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Detection of Bruch's Membrane Opening in Healthy Individuals and Glaucoma Patients with and without High Myopia

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Purpose: To determine the proportions of eyes with indiscernible Bruch's membrane opening (BMO) in glaucoma patients and healthy individuals with and without high myopia and to investigate factors contributing to indiscernible BMO.

Design: Cross-sectional study.

Participants: Five hundred eyes from 315 participants, including 212 high myopic eyes (axial length [AL], ≥26 mm) from 80 glaucoma patients and 60 healthy individuals and 288 non-high myopic eyes (AL, <26 mm) from 96 glaucoma patients and 88 healthy individuals.

Methods: The optic disc was imaged by the Spectralis OCT (Heidelberg Engineering, Heidelberg, Germany) using 24 equally spaced radial B-scans. The BMO was located independently by 2 trained observers and was recorded as discernible or indiscernible over 48 meridians in each eye. The BMO of a meridian was determined to be indiscernible when both observers failed to identify its location. The agreement between the observers was evaluated with κ statistics. Factors associated with indiscernible BMO were identified with multivariable, multilevel logistic regression modeling.

Main Outcome Measures: Proportions of eyes with indiscernible BMO and hazard ratios (HRs) of factors associated with indiscernible BMO.

Results: The agreement for assessment of BMO visibility between the observers was good (κ, 0.631; 95% confidence interval, 0.602−0.661). In the groups with and without high myopia, 32.1% and 8.2% of glaucomatous eyes had 1 or more meridians with indiscernible BMO, respectively. In the healthy eyes, the respective proportions were 28.0% and 3.9%. The proportions were significantly higher in eyes with high myopia compared to eyes without high myopia in the glaucoma group ($P < 0.001$) and the healthy group ($P < 0.001$). The temporal meridian, followed by the inferotemporal and superotemporal meridians, of the optic disc were the most frequent locations with indiscernible BMO. Increased AL, advanced glaucoma, β parapapillary atrophy, and young age were associated with an increased HR of indiscernible BMO ($P \leq 0.032$).

Conclusions: A significant proportion of high myopic eyes have indiscernible BMO at the temporal, superotemporal, and inferotemporal meridians of the optic disc, which may compromise the measurement of neuroretinal rim in the diagnostic evaluation of glaucoma. *Ophthalmology 2018;■:1−10 © 2018 by the American Academy of Ophthalmology*

OCT imaging of the optic nerve head (ONH) has facilitated examination of an important landmark, the Bruch's membrane opening (BMO), for measurement of the minimum rim width (MRW) in the diagnostic evaluation of glaucoma.[1,2] Minimum rim width, defined as the shortest distance from the BMO to the internal limiting membrane, has been shown to have a higher diagnostic performance for detection of glaucoma and an improved structure−function association compared with rim area measured by confocal scanning laser ophthalmology.[2−6] Bruch's membrane opening-based MRW measurement has become a new standard for documentation of neuroretinal rim dimensions. A widely adopted scan protocol for MRW measurement comprises 24 equally spaced radial B-scans centered at the geometric center of the BMO (Spectralis OCT; Heidelberg Engineering, Heidelberg, Germany).[1−6] The locations of BMO are detected automatically by the OCT and then confirmed manually over 48 meridians. In the OCT analysis report, the 48 MRW measurements are averaged globally and regionally to generate global, inferotemporal, temporal, superotemporal, superonasal, nasal, and inferonasal MRWs. These measurements are annotated statistically with reference to the instrument's built-in normative data to indicate whether the MRWs are within the normal reference ranges or below the 1st or the 5th percentiles.

A prerequisite for reliable measurement of MRW is accurate localization of the BMO. However, we noted that BMO can become indistinct in eyes with myopia (Fig 1), rendering MRW measurement impossible or unreliable. With myopia being highly prevalent in many Asian countries and a risk factor for the development of primary open-angle glaucoma,[7−14] an investigation of the

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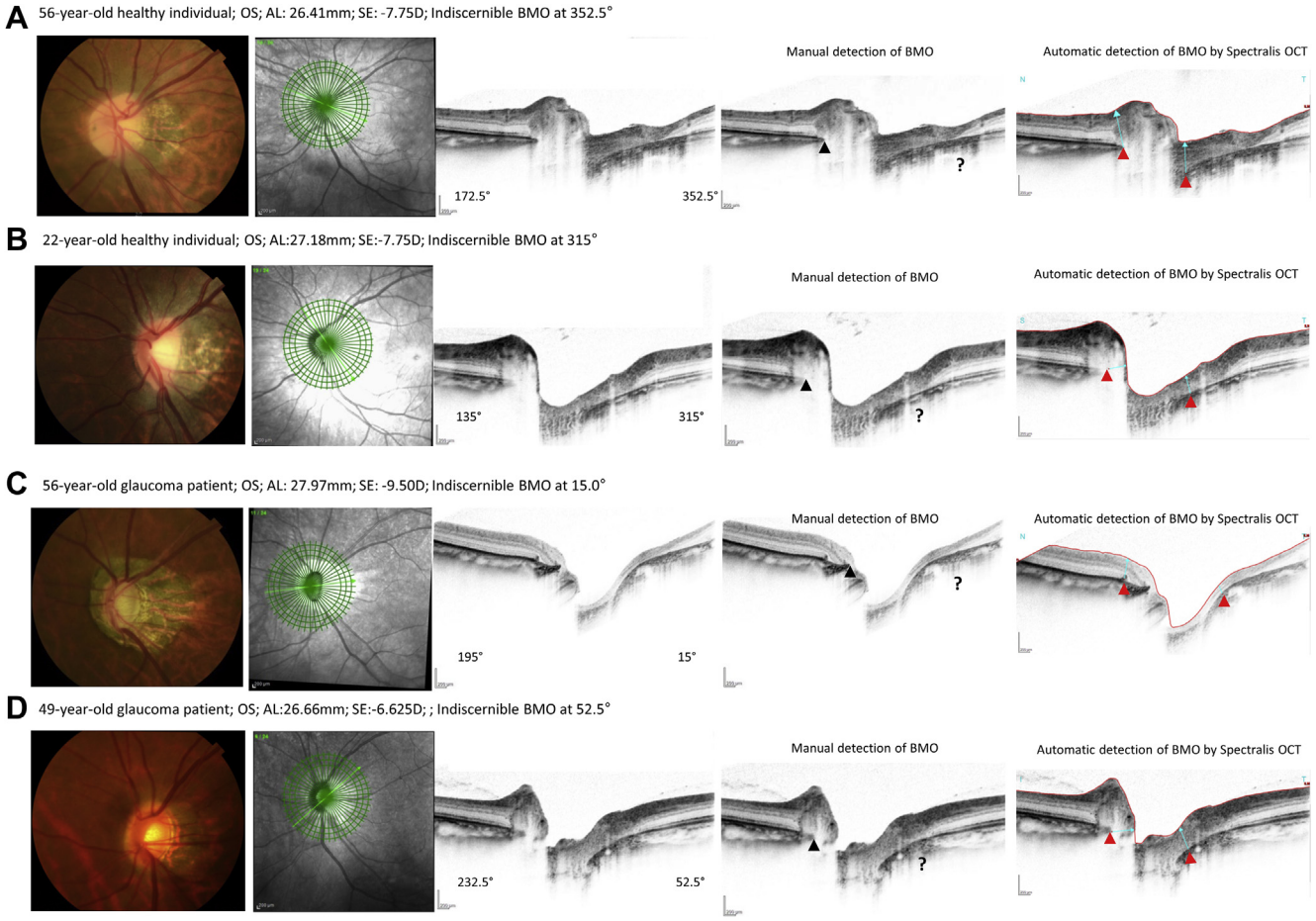

Figure 1. Examples from (**A**, **B**) healthy individuals and (**C**, **D**) glaucoma patients illustrating that the Bruch's membrane opening (BMO) may not be discernible at the inferotemporal and superotemporal meridians (marked with question marks). The locations of BMO detected and confirmed by 2 observers are marked with black arrowheads. The locations of BMO automatically detected by the Spectralis OCT are marked with red arrowheads. The cyan arrows are generated automatically from the Spectralis OCT to indicate the minimum rim width. AL = axial length; OS = left eye; SE = spherical equivalent.

proportion of myopic eyes with indiscernible BMO and factors contributing to indiscernible BMO is relevant to determine if MRW measurement is a feasible approach for diagnostic evaluation of glaucoma in eyes with myopia.

Methods

Participants

Five hundred eyes of 315 participants, including 100 high myopic eyes with axial length (AL) of 26 mm or more from 60 healthy individuals, 112 high myopic eyes from 80 patients with glaucoma, 154 non-high myopic eyes (AL, <26 mm) from 88 healthy individuals, and 134 non-high myopic eyes from 96 patients with glaucoma, were recruited consecutively between January 2015 and March 2017 at the University Eye Center, the Chinese University of Hong Kong and Hong Kong Eye Hospital, Hong Kong, China. Glaucoma patients were enrolled from the glaucoma clinic. Healthy individuals were enrolled from the general eye clinic and the corneal refractive surgery clinic. All participants underwent a comprehensive examination of the anterior and posterior segments. Visual acuity, AL (IOLMaster; Carl Zeiss Meditec, Dublin, CA), refraction, and intraocular pressure (Goldmann applanation tonometry) were measured. Optic disc photographs were obtained with a fundus camera (TRC-50DX; Topcon, Tokyo, Japan). Visual field assessment, OCT imaging of the ONH, and OCT imaging of the retinal nerve fiber layer (RNFL) were performed with the Humphrey Field Analyzer II-i (Carl Zeiss Meditec), the Spectralis OCT (Heidelberg Engineering, Heidelberg, Germany), and the Cirrus HD-OCT (Carl Zeiss Meditec), respectively. The Cirrus HD-OCT was used for evaluation of the RNFL thickness because it can reveal RNFL abnormalities over the 6×6-mm^2 parapapillary RNFL thickness map.[15,16] Inclusion criteria were visual acuity of 20/40 or better and no history of macular disease, neurologic disease, or refractive or retinal surgery at the time of recruitment. Glaucoma patients demonstrated narrowed neuroretinal rim and RNFL defects with corresponding visual field defects in at least 1 eye (only eyes with evidence of glaucoma were included in the glaucoma group). Retinal nerve fiber layer defects were defined when at least 20 contiguous superpixels (instrument default) were encoded in red (i.e., RNFL thickness below the first percentile) in the RNFL thickness deviation map with corresponding RNFL loss in the superotemporal or inferotemporal RNFL bundles, or both, in the RNFL thickness map. Because the diagnostic criteria of RNFL defects and visual field defects were objective criteria, masking