IMAGING THE VITREOUS AND VITREOMACULAR INTERFACE

Case presentations demonstrate the utility of 3-D SD-OCT in examining in vivo details of the vitreous structure.

BY MANISH NAGPAL, MS, DO, FRCS(EDIN), AND SHISHIR SHEKHAR SINGH, MS

Detailed biomicroscopic examination of the posterior vitreous gel can be severely compromised by bright, diffuse light reflected from the fundus and the low optical density of vitreous structures. Even the renowned biomicroscopist Vogt stated that, in his view, clinical observations in the posterior part of the vitreous are "illusory rather than real."[1]

As we age, biochemical and structural changes occur in the corpus vitreous, leading to posterior vitreous detachment (PVD).[2] Although generally benign, PVD can contribute to significant retinal morbidities, such as vitreomacular traction (VMT) syndrome, macular hole, epiretinal membrane (ERM), and retinal tears. Furthermore, the status of the vitreous plays a crucial role in the natural course of preexisting local and systemic conditions (eg, uveitis and diabetes), significantly affecting their prognosis and management.[3-8]

Although ultrasound has been considered the standard imaging technique to detect and document vitreous detachment, the higher resolution of optical coherence tomography (OCT) offers advantages when studying any intermediate step of this process.[9-11] Time-domain OCT (TD-OCT) studies have illustrated the posterior hyaloid and its adhesions to the retinal surface in VMT syndrome and related diseases.[12-15]

Spectral-domain OCT (SD-OCT) technology allows better visualization of the hyaloid and a more detailed image of its structure than TD-OCT. SD-OCT provides a dramatic increase of imaging speed, 50 times faster than standard-resolution OCT. A dense raster pattern with multiple consecutive B scans taken at high speed allows comprehensive retinal coverage. It is possible to acquire complete 3-D data in a time comparable with that of standard OCT protocols that acquire only several individual images.[16] The coupling of SD-OCT technology with 3-D imaging allows precise focusing from deep retinal planes to the mid-vitreous cavity. A 3-D volume of data can be viewed and rotated about three axes. Wanting to capitalize on these advantages, we explored the use of 3-D imaging in SD-OCT to image the vitreous architecture and the vitreomacular interface.

AT A GLANCE

- The status of the vitreous plays an important role in the natural course of local and systemic posterior segment conditions and can thus affect their prognosis and management.
- 3-D SD-OCT allows systematic study of the vitreous and vitreoretinal interface and can help the clinician to detect partial and total PVDs.
- Fine details that show how the retinal surface interacts with and is affected by the vitreous body can be visualized with 3-D SD-OCT.

3-D VIEWING IN PRACTICE

Following is an observational case series of patients who presented at our practice. All patients were scanned using the RS-3000 Advance (Nidek). Our goal was to visualize in vivo details of the vitreous structure during the aging process, including various vitreous and vitreomacular interface pathologies.

Case No. 1

A 55-year-old known diabetic and hypertensive woman presented with decreased visual acuity in her right eye (OD) lasting 6 months. Her BCVA was 6/36 OD with early

cataractous changes. Fundus examination revealed asteroid hyalosis with proliferative diabetic retinopathy (PDR) and clinically significant macular edema (CSME) OD (Figure 1). Examination with SD-OCT showed asteroid hyalosis, altered foveal contour with ERM, cystoid spaces, and hard exudates OD.

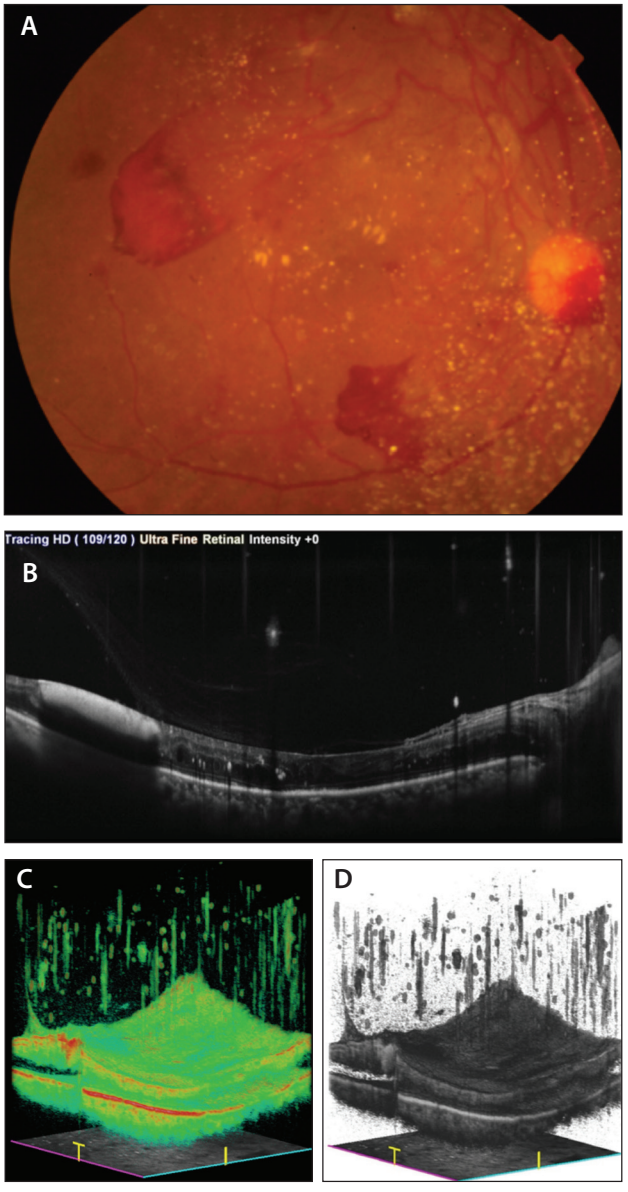

Figure 1. Fundus photograph OD shows asteroid hyalosis, hard exudates, and edema at macula, neovascularization of disc with retinal hemorrhage, neovascularization elsewhere, and areas of preretinal hemorrhage (A). Altered foveal contour with ERM, cystoid spaces, and hard exudates are shown with SD-OCT scan (B). Pseudocolor (C) and grayscale (D) 3-D reconstructions of SD-OCT scans show hyperreflective spots in vitreous with shadowing posterior to it, suggestive of asteroid hyalosis.

Case No. 2

A 71-year-old diabetic man, pseudophakic in each eye (OU), presented with diminished visual acuity in his left eye (OS) lasting 2 to 3 years. His BCVA was 6/9 OS. Fundus examination OS showed an ERM, and SD-OCT

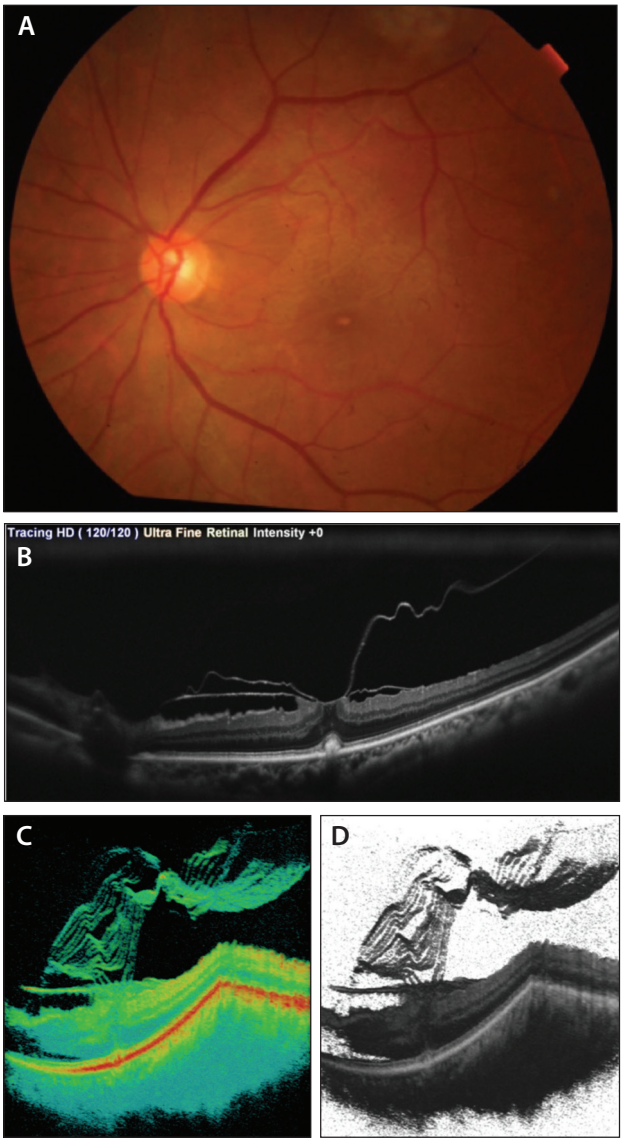

Figure 2. Altered foveal reflex OS with a yellow dot is seen with ERM on fundus photograph (A). SD-OCT scan shows lost foveal contour, focal attachments of taut posterior hyaloid over macula, ERM, corrugations of inner retinal layers, and subfoveal scarring (B). Pseudocolor (C) and grayscale (D) 3-D reconstructions of SD-OCT scans show the attachments of the thickened posterior hyaloid over the site of thick ERM, the configuration of the ERM at the vitreomacular interface, and the plane of detachment of posterior hyaloid at certain places over the posterior pole. The two planes of VMT and ERM can be well visualized in the 3-D reconstruction of SD-OCT.

examination OS showed lost foveal contour with VMT and ERM. Vitrectomy was advised for treatment of VMT and ERM removal with dexamethasone intravitreal implant 0.7 mg (Ozurdex, Allergan), but the patient declined treatment. He presented 19 months later with a BCVA of 6/12 OS. Fundus examination OS showed altered foveal reflex OS and a yellow dot with ERM.

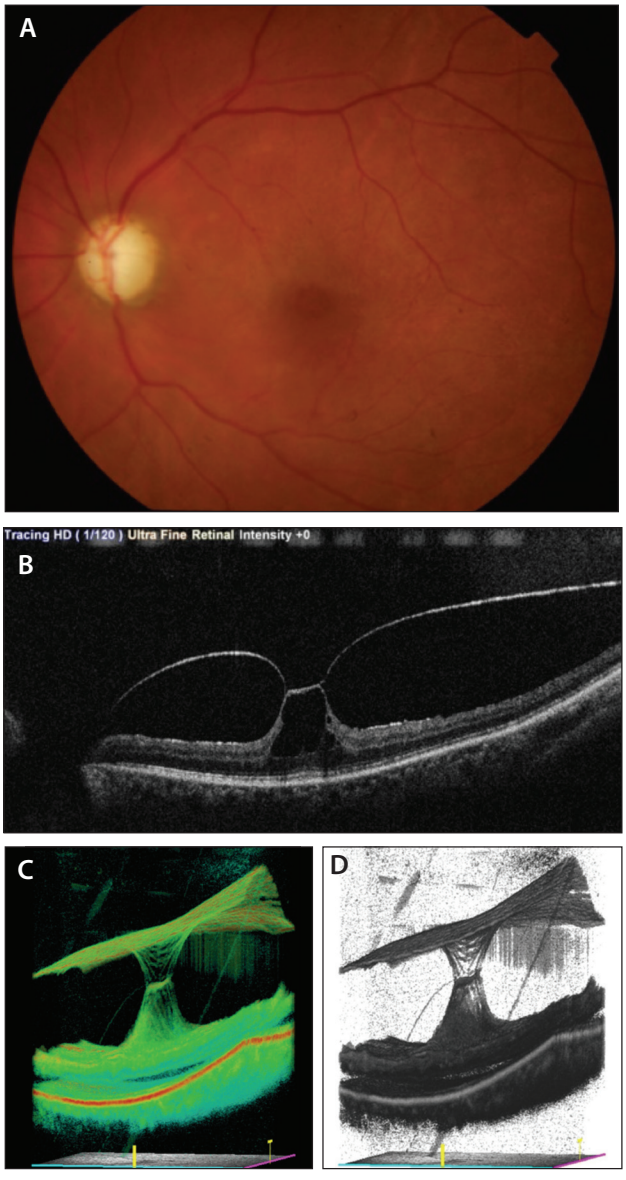

Figure 3. Fundus photograph OS shows altered foveal reflex with VMT and ERM and optic atrophy (A). Altered foveal contour with VMT syndrome is seen on SD-OCT (B). Pseudocolor (C) and grayscale (D) 3-D reconstructions of SD-OCT scans show the configuration of VMT caused by traction at fovea by the posterior hyaloid, leading to an impending operculum formation from the inner retinal layers at fovea.

SD-OCT examination OS showed lost foveal contour, focal attachments of taut posterior hyaloid over the macula, ERM, corrugations of inner retinal layers, and subfoveal scarring (Figure 2).

Case No. 3

A 70-year-old woman with pseudophakia OS presented with reduced visual acuity OS lasting 3 months. Fundus examination showed altered foveal reflex with VMT, ERM, and optic atrophy OS. SD-OCT examination OS revealed altered foveal contour with a thickened hyaloid causing traction on the macula (VMT syndrome; Figure 3).

Case No. 4

A 19-year-old man with chronic pars planitis OU presented with complaints of floaters OD. Fundus

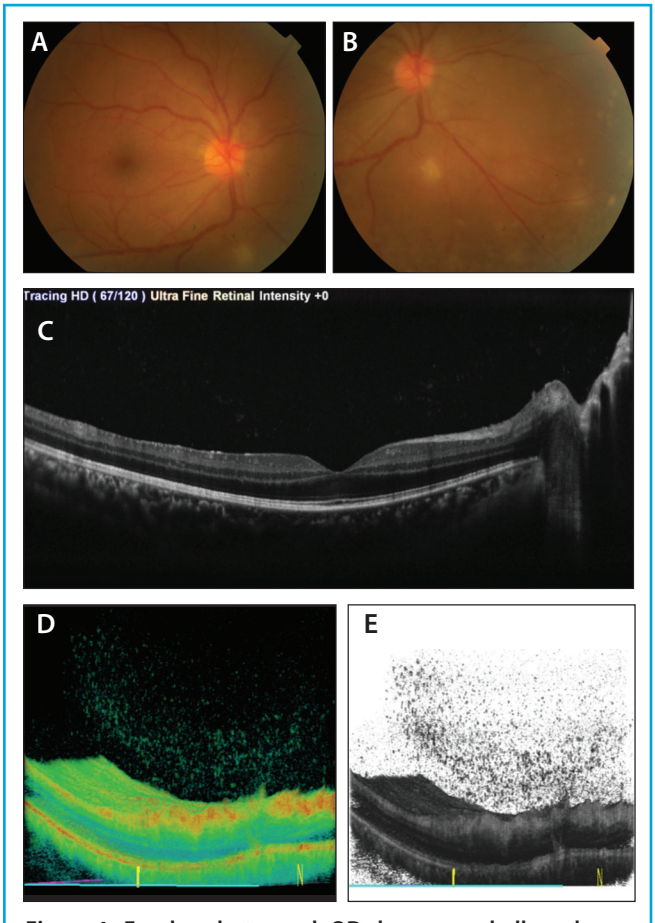

Figure 4. Fundus photograph OD shows snowballs and areas of exudation (A, B). SD-OCT scan shows punctate hyperreflective spots in the vitreous suggestive of vitreous cells and the presence of active pars planitis (C). Pseudocolor (D) and grayscale (E) 3-D reconstructions of SD-OCT scans show multiple punctate hyperreflective spots in the vitreous cavity suggestive of vitreous cells.

examination indicated vitritis OD, and SD-OCT examination revealed punctate hyperreflective spots in the vitreous suggestive of vitreous cells, which would indicate active pars planitis (Figure 4). Because the patient was a known steroid responder, he was started on an oral steroid on a tapering course, immunosuppressive therapy with azathioprine, and anti-Koch treatment. The oral steroid was gradually tapered, but the azathioprine was continued. When the patient returned 5 months later, SD-OCT showed a normal foveal contour with disappearance of vitreous cells (Figure 5).

Case No. 5

A 69-year-old man, pseudophakic OU, complained of metamorphopsia OD lasting 7 to 8 days. His BCVA was 6/12 OD. Fundus examination showed a macular hole OD. SD-OCT examination showed a full thickness macular hole with an operculum OD (Figure 6). The patient underwent 25-gauge vitrectomy with intravitreal gas injection OD. At follow-up 1 month later, his BCVA was 6/12 OD. SD-OCT at this visit showed normalization of the foveal contour (Figure 7). Additionally, the macular hole had closed.

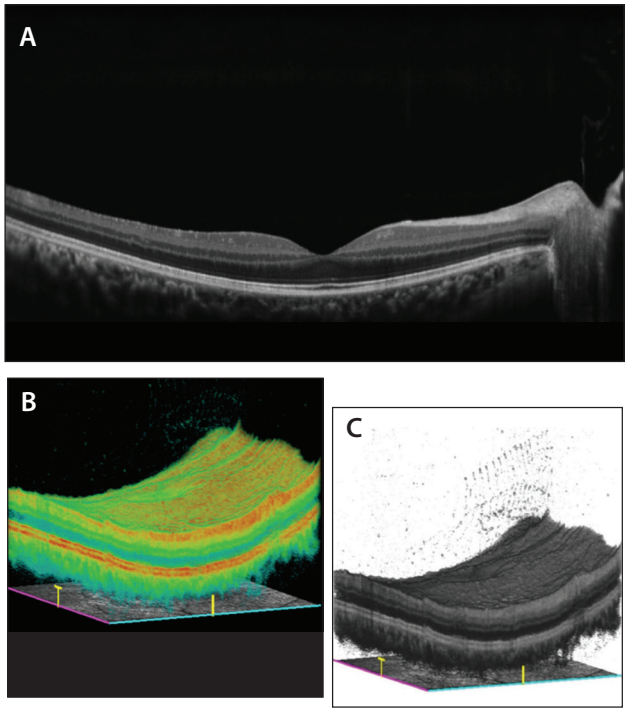

Figure 5. SD-OCT scan shows normal foveal contour 5 months after treatment (A). Pseudocolor (B) and grayscale (C) 3-D reconstructions of SD-OCT scans show disappearance of the punctate hyperreflective spots in the vitreous, suggestive of resolution of activity of pars planitis.

DISCUSSION

To date, in vivo imaging of the vitreous body has been difficult because of its transparency and movement, but the assessment of vitreoretinal separation is important in many diseases. Tractional forces play major roles in the development of retinal tears and detachments, and it is likely that a complete PVD reduces the risk of retinal detachment in patients with symptomatic floaters after the acute onset of symptoms.[17]

Some studies also suggest that knowledge of vitreous anatomic features may influence surgical approach and outcome in diseases such as macular hole.[18,19] The identification of vitreomacular adhesions in partial vitreous detachment can be useful in the management of diabetic macular edema and VMT.[20-22] Unfortunately, vitreous status can be difficult to determine clinically. Although the detection of Weiss ring on biomicroscopy is believed to indicate a complete PVD, it may be difficult to precisely determine the completeness of vitreoretinal detachment or attachment using clinical observation alone.

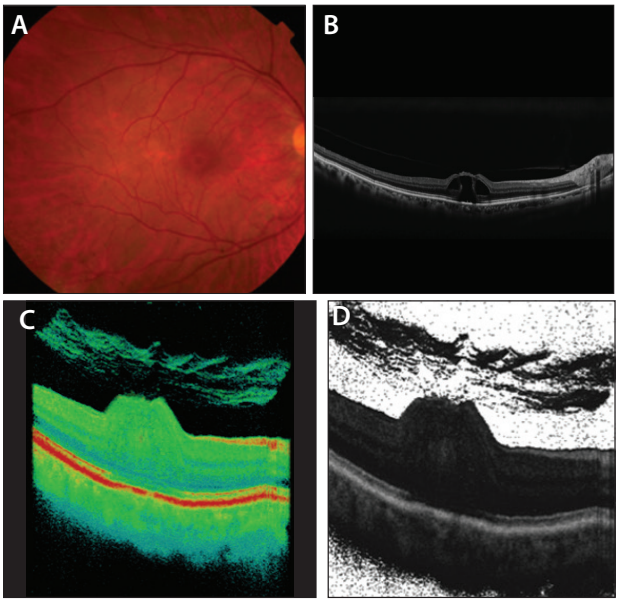

Figure 6. Fundus photograph OD shows an altered foveal reflex, suggesting a macular hole (A). SD-OCT scan shows a stage 2 full thickness macular hole. The posterior hyaloid is still attached to the operculum, which is only partially detached from the hole edge (detachment is not visible in this scan). The cystoid space along the edges of the full thickness macular hole are also shown (B). Pseudocolor (C) and grayscale (D) 3-D reconstruction of SD-OCT scans show the posterior hyaloid attached to the operculum of the full thickness macular hole. The elevation of the full thickness macular hole's edges can also be made out, as can the plane of the detached portion of the posterior hyaloid.

Ultrasound is the traditional imaging technique for dynamic study of the posterior hyaloid, and it has been used in clinical trials to monitor PVD induced by pharmacologic agents.[23] It has a lower depth and horizontal resolution than SD-OCT.[24] We used 3-D imaging with SD-OCT in the patient case series described above to image the vitreous architecture and the vitreomacular interface. This modality enabled visualization of details of the vitreoretinal interface and vitreous body not discernible clinically or on B-scan OCT images. On the retinal surface, these details included areas of incomplete PVD, focal vitreoretinal adhesion and traction, vitreous remnants on the foveal surface of eyes with complete PVD, and attachment of posterior hyaloid to opercula of full thickness macular holes. In the vitreous cavity, these details included distinction between vitreous opacities such as asteroid hyalosis, vitreous cells, vitreous degeneration, and vitreous hemorrhage. Use of 3-D imaging in SD-OCT can help to objectively assess the reduction of vitritis following treatment in inflammatory pathologies involving the vitreous. Other SD-OCT studies have also used 3-D reconstruction of the retina to analyze the vitreoretinal interface.[25,26]

CONCLUSION

Reconstruction of 3-D volumes using SD-OCT imaging allows systematic study of the vitreous and vitreoretinal interface and can help clinicians to detect partial and total PVDs. It can also enable the visualization of fine details that show how the retinal surface interacts with and is affected by the vitreous body. Furthermore, information regarding hyaloid cleavage planes can be obtained from this imaging modality in pathologies of the vitreomacular interface, facilitating clinical and surgical decisions. Objective assessment of different causes of vitreous opacities is also possible using 3-D imaging in SD-OCT. ■

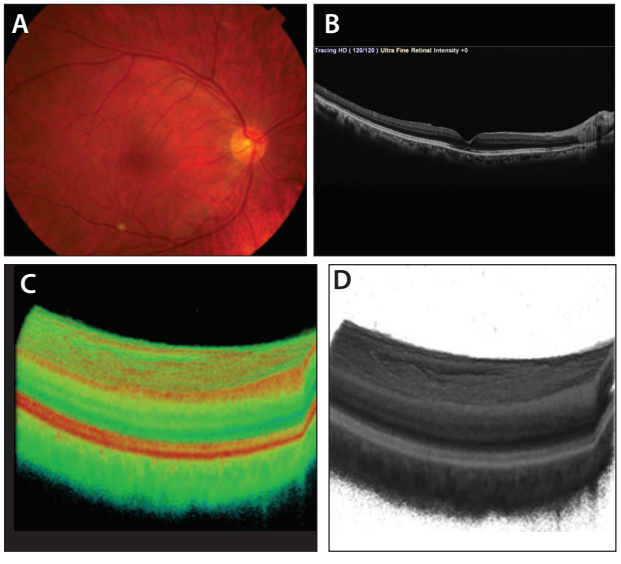

Figure 7. One month post vitrectomy with intravitreal gas injection. Fundus photograph OD shows fairly normal foveal reflex (A). Normalized foveal contour is seen on SD-OCT scan (B). Pseudocolor (C) and grayscale (D) 3-D reconstruction of SD-OCT scans show disappearance of the attached posterior hyaloid and subsidence of the elevated edges of the full thickness macular hole.

1. Hruby K. Clinical examination of the vitreous body. *Proc R Soc Med*. 1954;47(3):163-170.
2. Schepens CL. *The Vitreous and Vitreoretinal Interface*. New York, NY: Springer-Verlag; 1987.
3. Ono R, Kakehashi A, Yamagami H, et al. Prospective assessment of proliferative diabetic retinopathy with observations of posterior vitreous detachment. *Int Ophthalmol*. 2005;26(1-2):15-19.
4. Schepens CL, Avila MP, Jalkh AE, Trempe CL. Role of the vitreous in cystoid macular edema. *Surv Ophthalmol*. 1984; 28(Suppl):499-504.
5. Hikichi T, Trempe CL. Role of the vitreous in the prognosis of peripheral uveitis. *Am J Ophthalmol*. 1993;116(4):401-405.
6. Takahashi MK HT, Akibe J, Yoshida A, Tremple CL. Role of the vitreous and macular edema in branch retinal vein occlusion. *Ophthalmic Surg Lasers*. 1997;28(4):294-299.
7. Sebag J, Balazs EA. Pathogenesis of cystoid macular edema: an anatomic consideration of vitreoretinal adhesions. *Surv Ophthalmol*. 1984;28(Suppl):493-498.
8. Hikichi T, Konno S, Trempe CL. Role of the vitreous in central retinal vein occlusion. *Retina*. 1995;15(1):29-33.
9. Arzabe CW, Akiba J, Jalkh AE, et al. Comparative study of vitreoretinal relationships using biomicroscopy and ultrasound. *Graefes Arch Clin Exp Ophthalmol*. 1991;229(1):66-68.
10. Uchino E, Uemura A, Ohba N. Initial stages of posterior vitreous detachment in healthy eyes of older persons evaluated by optical coherence tomography. *Arch Ophthalmol*. 2001;119(10):1475-1479.
11. Sebag J. To see the invisible: the quest of imaging vitreous. *Dev Ophthalmol*. 2008;42:5-28.
12. Johnson MW, Van Newkirk MR, Meyer KA. Perifoveal vitreous detachment is the primary pathogenic event in idiopathic macular hole formation. *Arch Ophthalmol*. 2001; 119(2):215-222.
13. Johnson MW. Perifoveal vitreous detachment and its macular complications. *Trans Am Ophthalmol Soc*. 2005;103:537-567.
14. Johnson MW. Tractional cystoid macular edema: a subtle variant of the vitreomacular traction syndrome. *Am J Ophthalmol*. 2005;140(2):184-192.
15. Gaucher D, Tadayoni R, Erginay A, et al. Optical coherence tomography assessment of the vitreoretinal relationship in diabetic macular edema. *Am J Ophthalmol*. 2005;139(5):807-813.
16. Wojtkowski M, Srinivasan VJ, Fujimoto JG, et al. Three-dimensional retinal imaging with high-speed ultrahigh-resolution optical coherence tomography. *Ophthalmology*. 2005;112(10):1734-1746.
17. Richardson PS, Benson MT, Kirkby GR. The posterior vitreous detachment clinic: do new retinal breaks develop in the six weeks following an isolated symptomatic posterior vitreous detachment? *Eye*. 1999;13(Pt 2):237-240.
18. Chan CK, Wessels IF, Friedrichsen EJ. Treatment of idiopathic macular holes by induced posterior vitreous detachment. *Ophthalmology*. 1995;102(5):757-767.
19. Ripandelli G, Parisi V, Friberg TR, et al. Retinal detachment associated with macular hole in high myopia: using the vitreous anatomy to optimize the surgical approach. *Ophthalmology*. 2004;111(4):726-731.
20. Hikichi T, Fujio N, Akiba J, et al. Association between the short-term natural history of diabetic macular edema and the vitreomacular relationship in type II diabetes mellitus. *Ophthalmology*. 1997;104(3):473-478.
21. Pendergast SD. Vitrectomy for diabetic macular edema associated with a taut premacular posterior hyaloid. *Curr Opin Ophthalmol*. 1998;9(3):71-75.
22. Sonmez K, Capone A Jr, Trese MT, Williams GA. Vitreomacular traction syndrome: impact of anatomical configuration on anatomical and visual outcomes. *Retina*. 2008;28(9): 1207-1214.
23. Byrne SF, Green RL. *Ultrasound of the Eye and Orbit*. 2nd ed. Philadelphia, PA: Mosby, 2002.
24. Coleman DJ, Silverman RH, Chabi A, et al. High-resolution ultrasonic imaging of the posterior segment. *Ophthalmology*. 2004;111(7):1344-1351.
25. Koizumi H, Spaide RF, Fisher YL, et al. Three-dimensional evaluation of vitreomacular traction and epiretinal membrane using spectraldomain optical coherence tomography. *Am J Ophthalmol*. 2008;145(3):509-517.
26. Glittenberg C, Krebs I, Falkner-Radler C, et al. Advantages of using a ray-traced, three-dimensional rendering system for spectral domain Cirrus HD-OCT to visualize subtle structures of the vitreoretinal interface. *Ophthalmic Surg Lasers Imaging*. 2009;40:127–134.

Manish Nagpal, MS, DO, FRCS(Edin)
- vitreoretinal consultant at the Retina Foundation in Ahmedabad, Gujarat, India
- financial interest: consultant for Nidek
- drmanishnagpal@yahoo.com

Shishir Shekhar Singh, MS
- second-year vitreoretinal fellow at the Retina Foundation in Ahmedabad, Gujarat, India
- financial interest: none acknowledged