Comparison of choroidal thickness using swept-source and spectral-domain optical coherence tomography in normal Indian eyes

Siddharth Narendran, George Manayath, Narendran Venkatapathy

Abstract:

BACKGROUND/AIMS: Choroidal thickness measurements are reported to differ between spectral-domain optical coherence tomography (SD-OCT) and swept-source OCT (SS-OCT). The aim of this study was to assess the comparability of choroidal thickness measurements using SS-OCT and SD-OCT devices among normal participants.

MATERIALS AND METHODS: This was a prospective study of 31 (62 eyes) normal participants. Choroidal imaging was performed sequentially with the Spectralis OCT (SD-OCT) and the deep range imaging OCT (DRI OCT-1) (SS-OCT) using standardized imaging protocols. The subfoveal choroidal thickness (SFChT) was measured manually by two masked retinal specialists. Paired t-tests and intraclass correlation coefficients (ICCs) were used to compare the measurements.

RESULTS: The mean SFChT was 319.5 µm and 325.3 µm for DRI OCT-1 and Spectralis OCT, respectively (P=0.001), with a mean difference of 5.9 with ICC of 0.97. The mean difference in choroidal thickness between the OCT devices was larger among eyes with choroidal thickness > 350 µm compared with eyes with thinner choroids (8.0 µm vs. 4.7 µm).

CONCLUSIONS: SFChT measurements are comparable between DRI OCT-1 and Spectralis OCT. The variability between the devices increases in thicker choroids.

Keywords: Choroidal thickness, spectral-domain optical coherence tomography, swept-source optical coherence tomography

Introduction

The choroid has been traditionally viewed as the major supply of oxygen and nutrients to the outer retina. However, its role in thermoregulation and emmetropization is now becoming increasingly evident.[1-3] The role of the choroid in the development of several ocular diseases including central serous chorioretinopathy (CSCR), Vogt–Koyanagi–Harada syndrome, polypoidal choroidal vasculopathy, age-related macular degeneration, and pathologic myopia has now been well established.[4-7] The choroidal thickness has been reported to change in response to the treatment of diseases such as CSCR, Behcet’s disease, and diabetic retinopathy.[8-10] This shows that the quantitative assessment of the choroid may play a role in prognosticating the disease outcome and also to assess the response to treatment.

Quantitative assessment of the choroid was first made possible with the advent of enhanced depth imaging (EDI) as defined by Spaide et al.[11] At present, two optical coherence tomography (OCT) technologies allow imaging of the choroid: (1) spectral-domain (SD) OCT with conventional light sources using EDI...
and (2) swept-source (SS) OCT using a long wavelength light source. In SD-OCT with EDI, by simply positioning the patient slightly closer to the machine, imaging of the choroid is possible. This is done by inverting the image, which brings the choroid/sclera interface closer to the zero delay line. This zero delay line by convention is present at the top of the imaging screen and it represents the area of the most precise focus. The newest OCT system to be commercially available is the SS-OCT.\(^{[12]}\) The SS-OCT has the following advantages over the SD-OCT: (1) the longer wavelength source enables deeper penetration of tissue and (2) the presence of photodiodes compared to the spectrometer in conventional OCT systems helps in more efficient detection of interference patterns.

Several previous studies have reported differences in retinal thickness measured using the SD-OCT and the time domain OCT and have suggested that measurements from these two systems may not be used interchangeably.\(^{[13,14]}\) Accurate and repeatable measurements of the choroid are needed to better understand the role of the choroid in the pathogenesis of several retinal diseases.

The aim of this study was to compare the subfoveal choroidal thickness (SFChT) measurements obtained using SD-OCT and SS-OCT.

**Materials and Methods**

This was a prospective and noninterventional cohort study of 31 normal participants who underwent sequential imaging using SD-OCT and SS-OCT at our institution. The study was approved by our Institutional Review Board and conformed to the tenets of the Declaration of Helsinki. Patients with any ocular pathology or any history of ocular surgery/procedure were excluded. High myopic and hyperopic refractive errors >−3.0 or +3.0 diopters were excluded from this study. Written, informed consent was obtained from all participants.

All OCT scans were performed sequentially using standardized imaging protocols between noon and 4 pm to account for the diurnal variations in choroidal thickness.\(^{[13]}\)

An SS-OCT device (Topcon deep range imaging [DRI] OCT-1; Topcon Inc., Tokyo, Japan) performed radial 12.0 mm scans centered on the fovea, with 128 averaged automatically for each OCT B-scan.

The Spectralis OCT (Heidelberg Engineering, Heidelberg, Germany) was used to perform 19 horizontal line raster scans (30° × 15°) centered on the fovea, with 100 frames averaged in each OCT B-scan.

All choroidal thickness measurements were done by two masked retinal specialists. All participants also underwent a comprehensive ocular examination along with keratometry and axial length measurement.

Choroidal thicknesses were independently measured by two masked retinal specialists using the inbuilt caliper tool available with the proprietary OCT viewing software (DRI OCT-1 V.9.12.003.04 and Heidelberg Eye Explorer V.1.7.1.0). The perpendicular distance from the bottom of the RPE-Bruch’s membrane complex to the choriocapillary junction was recorded as the SFChT [Figure 1].

All OCT images were graded qualitatively based on the visibility of the choriocapillary interface (CSI) across the entire scan [Figure 2].

- Grade 1: <25% CSI visible
- Grade 2: 25%–50% CSI visible
- Grade 3: 50%–75% CSI visible
- Grade 4: >75% visible.

Statistical analysis was performed using SPSS V.16.0 (SPSS Inc., Chicago, Illinois, USA). The differences in choroidal thickness between the two machines were analyzed using paired \(t\)-tests. Intraclass correlation coefficients (ICCs) were used to assess the agreement between the machines (interdevice) and the agreement among the graders (intergrader).

**Results**

The mean age of the 31 participants was 45.8 years (range 30–67, SD ± 8.6), with 15 men and 16 women. The mean SFChT measured using the Spectralis OCT with was 325.3 µm (range 230–486.5, SD ± 67.1). Using the DRI-1 OCT, the mean SFChT was 319.5 µm (range 218–481, SD ± 69.8). Agreement between the two devices was good (ICC >0.97, \(P < 0.0001\)) with a mean difference of 5.9 µm and 2.8 mm for Spectralis OCT and DRI-1 OCT, respectively. Interobserver agreement was excellent (ICC >0.97, \(P < 0.0001\)) in both devices with a mean difference < 2 µm. The median image quality grade was 4 for DRI-1 OCT and 3 for Spectralis OCT.

![Figure 1: Optical coherence tomography image showing the measurement of the subfoveal choroidal thickness](image-url)
In thicker choroids (SFChT > 350 µm), the mean difference between the devices increased to 8 µm compared to thinner choroids (4.7 µm). The interobserver variability in thicker choroids was 6.2 µm (ICC 0.95, P < 0.0001) for Spectralis OCT and 2.7 µm (ICC 0.99, P < 0.0001) for DRI-OCT. Although the interobserver variability was more in thicker choroids, especially with Spectralis OCT, this difference was not statistically significant. The median image quality grade in thicker choroids was 3 for DRI-1 OCT and 2 for Spectralis OCT.

Figure 3 is a scatter plot with SFChT sorted by Spectralis OCT and plotted against DRI-1 OCT.

**Discussion**

The results of this study show that there is no significant difference in the SFChT measurements between the two OCT devices. However, visualization of the CSI is better with DRI-1 OCT.

There have been several previous studies comparing these devices both in normal participants and in eyes with ocular diseases [Table 1].[16-19] Two of these studies reported thicker choroidal thickness measurements with swept-source OCT. Matsuo et al. hypothesized that this difference may be due to the fact that the CSI in SD-OCT may not be the true junction.[19] Although this was also seen in some of our cases, repeat scans usually helped in identifying the correct CSI. The results of our study are similar to the results reported by Tan et al. who reported consistently but not significantly thicker choroids with Spectralis OCT in both normal and diseased eyes.[17] The median image quality was slightly better in SS-OCT compared to SD-OCT. This may be due to the longer wavelength light source employed in SS-OCT that aids in better penetration. However, Waldstein et al. reported a slightly better penetration with SD-OCT compared to SS-OCT.[20] This discrepancy could be answered by the difference in image averaging employed in their study (50 images averaged for SD-OCT and single image for SS-OCT). Image averaging significantly improves image quality as reported by Pappuru et al.[21] Adhi et al. reported better visualization of the CSI with SS-OCT compared to SD-OCT, similar to the results of our study.[22]

The strengths of our study were the imaging protocol with the highest possible images averaged in each device and the good interobserver agreement between the graders. This study is limited in its sample size and participant selection. A sampling bias may be present because of the small sample size. Since only normal participants were included in our study, the variation between the OCT devices in eyes with chorioretinal diseases and in eyes with media opacities cannot be estimated.

**Conclusion**

The choroidal thickness measurements between the two devices are comparable. The variability between the devices increases in thicker choroids. SS-OCT may provide better visualization of the CSI.
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Nil.

Conflicts of interest
There are no conflicts of interest.

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