Comparing Gonioscopy With Visante and Cirrus Optical Coherence Tomography for Anterior Chamber Angle Assessment in Glaucoma Patients

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Purpose: The aim of this study was to compare gonioscopy with Visante and Cirrus optical coherence tomography (OCT) for identifying angle structures and the presence of angle closure in patients with glaucoma. A secondary objective was to assess interrater agreement for gonioscopy grading among 3 independent examiners.

Methods: Gonioscopy grading using Spaeth Classification and determination of angle-closure risk was performed on 1 randomly selected eye for 50 phakic patients. Images of the same eye using both Visante and Cirrus OCT were obtained in both light and dark conditions. Agreement of angle closure among 3 devices and interrater agreement for gonioscopy were determined using Cohen's κ (K) or Kendall's coefficient of concordance (W).

Results: Of the 50 patients, 60% were female, 64% were white, and the mean age was 62 years. Angle closure was detected in 18%, 16%, and 48% of quadrants with Visante, Cirrus, and gonioscopy, respectively. The scleral spur was identified in 56% and 50% of quadrants with Visante and Cirrus OCT, respectively. Visante and Cirrus OCT showed moderate agreement in detecting angle closure ($K = 0.42$ light, $K = 0.53$ dark) but slight-to-fair agreement with gonioscopy (Visante $K = 0.25$, Cirrus $K = 0.15$). Gonioscopy demonstrated substantial agreement in angle closure ($K = 0.65$ to 0.68) and angle-closure risk assessment ($W = 0.83$) among 3 examiners.

Conclusions: Visante and Cirrus OCT imaging may have limited ability to identify angle closure because of difficulty identifying angle structures. Gonioscopy by well-trained clinicians had remarkably consistent agreement for identifying angle-closure risk.

Key Words: Visante, Cirrus, optical coherence tomography, anterior segment, anterior chamber angle, gonioscopy, glaucoma, angle closure

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Glaucoma is one of the leading causes of blindness worldwide.[1–3] The estimated worldwide prevalence of angle-closure glaucoma (ACG) is nearly 16 million.[3] Management of narrow angle and ACG are dependent on a precise assessment of the anterior chamber angle (ACA). Gonioscopy is the current standard for assessing the ACA. However, it is a subjective and semiquantitative assessment. Gonioscopy also requires considerable training and grading may vary among clinicians.

Biometric analyses of the ACA may provide a more objective assessment than gonioscopy. In 1994, Izatt et al[4] first considered optical coherence tomography (OCT) as a potential tool for anterior segment imaging. Since then, OCT technology has improved to capture quick high-quality cross-sectional images.[5–8] Carl Zeiss Meditec, of Dublin, CA, manufactures 2 such systems: Visante and Cirrus OCT.

Visante, an anterior segment OCT (AS-OCT), produces images similar to B-mode ultrasound imaging using light instead of sound. AS-OCT uses a diode with 1310 nm wavelength infrared light to quickly capture cross-sectional images of the ACA.[9] This wavelength allows penetration through scleral tissue but not through pigmented iris tissue; therefore, Visante only allows imaging of the anterior segment.[9] Images have a resolution of 10 to 20 μm.[7] Acquisition takes from 1 to 5 seconds.[7]

Meditec has modified the newer Cirrus high-definition OCT (HD-OCT), originally designed to capture images of the retina, to image the anterior segment.[10] Cirrus uses a shorter wavelength (830 nm) to capture images at a higher scanning speed with resolutions of 3 to 5 μm.[11]

Compared with gonioscopy, OCT may provide more objective, quantitative, and reproducible images of the ACA. It requires minimal training to acquire images. Because of its speed of scanning and simplicity of obtaining images, OCT may potentially be used to screen large populations for detection of anterior segment disease.

This study aimed to compare gonioscopy with Visante AS-OCT and Cirrus HD-OCT for identifying angle structures and the presence of angle closure. A secondary objective was to assess interrater agreement for gonioscopy grading among 3 independent examiners.

METHODS

Participants

A total of 54 phakic patients with primary open-angle glaucoma, ACG, ocular hypertension, or pseudoexfoliative

glaucoma were recruited from the Glaucoma Service at Wills Eye Hospital after obtaining informed consent. Three patients withdrew because of scheduling conflicts and 1 withdrew after refusing to have images obtained using Visante OCT. Patients with prior intraocular surgery, including laser iridotomy; a history of trauma; or prior use of a topical miotic medication were excluded. The Institutional Review Board of Wills Eye Hospital approved the study following the principles of the Declaration of Helsinki.

Gonioscopy

All participants underwent a comprehensive ophthalmic examination, including visual acuity testing, slit-lamp examination, intraocular pressure measurements with Goldmann applanation tonometry, and optic disc examination with 90 D lens through an undilated pupil. Three independent glaucoma fellowship trained examiners (L.J.K., A.V.M., J.R.) performed gonioscopy in the dark at a standardized ambient light on one randomly selected eye. A 1 mm light beam was reduced to narrow slit, which was offset horizontally to assess the superior and inferior angles and vertically to assess the nasal and temporal angles. A Posner handheld gonioprism lens was used to assess these 4 quadrants with the eye focused on the primary position of gaze. Care was taken to avoid aiming the light directly on the pupil.

Gonioscopy results were recorded using the Spaeth grading system for iris insertion [anterior to Schwalbe's line (SL), between SL and scleral spur (SS), SS visible, deep to ciliary body (CB) visible, extremely deep with >1 mm of CB visible], angular approach (0 to 50 degrees), and peripheral iris contour (bowing anteriorly, flat, or concave posterior bowing). The ACA was considered closed if the iris contacted the cornea anterior to the SS. It was considered open if the SS was visible. Each examiner clinically assessed the angle-closure risk and classified the risk as: no or low risk, medium risk, or high risk. For statistical analyses, presence of angle closure and angle-closure risk assessment was based on the response by a majority (2 of 3) of the examiners. Gonioscopy examiners were masked to patient information during gonioscopy and risk assessment.

Visante and Cirrus Imaging

After gonioscopy, an examiner (C.Z.) who was masked to gonioscopy findings used both Visante and Cirrus OCT (Carl Zeiss Meditec, Dublin, CA) to obtain images of the same eye. Visante and Cirrus images were acquired using Enhanced Anterior Segment Single Scan and Anterior Segment 5 Line Raster Scan, respectively. Images were obtained of 4 quadrants of the ACA under both scotopic and photopic conditions. Using a cotton tip applicator stick, the upper and lower eyelids were displaced to acquire images of the superior and inferior quadrants. Care was taken to avoid inadvertent pressure to the globe while using the applicator stick. During the image acquisition process, images were repeated if image quality was subpar based on the discretion of the examiner.

All images were exported to a research computer after removing identifying information. Three examiners with OCT training (C.Z., B.M.F., M.A.) evaluated the masked images and independently identified the SS and SL. Examiners independently determined whether the ACA was open, closed, or unable to be determined. The response of a majority (2 of 3) of the examiners was used for statistical analysis.

Statistical Analysis

Data were analyzed using SAS Analytics Pro software, version 9.2 (SAS Institute Inc., Cary, NC). Comparison of dark versus light conditions for identification of angle structures and angle closure was assessed using the McNemar test or the Bowker test of symmetry. *P*-values <0.05 were considered statistically significant.

Agreement of test results were quantified using Cohen's κ (K) or Kendall's coefficient of concordance (W), with 0 indicating no agreement and 1 indicating perfect agreement. Qualitative ratings of agreement statistics were used based on a study by Landis and Koch[12]: poor (≤ 0), slight (0 to 0.2), fair (0.2 to 0.4), moderate (0.4 to 0.6), substantial (0.6 to 0.8), and almost perfect (0.8 to 1.0) agreement.

RESULTS

Demographics

Fifty eyes from 50 participants were included in this study. The mean age was 62 years (range, 23 to 83 y). Most participants were female (60%), white (64%), and diagnosed with ACG (60%) (Table 1).

Identification of Angle Structures

Identification of angle structures is summarized in Table 2. In the dark, the SS was not visible in 89/200 (45%) and 100/200 (50%) quadrants for Visante and Cirrus, respectively. For both Visante and Cirrus, the SS was most difficult to visualize in the superior quadrants [not visible in 34/50 (68%) and 40/50 (80%)] and inferior quadrants [not visible in 34/50 (68%) and 43/50 (86%)], respectively.

Using Cirrus, SL was not visible in 120/200 (60%) quadrants, particularly in the superior [38/50 (76%)] and inferior [39/50 (78%)] quadrants. SL was not visible using Visante.

TABLE 1. Characteristics of 50 Patients

Characteristics	n (%)
Age (y)	
Mean (range)	62 (23-83)
Sex	
Female	30 (60)
Male	20 (40)
Race	
White	32 (64)
African American	16 (32)
Other	2 (4)
Type of glaucoma	
Chronic angle-closure glaucoma	30 (60)
Primary open-angle glaucoma	17 (34)
Ocular hypertension	2 (4)
Pseudoexfoliative glaucoma	1 (2)
Lens status	
No nuclear sclerosis or other apparent lens change	11 (22)
Nuclear sclerosis—trace	5 (10)
Nuclear sclerosis— + 1 or + 2	32 (64)
Nuclear sclerosis— + 3 or + 4	2 (4)

TABLE 2. Identification of Angle Structures in Light and Dark Conditions for Visante and Cirrus

	Visante [n (%)]			Cirrus [n (%)]		
Angle Structure	**Visible**	**Not Visible**	***P****	**Visible**	**Not Visible**	***P****
Scleral spur (dark)	111 (56)	89 (45)	0.35	100 (50)	100 (50)	0.001
Scleral spur (light)	116 (58)	84 (42)		118 (59)	82 (41)	
Schwalbe's line (dark)				80 (40)	120 (60)	0.11
Schwalbe's line (light)				89 (45)	111 (56)	

*The McNemar test.

Angle Closure by Imaging

Angle closure was detected in 35/200 (18%) and 32/200 (16%) of quadrants with Visante and Cirrus, respectively (Table 3). Angle closure could not be determined in 86/200 (43%) and 95/200 (48%) quadrants for Visante and Cirrus, respectively. Of the 86 quadrants wherein angle closure could not be determined using Visante, 39/86 (45%) were closed and 47/86 (55%) were open using gonioscopy. Of the 95 quadrants wherein angle closure could not be determined using Cirrus, 42/95 (44%) were closed and 53/95 (56%) were open using gonioscopy.

It was most difficult to determine angle closure in the superior quadrants [not visible in 33/50 (66%) and 39/50 (78%)] and inferior quadrants [not visible in 33/50 (66%) and 39/50 (78%)] for Visante and Cirrus, respectively. There was substantial agreement between light and dark conditions for identification of angle closure for both Visante ($K = 0.67$) and Cirrus ($K = 0.63$).

Angle Closure by Gonioscopy

Table 4 shows the distribution of open and closed quadrants using gonioscopy. Of the 95 quadrants that were closed by gonioscopy, Visante identified 32/95 (34%) as closed, 24/95 (25%) as open, and 39/95 (41%) as unable to be determined. Cirrus identified 27/95 (28%) as closed, 26/95 (27%) as open, and 42/95 (44%) as unable to be determined. Gonioscopy found 32/35 (91%) quadrants that Visante identified as closed and 27/32 (84%) quadrants that Cirrus identified as closed (Fig. 1).

Agreement of Angle Closure Among Gonioscopy, Visante, and Cirrus

Table 5 shows the agreement of angle closure among gonioscopy, Visante, and Cirrus. All angles wherein closure was unable to be determined were excluded from this analysis. Agreement among the 3 tests was fair ($K = 0.31$). Gonioscopy had slightly better agreement with Visante ($K = 0.25$) than with Cirrus ($K = 0.15$).

Interrater Agreement for Gonioscopy

Table 6 shows the interrater agreement for gonioscopy among 3 examiners. Agreement for angle-closure assessment was substantial ($K = 0.65$ to 0.68). Agreement of angle-closure risk was near perfect ($W = 0.83$).

DISCUSSION

There is great interest in using emerging technologies to screen large populations for the presence of angle closure. Visante AS-OCT and Cirrus HD-OCT are the 2 devices that may conceivably be used for this purpose. This study demonstrated that the SS was not visible in 45% and 50% of images using Visante and Cirrus, respectively, in their current iterations. Visante more often identified SS, but both devices were unable to identify structures for a large percentage of images, a finding that is consistent with other studies.[11,13–15] Sakata et al[13] could not determine SS location in at least 1 quadrant for 66% of eyes using Visante. Difficulty visualizing these structures may be due to inherent difficulty in image acquisition or to these devices' processing. On a histologic level, variations in size, form, tissue composition of the SS, and the number of ciliary muscle fibers attaching to the SS may reduce SS visibility.[14,15] We often had difficulty grading images because of large or dark shadows in the angle area (Figs. 2, 3). Previous studies have shown that images obtained by OCT may be limited by shadows casted by abnormal pigmentation of the conjunctiva, such as melanosis or nevi, or increased vascularity of the cornea.[16,17]

The visibility of the SS was lower in the superior and inferior quadrants than in the nasal and temporal quadrants on OCT images, also consistent with other studies.[13] The limited detection of SS in the superior and inferior quadrants may be due to additional difficulties, such as manipulating the eyelids. Special care was taken to move the eyelids with a cotton tip applicator stick when imaging the superior and inferior quadrants. However, inadvertent pressure on the cornea, especially in patients with small palpebral fissures, may have caused some displacement of

TABLE 3. Identification of Angle Closure in Light and Dark Conditions for Visante and Cirrus

	Visante [n (%)]		Cirrus [n (%)]		
Angles	**Light**	**Dark**	**Light**	**Dark**	***P**** **(Light vs. Dark)**
Open	82 (41)	79 (40)	92 (46)	73 (37)	0.71 (Visante)
Closed	33 (17)	35 (18)	31 (16)	32 (16)	0.006 (Cirrus)
Cannot determine	85 (43)	86 (43)	77 (39)	95 (48)	

*The Bowker test of symmetry.

TABLE 4. Distribution of Open and Closed Quadrants by Gonioscopy

	n (%)	
Regions	**Open**	**Closed**
Superior	26 (52)	24 (48)
Inferior	26 (52)	24 (48)
Temporal	26 (52)	24 (48)
Nasal	27 (54)	23 (46)
Overall	105 (53)	95 (48)

anterior segment structures, making the drainage angle appear artificially smaller.[18] As a result, an artificially smaller angle may have reduced the visibility of SS while imaging the superior and inferior quadrants. Furthermore, acquiring images while simultaneously manipulating the eyelids may have been more challenging for the examiner, which may have reduced the detection of the SS in the superior and inferior quadrants.

A considerable limitation of both Visante and Cirrus was the inability to identify angle closure because of difficulty identifying angle structures, particularly the SS. We could not determine angle closure in 43% and 48% of quadrants using Visante and Cirrus, respectively. In some cases, we were able to classify angles as closed, even without identifying angle structures, because of a large area of iris contact to the angle wall anterior to the insertion of the iris. Other angles were classified as open because they appeared deep with the CB clearly visible. Of the quadrants wherein angle closure could not be determined on OCT images, almost half (45% and 44%) were closed on gonioscopy examination for both Visante and Cirrus, respectively. A closed angle may have increased "crowding" of angle structures, thereby reducing the ability to determine angle

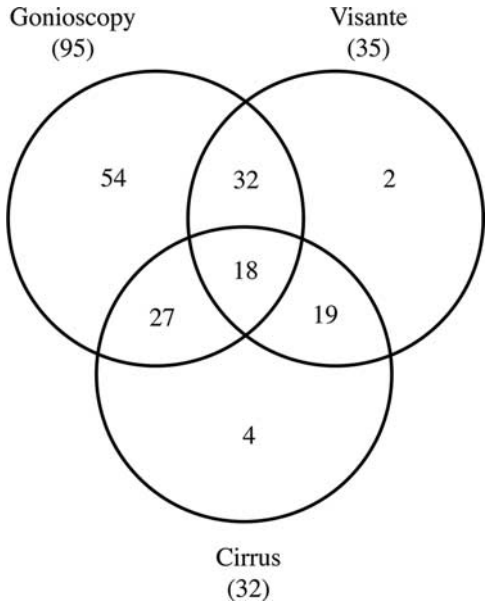

FIGURE 1. Identification of angle closure among gonioscopy, Visante, and Cirrus. The number in parentheses indicates the total number of closed angles that each device identified.

TABLE 5. Agreement of Angle Closure Between Visante, Cirrus, and Gonioscopy

Device	% Agreement	κ (95% CI)
Gonioscopy vs. Visante vs. Cirrus (dark)	70	0.31 (0.26, 0.35)
Gonioscopy vs. Visante (dark)	76	0.25 (0.15, 0.36)
Gonioscopy vs. Cirrus (dark)	70	0.15 (0.05, 0.25)
Visante vs. Cirrus (light)	88	0.42 (0.37, 0.47)
Visante vs. Cirrus (dark)	90	0.53 (0.47, 0.59)

CI indicates confidence interval.

closure. This may be supported by the fact that there were more angles where closure could not be determined, the dark compared with light for Cirrus ($P < 0.01$).

Gonioscopy identified angle closure in 48% of quadrants, compared with 18% and 16% of quadrants using Visante and Cirrus, respectively. Gonioscopy determined the status of angle closure for all 200 quadrants. This study found that gonioscopy identified most of the closed quadrants that Visante and Cirrus found (91% and 84%, respectively). Gonioscopy was able to determine angle closure in an additional 54 quadrants that neither Visante nor Cirrus could identify. Although other studies have found that AS-OCT tended to overestimate angle closure compared with gonioscopy, our data did not support this finding.[19,20] One possible reason that gonioscopy identified more closed angles compared with OCT in our study was that the closed angles identified by gonioscopy may have actually been narrow but open angles. For the angle to be considered closed on the OCT images, we required contact between the iris and the cornea anterior to the SS. With gonioscopy, the angle may have appeared closed to the clinician, but it was actually very narrow with no iridoangle contact seen on the OCT image. In this case, the angle would be graded as closed using gonioscopy but open with OCT images. Furthermore, another reason that gonioscopy may have identified more closed angles in our study was that angle closure was unable to be determined in almost half of OCT images.

Our study demonstrated fair agreement among gonioscopy, Visante, and Cirrus in the dark ($K = 0.31$). Gonioscopy and Visante had slightly better agreement ($K = 0.25$) than gonioscopy and Cirrus ($K = 0.15$). However, we excluded from the agreement analysis almost half of angles originally imaged because of our inability to

TABLE 6. Interrater Agreement Among 3 Independent Examiners Using Gonioscopy

	Agreement Coefficient*			
	Superior	**Inferior**	**Temporal**	**Nasal**
Iris insertion (W)	0.80	0.83	0.81	0.83
Angle (W)	0.78	0.81	0.81	0.80
Iris configuration (W)	0.42	0.43	0.43	0.42
Angle open vs. closed (K)	0.65	0.65	0.65	0.68
Angle-closure risk (W)	0.83	0.83	0.83	0.83

*Cohen's κ (K) for agreement of angle closure and Kendall's Coefficient of Concordance (W) for all other measures.

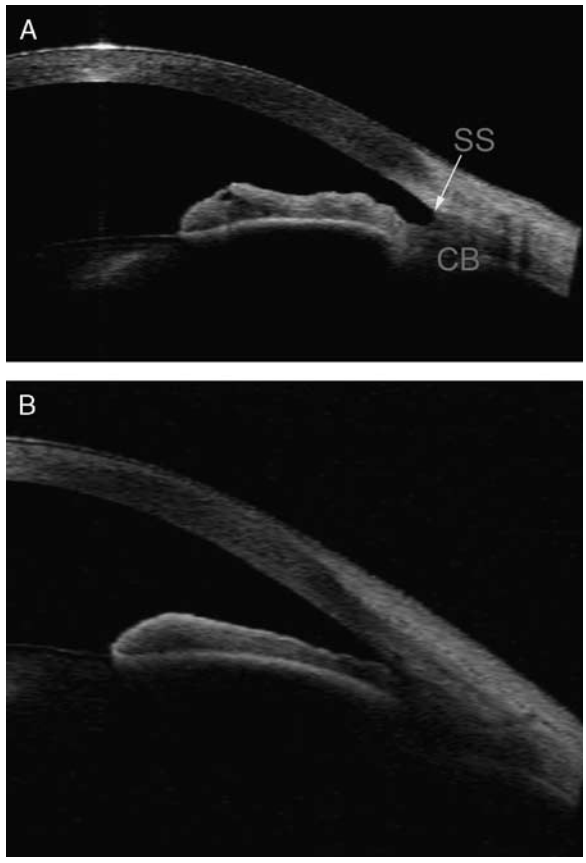

FIGURE 2. A and B, Image of the anterior chamber angle using Visante. The scleral spur (SS) and ciliary body (CB) are visible in (A) but not (B).

assess whether the angle was open or closed. Exclusion of these images may have reduced agreement between gonioscopy and OCT. Other studies have found moderate agreement between Visante and gonioscopy and fair agreement between Cirrus and gonioscopy.[11,20,21] The discrepancy between gonioscopy and OCT may occur for several reasons.[19] Gonioscopy allows visualization of the entire quadrant, whereas a cross-section by Visante and Cirrus images may have missed variations within the quadrant. Furthermore, it is possible to obtain OCT images in complete darkness. During gonioscopy, unintended illumination on the pupil may occur, despite careful efforts to avoid it. A small amount of light may be sufficient to open the angle.[19] Further, inadvertent pressure by the gonioscopy lens may displace anterior chamber structures in some quadrants.[19] Other studies have suggested that when gonioscopy considered the ACA as closed and OCT considered it open, a steep iris configuration may have blocked the indirect view of the angle structures with a gonioscopy lens.[20,22,23]

Cirrus and Visante showed moderate agreement for detecting angle closure ($K = 0.42$ light and 0.53 dark). There was greater agreement in the dark, which emphasizes the importance of standardizing illumination while taking images.[24] This also supports the previous comment that inadvertent light on the pupil may open to the angle to varying degrees, thereby decreasing agreement between the devices. Our study found significantly more angles where closure could not be determined in dark compared with light ($P < 0.01$) for Cirrus but not Visante ($P = 0.71$). This suggests that Visante imaging may be inherently less sensitive than Cirrus to light conditions.

For gonioscopy assessment, agreement for iris insertion, angle, angle closure, and angle-closure risk was substantial to near perfect among the 3 examiners. Only iris configuration had fair agreement. Previous studies have found that experienced examiners have moderate agreement in gonioscopy findings.[25,26] All 3 examiners in this study have had extensive training, including glaucoma subspecialty training, and considerable experience performing gonioscopy. Although gonioscopy was able to achieve substantial agreement among examiners, the extensive training required may limit its use as a screening tool for detection of ACG.

Future iterations of AS-OCT imaging devices have the potential to be used as a screening tool for detection of anterior segment disease. Our study found that images from Visante and Cirrus OCTs in their current iterations were limited by the ability to detect angle structures. Adjustments to these OCT devices may ultimately provide more objective, quantitative, and reproducible images of the ACA. Along with fast image acquisition speed and minimal training of nonmedical personnel, AS-OCT devices have many conceivable advantages as a screening tool.

There were several limitations to our study. First, there was a small sample size, which was further reduced in agreement analysis because angle closure could not be assessed in almost half of images. Second, we specified external targets for patients to fixate on during image acquisition. However, patients may have had variations in gaze during image acquisition, especially with the slower scanning speed of Visante. Third, we did not standardize definitions of angle-closure risk among the examiners during gonioscopy. We aimed to simulate a clinical setting wherein angle-closure risk was determined based on gonioscopy findings. However, our study did not correlate angle-closure risk between gonioscopy and OCT, which was a limitation of our study. Fourth, our clinical assessment of angle-closure risk did not differentiate between chronic and acute ACG using either gonioscopy or OCT imaging. Differentiating the risk between chronic and acute ACG would be important for further management. Additional research needs to be done in this area. Fifth, Visante and Cirrus image quality was based on the discretion of the examiner acquiring the images. We did not have guidelines for determining image quality, which may have contributed to difficulty identifying angle structures and angle closure in our images. Finally, the patient population may not reflect the prevalence of the disease. Even though ACG is a major cause of blindness in Asian people, most participants in our study were white.[3,27,28]

In conclusion, Visante and Cirrus OCT imaging in their current forms may not be able to identify angle closure because of difficulty in identifying angle structures. Future iterations of these imaging devices have the potential to be used as a screening tool for detection of anterior segment disease. Visante and Cirrus had moderate agreement with each other in detecting angle closure but only slight-to-fair agreement with gonioscopy. Gonioscopy by well-trained clinicians had remarkably consistent agreement for identifying angle closure and angle-closure risk.

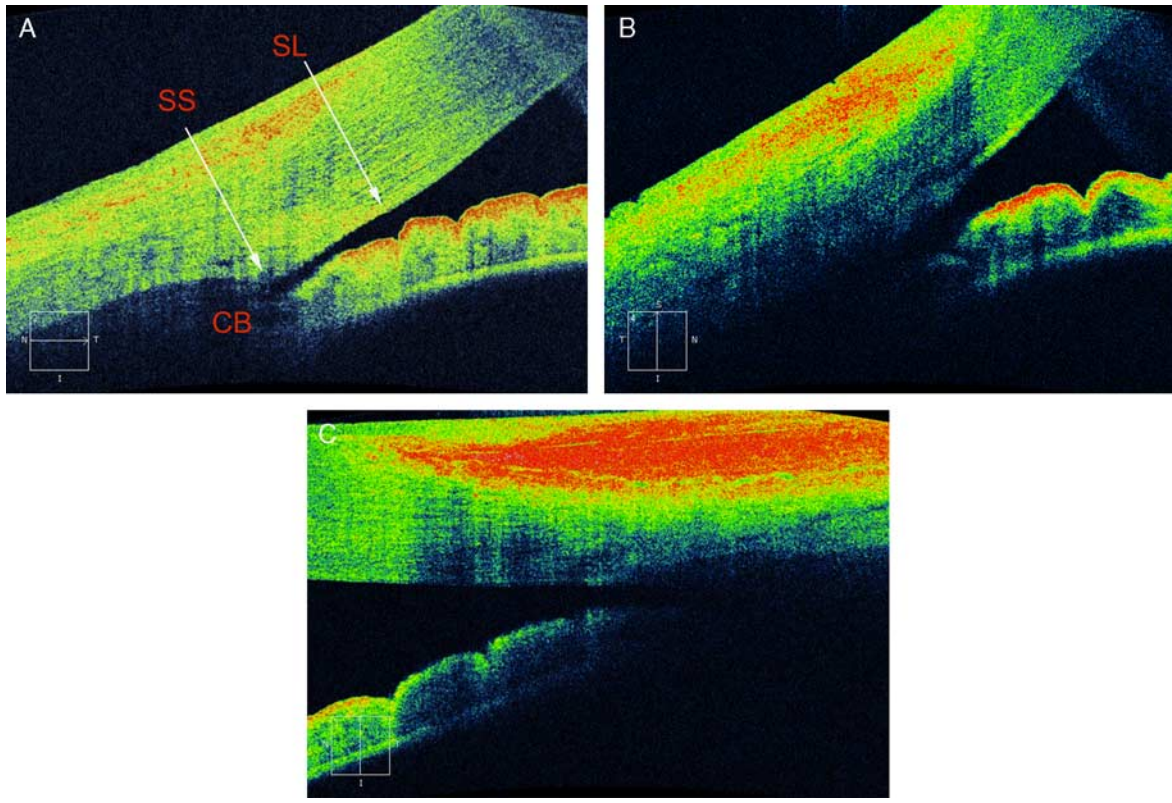

FIGURE 3. Image of the anterior chamber angle using Cirrus. The ciliary body (CB), scleral spur (SS), and the Schwalbe line (SL) are all visible in (A) but not visible in (B) or (C).

REFERENCES

1. Resnikoff S, Pascolini D, Etya'ale D, et al. Global data on visual impairment in the year 2002. *Bull World Health Organ*. 2004;82:844–851.
2. Pascolini D, Mariotti SP. Global estimates of visual impairment: 2010. *Br J Ophthalmol*. 2011;96:614–618.
3. Quigley HA, Broman AT. The number of people with glaucoma worldwide in 2010 and 2020. *Br J Ophthalmol*. 2006;90:262–267.
4. Izatt JA, Hee MR, Swanson EA, et al. Micrometer-scale resolution imaging of the anterior eye in vivo with optical coherence tomography. *Arch Ophthalmol*. 1994;112:1584–1589.
5. Goldsmith JA, Li Y, Chalita MR, et al. Anterior chamber width measurement by high-speed optical coherence tomography. *Ophthalmology*. 2005;112:238–244.
6. Hoerauf H, Scholz C, Koch P, et al. Transscleral optical coherence tomography: a new imaging method for the anterior segment of the eye. *Arch Ophthalmol*. 2002;120:816–819.
7. Radhakrishnan S, Rollins AM, Roth JE, et al. Real-time optical coherence tomography of the anterior segment at 1310 nm. *Arch Ophthalmol*. 2001;119:1179–1185.
8. Doors M, Berendschot TT, de Brabander J, et al. Value of optical coherence tomography for anterior segment surgery. *J Cataract Refract Surg*. 2010;36:1213–1229.
9. Penner V, Rocha G. Use of Visante for anterior segment optical coherence tomography. *Tech Ophthalmol*. 2007;5:67–77.
10. Wong HT, Lim MC, Sakata LM, et al. High-definition optical coherence tomography imaging of the iridocorneal angle of the eye. *Arch Ophthalmol*. 2009;127:256–260.
11. Quek DT, Narayanaswamy AK, Tun TA, et al. Comparison of two spectral domain optical coherence tomography devices for angle-closure assessment. *Invest Ophthalmol Vis Sci*. 2012;53:5131–5136.
12. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics*. 1977;33:159–174.
13. Sakata LM, Lavanya R, Friedman DS, et al. Assessment of the scleral spur in anterior segment optical coherence tomography images. *Arch Ophthalmol*. 2008;126:181–185.
14. Liu S, Li H, Dorairaj S, et al. Assessment of scleral spur visibility with anterior segment optical coherence tomography. *J Glaucoma*. 2010;19:132–135.
15. Hamanaka T. Scleral spur and ciliary muscle in man and monkey. *Jpn J Ophthalmol*. 1989;33:221–236.
16. Garcia JP Jr, Garcia PM, Buxton DE, et al. Imaging through opaque corneas using anterior segment optical coherence tomography. *Ophthalmic Surg Lasers Imaging*. 2007;38:314–318.
17. Shields CL, Belinsky I, Romanelli-Gobbi M, et al. Anterior segment optical coherence tomography of conjunctival nevus. *Ophthalmology*. 2011;118:915–919.
18. Schirmer KE. Gonioscopy and artefacts. *Br J Ophthalmol*. 1967;51:50–53.
19. Sakata LM, Lavanya R, Friedman DS, et al. Comparison of gonioscopy and anterior segment ocular coherence tomography in detecting angle closure in different quadrants of the anterior chamber angle. *Ophthalmology*. 2008;115:769–774.
20. Nolan WP, See JL, Chew PT, et al. Detection of primary angle closure using anterior segment optical coherence tomography in Asian eyes. *Ophthalmology*. 2007;114:33–39.
21. Park SB, Sung KR, Kang SY, et al. Assessment of narrow angles by gonioscopy, Van Herick method and anterior segment optical coherence tomography. *Jpn J Ophthalmol*. 2011;55:343–350.
22. Alsbirk PH. Primary angle closure glaucoma: oculometry, epidemiology, and genetics in a high risk population. *Acta Ophthalmol Suppl*. 1976;127:5–31.

23. Alsbirk PH. Anterior chamber depth and primary angle closure glaucoma. An epidemiological study in Greenland Eskimos. *Acta Ophthalmol*. 1975;53:89–104.
24. Scheie HG. Width and pigmentation of the angle of the anterior chamber. A system of grading by gonioscopy. *Arch Ophthalmol*. 1957;58:510–512.
25. Leung CK, Cheung CY, Li H, et al. Dynamic analysis of dark-light changes of the anterior chamber angle with anterior segment OCT. *Invest Ophthalmol Vis Sci*. 2007;48:4116–4122.
26. Nolan WP, Foster PJ, Devereux JG, et al. YAG laser iridotomy treatment for primary angle closure in east Asian eyes. *Br J Ophthalmol*. 2000;84:1255–1259.
27. Foster PJ, Devereux JG, Alsbirk PH, et al. Detection of gonioscopically occludable angles and primary angle closure glaucoma by estimation of limbal chamber depth in Asians: modified grading scheme. *Br J Ophthalmol*. 2000;84:186–192.
28. Foster PJ, Johnson GJ. Glaucoma in China: how big is the problem? *Br J Ophthalmol*. 2001;85:1277–1282.