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Optical coherence tomography for diagnosis of posterior vitreous detachment at the macular region

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PURPOSE. *To assess optical coherence tomography (OCT) for diagnosing posterior vitreous detachment (PVD) at the macular region compared to kinetic B-scan ultrasonography.*
METHODS. *In the present study, the authors prospectively investigated the frequency of PVD at the posterior pole utilizing ocular kinetic B-mode sonography in 315 eyes of 188 patients (113 female, 75 male; mean age, 72.8 years; range, 39–94) prior to cataract surgery. In addition, OCT scans of the macular region were performed in all subjects for detection of PVD at the macula.*
RESULTS. *A total of 130 eyes (41.3%) had no sonographic signs of PVD. In this subset of patients in 36 eyes (27.7%), OCT revealed a flat PVD at the macular region with the distance between the posterior hyaloid and retinal surface being less than 400 µm (mean distance, 234 ± 112 µm, range, 24–398). When combining both methods, the diagnosis of PVD at the posterior pole was made in 221 of 315 eyes (70.2%).*
CONCLUSIONS. *OCT is a valuable tool for detecting PVD at the macular region, particularly in cases with small distances between the retinal surface and posterior hyaloid. Proof of attachment of the posterior hyaloid can be established only by combining kinetic ultrasonography and OCT. (Eur J Ophthalmol 2009; 19: 442-7)*

KEY WORDS. *Optical coherence tomography, Posterior vitreous detachment, Ultrasonography, Vitreomacular interface*

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INTRODUCTION

Throughout life, rheologic and biochemical alterations in the vitreous body result in substantial structural changes. Collagen fibril aggregation and advanced liquefaction are assumed to cause a decrease in the gel volume and an increase in the liquid volume of the human vitreous (1). The simultaneous formation of liquid vitreous and aggregation of collagen fibrils into bundles, known as syneresis, culminates in vitreous collapse. Posterior vitreous detachment (PVD) is believed to develop after liquefied vitreous passes abruptly into the subhyaloid space and separates the posterior vitreous cortex and the inner limiting membrane of the retina (2, 3). However, incomplete PVD may result in harmful effects on the inner retina and the posterior vitreous cortex.

Because visualizing the vitreous is a quest to examine what is by design invisible, clinicians and researchers are faced with a diagnostic challenge. Established and primarily used in vivo examination techniques are biomicroscopy, ophthalmoscopy, and ultrasonography. Spectroscopy, dynamic light scattering, and optical coherence tomography (OCT) are applied to a lesser extent (1, 4-7). Biomicroscopy and preset lens biomicroscopy allow dynamic inspection of the vitreous and facilitate recording of the findings in real time (8). However, this approach is dependent on subjective interpretation and, therefore, a lack of reproducibility and limitations imposed by corneal

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opacities, lenticular opacities, or both. Ophthalmoscopy uses light rays emanating from a point in the patient's fundus that focuses on the observer's retina and forms an image. Nevertheless, only substantial alterations in the vitreous structure are diagnosed reliably.

Since the late 1950s, ultrasonography has been performed frequently to examine the vitreous body (9). The advantages of B-scanning over other imaging methods are safety, accessibility, and the ability to perform real-time kinetic examinations. In ophthalmology, frequencies from 8 to 20 MHz are used. However, to study the vitreous a 10-MHz probe is preferred (10). Although these high frequencies produce wavelights of 0.2 mm, they are still not sufficiently short to assess the normal internal vitreous structure. The resolution of conventional ultrasonography is 150 to 200 µm under optimal conditions. In daily clinical practice it is the objective method of choice for establishment of diagnosis of PVD. OCT is another imaging technology that has been introduced to examine the retinal laminar structure, the optic nerve head, and the anterior segment of the eye (11). OCT provides high-resolution, cross-sectional images of the posterior vitreous cavity and the retina (12, 13). OCT uses an incident wavelight of 800 nm and has increased axial resolution to 10 µm. The limitations of OCT include the inability to obtain high-quality images through dense opaque media and dependence on patient cooperation to maintain fixation for the acquisition time.

The vitreomacular interface appears to play a major role in the pathogenesis of various disorders of the posterior segment such as macular pucker or macular hole formation (14). The relationship between the posterior hyaloid and the retinal surface deserves special attention, both in research and in daily clinical practice (15, 16).

The purpose of this study was to assess the achievement potential of OCT for diagnosing PVD at the posterior pole compared to kinetic B-scan ultrasonography.

METHODS

Study population, diagnostic devices

We conducted a prospective study using kinetic B-scan ultrasonography (I^3 System-ABD unit, Innovative Imaging, Inc., Sacramento, CA) and OCT (Stratus OCT III; Humphrey Instruments, Carl Zeiss Division, San Leandro, CA) to evaluate the relationship of the posterior vitreous hyaloid to the retina at the macular region. The study procedures were in accordance with the Helsinki Declaration of 1975, as revised in 2000. The study population was recruited from patients who visited the outpatient clinic of Ludwigshafen hospital for preoperative assessment prior to cataract surgery. All subjects were examined between February and October 2006. Both eyes of every subject were included in this study, if not already pseudophakic. The ophthalmic examination included measurement of best-corrected visual acuity, refraction, slit-lamp biomicroscopy, tonometry, indirect ophthalmoscopy, measurement of anterior chamber depth and axial length of the ocular globe (IOL-Master, Zeiss, Jena, Germany), and keratometry. Sufficient visualization of the retina by biomicroscopic examination was required to provide useful quality for OCT evaluation of the posterior segment. Exclusion criteria were previous intraocular surgery, insulin-dependent diabetes mellitus or diabetic retinopathy, history of uveitis, or penetrating trauma.

B-scan ultrasonography

Kinetic B-mode ultrasonography was performed using a 10-MHz probe in all eyes in the hands of an experienced ultrasonographer (F.H.) under topical anesthesia with the eyelids open and the probe placed directly on the ocular surface using methylcellulose as a coupling gel. The settings of the ultrasound unit were standardized to a gain of 90 dB and a frequency of 10 MHz. Examinations consisted of longitudinal and transverse sections through the macula and periphery, obtained by positioning the probe on the conjunctiva in order to avoid beam attenuation by the crystalline lens. Scans were obtained at the 3, 6, 9, and 12 o'clock meridians, and kinetic B-mode assessments were used to help define the vitreoretinal relationship. Special attention was paid to the posterior pole of the ocular globe.

The eyes were classified into four groups: 1) total PVD with a continuous, mildly echodense, undulating, and mobile membrane spanning the vitreous cavity, with no adherence to the retina posterior to the vitreous base region; 2) partial PVD with macular region being involved: localized vitreous detachment was diagnosed when a thin, smooth, continuous membrane with minimal aftermovement was detected anterior to the retinal surface; 3) partial PVD with macular region being attached; and 4) complete attachment of the posterior hyaloid to the retinal surface.

OCT

OCT was performed through a dilated pupil. The OCT studies were comprised of scans 10 mm in length, oriented as six radial lines at 30-degree intervals. The study was centered on the subjective fixation. Where necessary, the intensity of the incident light was set to the maximum (750 μW) to detect the faintly reflective posterior hyaloid membrane. In order to minimize light scattering effects due to the cataract, incident light intensity, polarization, and dioptric controls of the optic system were adjusted to obtain the finest possible images and to detect even weak signals from the posterior vitreous cortex. Data analysis was performed with commercially available OCT software (Zeiss Stratus OCT III, version 4.0.5). Quantitative measurements of the diameter of the vitreomacular distance were performed with the caliper function of the OCT standard software. Where diameters differed between the several scans performed in a given eye, the largest diameter was recorded.

Data collection and statistical analysis

All data were collected and evaluated by the same person (F.H.) using SPSS software (version 12.0) and Microsoft Excel® (version 9.0).

RESULTS

A total of 315 eyes of 188 patients were included in this study. The mean patient age was 72.8 years (range 39–94 years). A total of 113 of 188 patients (60.1%) were female. The mean spherical equivalent of the subjective refraction was –0.25 diopters (median 0.25; range –10.75 to +6.25), the mean axial length using the IOL-Master was 23.15 mm (median 23.34; range 20.41–26.84).

Of the 315 eyes, 130 eyes (41.3%) had no sonographic signs of PVD (Fig. 1) at the macular region (Groups C and D). Furthermore, in ultrasonography studies, 155 (49.2%) eyes showed complete PVD (Group A) and 30 (9.5%) had partial PVD involving the macular region (Group B). In Group A (total PVD) the OCT failed constantly to detect the posterior vitreous surface, whereas in Group B (partial PVD) the posterior hyaloid could be identified to some extent. In 36 of the 130 eyes (27.7%) with echographic proof of attachment of the posterior hyaloid to the macula, OCT revealed a flat PVD that had not been detected previously by ultrasonography (Figs. 2 and 3). In this subgroup, OCT studies determined the greatest distance between the posterior hyaloid and retinal surface, being less than 400 μm in all cases (mean 234±112 μm, range 24–398 μm). A

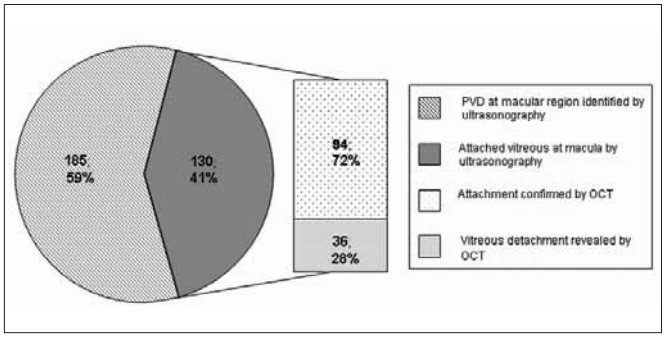

Fig. 1 - *Data on posterior vitreous detachment in the study group.*

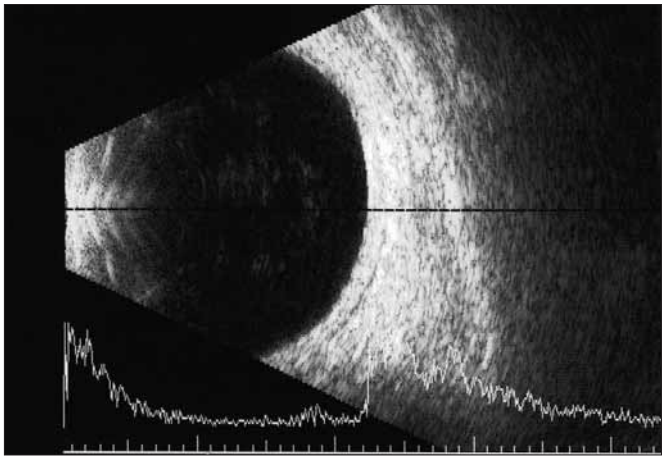

Fig. 2 - *B-scan ultrasonography scan with assumed attachment of the posterior hyaloid.*

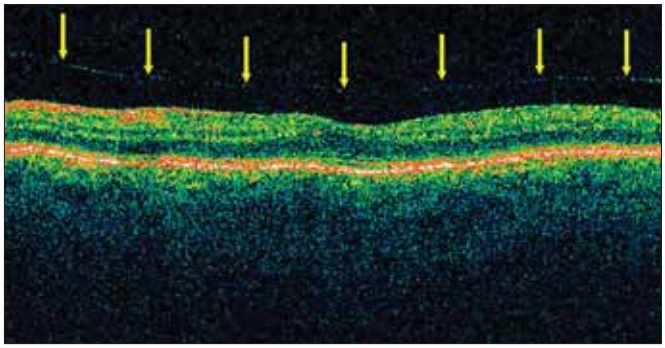

Fig. 3 - *Optical coherence tomography of the macula revealing a flat posterior detachment of the vitreous (arrows).*

total of 221 of the 315 examined eyes had PVD at the macular region, detected by kinetic ultrasonography and/or by OCT, corresponding to 70.2% of the study group.

DISCUSSION

The current study assessed the ability of OCT versus conventional B-scan ultrasonography for assessment of presence or absence of PVD at the macular region in adults. Accurate and detailed assessment of the relationship of the vitreous body to the macular region is of particular importance to visual function, as in recent years emergent theories proposed that vitreous plays an important role in the formation of several vitreoretinal diseases. Anomalous PVD is widely believed to play a critical role in the pathogenesis of macular hole and macular pucker (16, 17). Furthermore, several groups have reported that biomicroscopic examination of select eyes with diffuse diabetic macular edema (DME) shows a thickened, taut, and glistening posterior hyaloid (18) and OCT imaging has clarified that the posterior hyaloid in such eyes in not only taut and slightly thickened but also partially detached from the retina in a perifoveal geography (19). Consequently, DME exacerbated by the vitreomacular traction effects of perifoveal vitreous detachment has been termed tractional DME (18). In addition, a persistence of the vitreous cortex may be another risk factor for development of exudative age-related macular degeneration as recent OCT studies showed significantly higher prevalence of persistent central vitreoretinal adhesions in eyes with exudative age-related macular degeneration (20). Furthermore, It is generally believed that intraocular surgery, even with modern minimally invasive techniques, accelerates vitreous syneresis and PVD (21, 22). Hence, proof of the presence or absence of PVD at the macula can be an important criterion for further therapeutic decisions. For example, some surgeons prefer to perform vitrectomy—with or without peeling of the internal limiting membrane—for treatment of diffuse diabetic macular edema only if the posterior hyaloid is attached to the retinal surface at the macula preoperatively (23).

In our study, it was determined that OCT may provide additional information on the vitreomacular interface in cases of proven attachment of the vitreous body by ultrasonography. In more than one forth (27.7%) of all cases of assumed attached posterior vitreous by B-scan ultrasonography, OCT revealed a flat detachment being invisible with the used ultrasound device. Consequently, our observed PVD rates are to some extent a consequence of new and improved in vivo imaging techniques. Based on our results, we would recommend a combination of both B-scan and OCT for the assessment of the vitreomacular interface. B-scan ultrasonography will easily recognize highly detached hyaloid membranes that may not be seen in regular OCT scans, whereas OCT is able to visualize flat detachments more reliably that may not be detected by ultrasound B-scan. Furthermore, our study suggests that the currently available data in the literature on prevalence of PVD in human eyes based on B-scan studies may be revised when both methods will be applied in further studies, potentially revealing higher prevalence results than currently assumed. Postmortem studies reported PVD in up to 63% of subjects aged 70 years or older, while clinical trials showed a high variability of the prevalence of PVD between 11% and 65% (24-26). A total of 221 of the 315 examined eyes had PVD at the macular region, detected by kinetic ultrasonography and/or by OCT, corresponding to 70.2% of the study group.

Several limitations need to be addressed regarding our study. Various investigators have found close correlation between ultrasonographic and intraoperative findings in case of posterior hyaloid detachments (27, 28). In addition, Chauhan et al provide evidence that the discrete linear signal detected by OCT in eyes with presumed perifoveal vitreous detachment corresponds to the posterior hyaloid membrane (12). Nevertheless, the final proof of PVD remains surgical. Furthermore, ultrasonography and OCT examinations were carried out by one user, which may bias our findings, irrespective of the observer's skills and experience. Moreover, the study subgroups are small, especially because of the relative rarity of flat PVD. In addition, a potential limitation concerns the generalizability of the study results, because the study population was comprised primarily of Caucasian subjects from the central part of Germany. Furthermore, ultrasonographic data were acquired using an ABD Version 1 System unit. According to the manufacturer, its maximum B-mode resolution approximates 150 to 200 µm, and newer devices may have higher levels of resolution, potentially able to detect those flat PVDs that were overlooked in our B-scan studies. Finally, the role of vitreoschisis has not been evaluated in our study. This anomalous form of vitreoretinal separation can mimic true PVD. It results from splitting of the posterior vitreous cortex with forward displacement of the

anterior portion of the cortex, leaving part or all of the posterior layer of the split vitreous cortex still attached to the macula. Vitreoschisis can be considered present when two membranous layers are seen to join into one, forming the shape of "lambda" (29), and seems to play an important role in the pathogenesis of several vitreoretinal diseases such as vitreomacular traction syndrome (14, 30), macular hole, and macular pucker (31).

In summary, our study results suggest that OCT is a valuable tool for detecting PVD at the macular region, particularly in cases with small distances between the retinal surface and posterior hyaloid. Proof of attachment of the posterior hyaloid at the macula may be established only by combining kinetic ultrasonography and OCT.

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