eyes scanned with scleral lens on right eye only. Lens immediately removed from right eye. Scans repeated for right eye.
Day 3	Same procedure as Day 2, except 16 mm diameter scleral lens inserted on right eye.

RESULTS

Successful OCTA scans were obtained through an undilated pupil in each eye and through scleral lenses on the right eye. Figure 1 shows slit lamp photographs of the right eye with an 18.5 mm diameter scleral lens, the right eye with a 16.0 mm diameter scleral lens, and the left eye with no lens to serve as control. Figure 2 shows OCTA images of the optic disc with normal peripapillary tissue in each eye on Day 1.

Figure 1. Slit lamp photographs of scleral lenses in two diameters (18.5 mm upper left and 16.0 mm upper right) on the right eye and no lens wear on control left eye (lower).

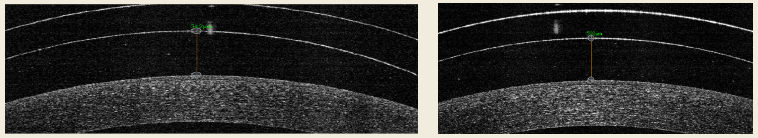
Figure 2. 6x6 mm OCTA scans of OD optic disc (left) and OS optic disc (right) on Day 1.

For Day 1, all the OCTA parameters (VAD, flux, PD, and FI) measured at each time point (8:00 AM and 4:00 PM) for OD and OS were averaged for individual eyes. For Days 2 and 3, all parameters measured at every time point (8:00 AM, 12:00 PM, 4:00 PM) for OD with lens and OS without lens were averaged for individual eyes. There was no significant difference between the OD without lens on Day 1 and the OD with lenses on Days 2 and 3 for all parameters. The OS showed insignificant changes in all parameters across all three days. Repeatability estimates for each eye showed small measurement error, repeatable measurements, and small variation of the measurements for all parameters for all three days.

DISCUSSION

The ideal scleral lens fit vaults the entire cornea and limbus, resting on the sclera and conjunctiva without impinging the conjunctiva[1]. The bearing zones of scleral lenses may compress the conjunctiva as the lenses settle posteriorly throughout the day[5,6]. For the 18.5 mm diameter lens on Day 2, a 29 micron change in apical clearance was observed as a result of lens settling over 8 hours. For the 16.0 mm diameter lens on Day 3, a 40 micron change in apical clearance was observed, as shown in Figure 3. Studies evaluating the amount of settling throughout the day[6] and the effect of scleral lens wear on IOP[2] have found conflicting results. Compression of deeper vascular structures may cause resistance to aqueous humor outflow and elevate IOP[2,5]. With the increasing prevalence of glaucoma, it is important to consider the effect of any ocular device or therapy on IOP or optic disc perfusion. Adequate perfusion is critical in maintaining the health of the optic disc. Several studies have evaluated the relationship between ocular perfusion pressure and open angle glaucoma[7].

Figure 3. Anterior segment optical coherence tomography (AS-OCT) images using the Optovue RTVue (Optovue, Fremont, CA) demonstrating change in apical clearance from 542 microns at 8:00 AM (left) to 502 microns at 4:00 PM (right) with the 16.0 mm diameter scleral lens on Day 3.



CONCLUSION

The findings from this pilot study suggest that optic disc perfusion is not affected by scleral lens wear, with diameters of 18.5 and 16.0 mm, over an 8 hour period. A limitation of this study is that data was collected from only one study participant. Further studies with larger sample sizes over longer periods of time are required to further investigate the effect of scleral lens wear on optic nerve head perfusion.

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