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Posterior Vitreous Detachment as Observed by Wide-Angle OCT Imaging

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Purpose: Posterior vitreous detachment (PVD) plays an important role in vitreoretinal interface disorders. Historically, observations of PVD using OCT have been limited to the macular region. The purpose of this study is to image the wide-angle vitreoretinal interface after PVD in normal subjects using montaged OCT images.

Design: An observational cross-sectional study.

Participants: A total of 144 healthy eyes of 98 normal subjects aged 21 to 95 years (51.4±22.0 [mean ± standard deviation]).

Methods: Montaged images of horizontal and vertical OCT scans through the fovea were obtained in each subject.

Main Outcome Measures: Montaged OCT images.

Results: By using wide-angle OCT, we imaged the vitreoretinal interface from the macula to the periphery. PVD was classified into 5 stages: stage 0, no PVD (2 eyes, both aged 21 years); stage 1, peripheral PVD limited to paramacular to peripheral zones (88 eyes, mean age 38.9±16.2 years, mean ± standard deviation); stage 2, perifoveal PVD extending to the periphery (12 eyes, mean age 67.9±8.4 years); stage 3, peripapillary PVD with persistent vitreopapillary adhesion alone (7 eyes, mean age 70.9±11.9 years); stage 4, complete PVD (35 eyes, mean age 75.1±10.1 years). All stage 1 PVDs (100%) were observed in the paramacular to peripheral region where the vitreous gel adheres directly to the cortical vitreous and retinal surface. After progression to stage 2 PVD, the area of PVD extends posteriorly to the perifovea and anteriorly to the periphery. Vitreoschisis was observed in 41.2% at PVD initiation (stage 1a).

Conclusions: Whereas prior work suggests that PVD originates in the perifoveal region and after the sixth decade, our observations demonstrate that (1) PVD first appears even in the third decade of life and gradually appears more extensively throughout life; (2) more than 40% of eyes without fundus diseases at their PVD initiation are associated with vitreoschisis; and (3) PVD is first noted primarily in the paramacular-peripheral region where vitreous gel adheres to the retinal surface and is noted to be more extensive in older ages to ultimately involve the fovea. *Ophthalmology 2018;■:1–12 © 2018 by the American Academy of Ophthalmology*

Posterior vitreous detachment (PVD) is one of the more universally experienced and potentially important normal ocular events. It is often the underlying cause of a patient's symptoms of flashes and floaters in the eye. Posterior vitreous detachment also plays a key role in the pathogenesis of multiple visually significant vitreoretinal interface disorders, such as macular hole,[1–3] premacular membrane with pucker (so-called epiretinal membrane),[4,5] vitreomacular traction syndrome,[3,6] retinal detachments,[7,8] vitreous hemorrhages,[8] and others. Posterior vitreous detachment manifests as vitreous gel liquefaction and weakening of vitreoretinal adhesion.[3,9] Therefore, it is integral to pathology occurring at the vitreoretinal interface. Historically, PVD has been considered an acute event initiated by an abrupt break developing in the posterior vitreous cortex. The timing of such vitreous separation in the setting of PVD was believed to be age related and occurred after the sixth decade of life.[7,10] Recent reports using OCT and ultrasonography suggest that age-related PVD may be less of an acute event and more of an insidious and slowly progressive condition evolving over many years. Moreover, PVD origination is now believed to occur in the perifoveal macula.[10–14] However, the OCT observations leading to these present descriptions were limited to the macular region as is provided in standard OCT studies.

Our group has recently reported a novel imaging strategy and method that uses wide-angle images of OCT of the whole vitreoretinal interface extended from the macula to the periphery. With this novel wide-field imaging technique, we reported baseline images of the vitreous, retina, and choroid;[15] normative data describing regional differences and aging changes in the macula and more peripheral retina (Omata et al, Abstract no. 1770, presented in the Association of Research in Vision and Ophthalmology, May 3, 2010, Fort Lauderdale, FL); and morphologic relationships between these structures during the development and progression of macular holes.[16,17] Moreover, the feasibility of this montaging imaging technique has now been replicated by other study groups.[18–20] The purpose of the present study is to describe the first appearance and subsequent extent of PVD at various ages of

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physiologic PVD throughout the entire vitreoretinal interface from the macula to the periphery using wide-angle OCT imaging.

Methods

Patients and Study Design

This is an observational cross-sectional study. A total of 144 eyes of 98 healthy normal volunteers underwent a wide-angle montage of OCT images of their entire viewable vitreoretinal interface. The investigation adhered to all of the tenets of the Declaration of Helsinki. This study was approved by the institutional review board of the Saitama Medical University (approval no. 11-041-01) and the Ethics Committee of International University of Health and Welfare (approval no. 13-B-225). Subjects were enrolled from August 2011 to December 2012 in the Saitama Medical University and from October 2016 to April 2017 in the International University of Health and Welfare. The composition of the subject population was 60 female and 38 male participants, ranging in age from 21 to 95 years (51.4±22.0, mean ± standard deviation) (Table 1). All subjects were examined by indirect ophthalmoscopy, slit-lamp biomicroscopic examination, refraction, and best-corrected visual acuity testing. Excluded were eyes with present or past vitreous-retina-choroid disease, hyperopia >+3.0 diopters or myopia exceeding −5.0 diopters, and advanced cataract that may affect the image quality.

Spectral-Domain and Swept-Source OCT

All OCT examinations were performed through a dilated pupil using commercially available spectral-domain OCT (Spectralis, Heidelberg Engineering, Vista, CA) or swept-source OCT (DRI OCT Triton plus, Topcon, Tokyo, Japan). Standardized horizontal and vertical vitreoretinal sections through the fovea were collected for each subject. All scans with swept-source OCT were obtained by pulling back to focus on the vitreous. The retinochoroidal layers were positioned inferiorly on the images screen to obtain maximum imaging depth into the vitreous and vitreoretinal interface.[21] To enhance visualization of the vitreous image, contrast was adjusted by the planimetric image-editing system, enhanced vitreous visualization.[22−24] To examine the morphologic features of the entire posterior vitreous cortex and the vitreoretinal interface, wide-angle montage OCT images from the macula to the periphery (approximately to the equator) were obtained as previously described.[15−17] Montaged images were assembled using picture-editing software (Photoshop version 5.5, Adobe, San Jose, CA). Conventional OCT imaging is typically limited to the macular zone, ranging from 7 to 12 mm.[10−14] Our montaging technique allows evaluation of images that are on the order of 25 to 36 mm.[15]

Incidence of PVD in each quadrant of each stage was statistically evaluated by the chi-square test. The association of known PVD risk factors, including age, female gender, and myopic refraction, was analyzed with polytomous logistic regression analysis. Statistical data analysis was performed with commercially available software (Bell Curve for Excel ver. 2.14, SSRI, Tokyo, Japan). P values less than 0.05 were considered statistically significant.

Results

On the basis of the findings observed in montaged OCT images, PVD was classified into the following 5 stages: stage 0, no PVD present (2 eyes, both aged 21 years); stage 1, peripheral PVD limited to paramacular, peripheral or from paramacular to peripheral zones (88 eyes, mean age 38.9±16.2 years, mean ± standard deviation, median 34.5, range 21−73); stage 2, perifoveal PVD expanding to the periphery (12 eyes, mean age 67.9±8.4 years, median 68.5, range 56−85); stage 3, peripapillary PVD with persistent vitreopapillary adhesion alone (7 eyes, mean age 70.9±11.9 years, median 72, range 56−85); stage 4, complete PVD (35 eyes, mean age 75.1±10.1 years, median 77, range 59−95). Stage 1 was divided into 2 subcategories: stage 1a, peripheral PVD with multilayered linear hyperreflective lines or interposed reflective material between retina and vitreous (34 eyes, mean age 29.4±13.0 years, median 23, range 21−65); stage 1b, peripheral PVD without interposed material between retina and vitreous (54 eyes, mean age 44.9±15.5 years, median, 44.5, range, 21−73 years) (Table 1). The mean age of occurrence for each stage increased, commensurate with progression of the stage of PVD.

Stage 0

In all 144 eyes examined in these age groups and without other ocular pathology, only 2 eyes (1.4%) had no PVD in all 4 quadrants. In these eyes, the perifoveal retina and macular choroid were the thickest regions. Both retinal and choroidal thickness decreased toward the periphery. In both eyes granular hyper-reflections, mainly in the posterior cortical vitreous, were noticed (Fig 1).

Stage 1a

Thirty-four eyes (23.6% of all eyes examined) had stage 1a PVD: peripheral PVD with multilayered linear hyperreflective lines (Figs 2 and 3) or interposed material (Fig 3) between the retina and

Table 1. Subject Age, Refraction, and Posterior Vitreous Detachment Stages

Subject Age, yrs	Refraction (Mean ± SD)	PVD Stage						
		0	1a	1b	2	3	4	All
20−29	−2.2±1.7	2 (5.6)	25 (69.4)	9 (25.0)	0	0	0	36 (100)
30−39	−2.2±1.9	0	3 (20.0)	12 (80.0)	0	0	0	15 (100)
40−49	−0.9±0.7	0	2 (12.5)	13 (81.3)	0	0	1 (6.3)	16 (100)
50−59	−0.5±1.4	0	2 (13.3)	8 (53.3)	3 (20)	1 (6.7)	1 (6.7)	15 (100)
60−69	+0.15±1.4	0	2 (7.4)	10 (37.0)	5 (18.5)	2 (7.4)	8 (29.6)	27 (100)
70−79	+0.3±1.5	0	0	2 (10.5)	3 (15.8)	2 (10.5)	12 (63.2)	19 (100)
80-	+0.3±2.0	0	0	0	1 (6.3)	2 (12.5)	13 (81.3)	16 (100)
Total	−0.8±1.9	2 (1.4)	34 (23.6)	54 (37.5)	12 (8.3)	7 (4.9)	35 (24.3)	144 (100)

PVD = posterior vitreous detachment; SD = standard deviation.
Data are expressed as the number of eyes (% of entire group).