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RTVue Optical Coherence Tomography as an Imaging Modality for Scleral Thickness

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Authors' contributions

This work was carried out in collaboration between all authors. Authors CJF and EBS designed the study, recruited patients and wrote the protocol. Author SKC performed imaging, analyzed data, performed literature searches and wrote the first draft of the manuscript. Authors RB, KB and NS performed imaging. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Purpose: To examine RTVue (Optovue, Inc) optical coherence tomography (OCT) as a method for measuring scleral thickness.
Methods: A prospective, single-center study of eyes with a variety of ocular diseases (no scleral diseases) was performed to image scleral thickness utilizing the RTVue OCT. Repeated measurements of scleral thickness were performed using a line scan 3 mm from the limbus in the inferior nasal and inferior temporal quadrants of each eye. Obtained values were analyzed statistically.
Results: A total of 25 eyes in 14 subjects were measured. An average of 3 measurements per location per eye were taken. The mean scleral thickness 3 mm from the limbus was 654.22 µm. The average standard deviation of the measurements from each location was 30.88 µm. The

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boundary of the conjunctiva and sclera was easily distinguishable.
Conclusion: The results of this study suggest that RTVue high-resolution OCT is a user-friendly modality for measuring scleral thickness.

Keywords: Imaging; optical coherence tomography; scleral thickness.

1. INTRODUCTION

Optical coherence tomography (OCT) is a noncontact, noninvasive, high-speed, high-resolution imaging modality that has been used to image the retina and the optic nerve [1-6]. Anterior segment OCT uses a longer wavelength (1310 nm) than the older retinal OCT (820 nm). This allows for greater penetration through the sclera and the limbus (2 tissues that can scatter light greatly) [2]. As such, anterior segment OCT can acquire and analyze cross sections of the cornea, anterior chamber, iris and the central portion of the lens [5]. Anterior segment OCT has been used to assess corneal and laser-assisted *in situ* keratomileusis (LASIK) flap thickness, anatomic outcomes of Descemet stripping automated endothelial keratoplasty (DSAEK), trabeculectomy morphology, anterior chamber angle anatomy and clear corneal incisions [5-17]. The aim of the present study was to assess the ability of the RTVue (Optovue, Inc) OCT to measure scleral thickness.

2. METHODS

A prospective, single-center study of a variety of subjects from our retina and uveitis clinic was performed to determine the ease of use of the RTVue and the utility of the device. The only inclusion criterion was consent to participate in the study. We used the RTVue by Optovue, Inc, which allows real-time eye tracking and offers 30 frames per second tracking of the visible ocular structures while scanning. Anterior and cornea imaging offers a 6-mm pachymetry map, angle measurement and high-resolution B scanning of anterior segment structures. Repeated measurements of scleral thickness were performed using a line scan 3 mm from the limbus in the inferior nasal and inferior temporal quadrants of each eye. The area measured is indicated in Fig. 1 for illustrative purposes.

An attempt was made to repeat the same number of scans in each subject; however, some initial subjects only received 1 to 2 scans per region. Only those scans with clear boundaries between the sclera and conjunctiva were included for the measurement data. Thus, some eyes had more scans than others, but the average number of scans per area scanned was 3. The 3-mm location was selected because it is easily measurable with the hub of a tuberculin syringe and is the common location for intravitreal injections as well as placement of intraocular devices such as the Retisert. The location of the scan was marked with a marking pen after making an impression on the sclera with a tuberculin syringe hub. The line scan was directed toward the center of the pupil for consistency. Statistical analysis was performed with the use of Microsoft Excel functions for descriptive statistics. All applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during this research.

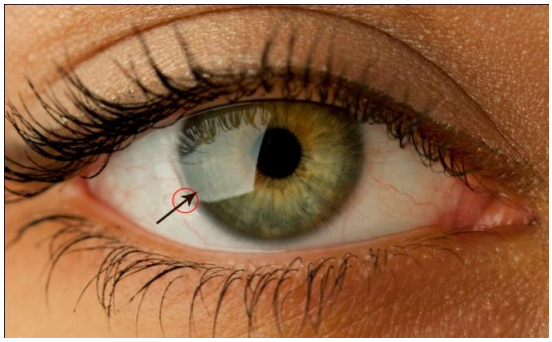

Fig. 1. Region measured (arrow)

3. RESULTS

A total of 25 eyes in 14 subjects (no scleral diseases) were assessed (Table 1).

An average of 3 measurements per location per eye were obtained. The mean scleral thickness 3 mm from the limbus was 654.22 µm. The mean standard deviation of the measurements from each location was 30.88 µm. The data obtained in the present study represent an extension of early data collected and presented in abstract form; the boundary of the sclera and conjunctiva was readily distinguishable in 78/124 (63%) total measurements in that abstract [18]. We deleted

data for poorly distinguishable scans and added additional scans; the boundary of the conjunctiva and sclera was readily distinguishable in all scans in the present study (Fig. 2). The data recorded were from the eyes with clear anatomic landmarks.

Table 1. Thickness of sclera 3 mm from the limbus

Subject no.	Gender	Age (y)	Race	Eye	Scleral thickness (μm)
1	F	78	White	OD	660, 778
2	M	85	White	OS	542, 598
3	F	47	White	OS	559, 685, 654, 589
4	F	57	White	OD	465, 610, 556
				OS	552, 572, 599
5	M	25	Hispanic	OD	601
				OS	542, 586, 648
6	F	20	White	OD	621, 633
				OS	762, 778
7	F	63	White	OD	658, 617, 660, 580
				OS	598, 626, 607, 598
8	F	62	White	OD	703, 695, 670, 607, 679, 648
				OS	635, 654, 679, 647, 653
9	M	30	Hispanic	OD	664, 620, 611, 614, 604
				OS	617, 648, 648
10	F	34	White	OD	706, 645, 682
				OS	682, 666, 643, 624
11	F	64	White	OD	553, 517, 632
				OS	673, 670, 638
12	F	64	White	OD	651, 666, 651
				OS	785
13	M	62	White	OD	840, 749, 858
				OS	790, 766, 831
14	M	57	White	OD	791, 772, 791
				OS	756, 807, 727

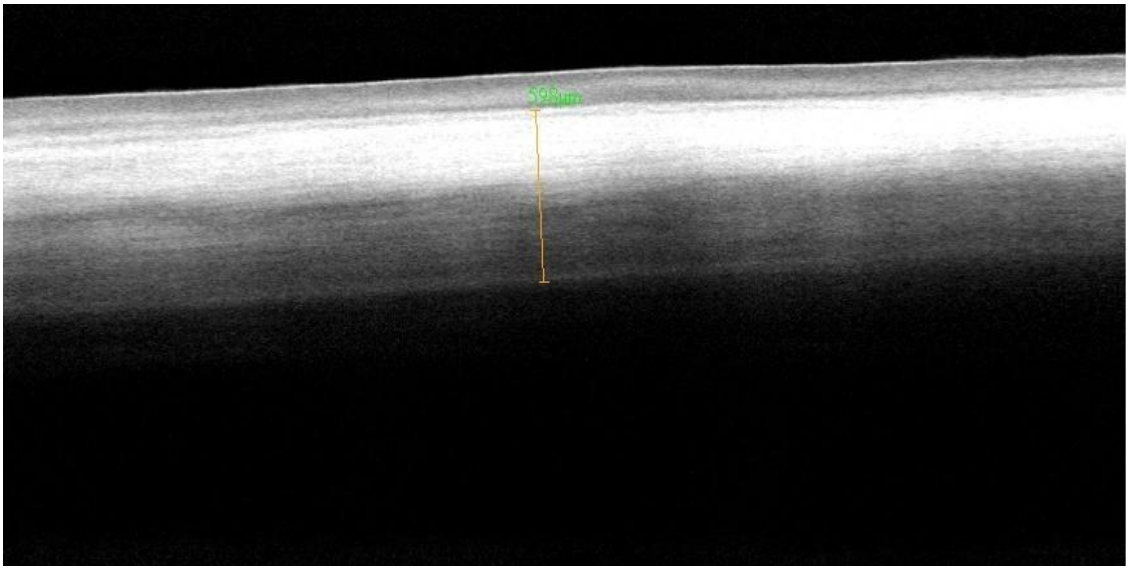

Fig. 2. Images of sclera 3 mm from the limbus with RTVue OCT. We propose that the boundary between the conjunctiva and sclera is as is marked by the calipers

4. DISCUSSION

Although anterior segment OCT has been used to image many different aspects of the eye, there are few studies in which it has been used to image the sclera. The study by Taban and colleagues assessed scleral thickness with the Visante OCT in patients who had received fluocinolone acetonide implants [1]. That study yielded results that were precise but not consistent with those of other imaging modalities of scleral thickness at that particular location; their results showed an average scleral thickness of 918 µm 3.5 mm from the limbus [1]. Previous studies using ultrasound pachymetry measured that same location to be 470 µm thick; light microscopy measured 509 µm; and ultrasound biomicroscopy measured 550 µm 3 mm from the scleral spur [1]. The large difference between previously studied modalities and the study using Visante OCT spurred us to look for another anterior segment OCT device that might have better anatomic resolution and would provide more consistent data.

We found average scleral thickness was 654.22 µm with the RTVue OCT, which was 305.78 µm thinner than the value reported with the Visante OCT [1]. We hypothesize that the difference is due to a greater clarity of demarcation between anatomic structures with the RTVue OCT. A proposed anatomic distinction between the conjunctiva and the sclera was identified with RTVue OCT in images; this was not discerned in the Visante images. This would be expected to lead to more accurate measurements of scleral thickness.

The results of the present study suggest that RTVue high-resolution OCT is a useful modality for measuring scleral thickness. It is a noncontact, user-friendly mode of imaging that does not require the photographer expertise or imaging expense of other methods such as ultrasound biomicroscopy. Future directions for this imaging method will focus on the repeatability of RTVue OCT measurements of scleral thickness and include population-based studies to determine average scleral thickness in different age groups and ethnicities and between sexes. It could also be used to quantify progressive scleral thinning after intravitreal injections, pars plana implants, or other therapy delivered through the anterior sclera.

5. CONCLUSION

Using the RTVue high-resolution OCT, we measured an average scleral thickness of 654.22 µm. This method is a user-friendly modality for measuring scleral thickness.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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