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Diagnostic Accuracy of Optical Coherence Tomography and Scanning Laser Tomography for Identifying Glaucoma in Myopic Eyes

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Purpose: Ruling out glaucoma in myopic eyes often poses a diagnostic challenge because of atypical optic disc morphology and visual field defects that can mimic glaucoma. We determined whether neuroretinal rim assessment based on Bruch's membrane opening (BMO), rather than conventional optic disc margin (DM)-based assessment or retinal nerve fiber layer (RNFL) thickness, yielded higher diagnostic accuracy in myopic patients with glaucoma.

Design: Case-control, cross-sectional study.

Participants: Myopic patients with glaucoma (n = 56) and myopic normal controls (n = 74).

Methods: Myopic subjects with refraction error greater than −2 diopters (D) (spherical equivalent) and typical myopic optic disc morphology, with and without glaucoma, were recruited from a glaucoma clinic and a local optometry practice. The final classification of myopic glaucoma or myopic control was based on consensus assessment by 3 clinicians of visual fields and optic disc photographs. Participants underwent imaging with confocal scanning laser tomography for measurement of DM rim area (DM-RA) and with spectral domain optical coherence tomography (SD OCT) for quantification of a BMO-based neuroretinal rim parameter, minimum rim width (BMO-MRW), and RNFL thickness.

Main Outcome Measures: Sensitivity of DM-RA, BMO-MRW, and RNFL thickness at a fixed specificity of 90% and partial area under the curves (pAUCs) for global and sectoral parameters for specificities ≥90%.

Results: Sensitivities at 90% specificity were 30% for DM-RA and 71% for both BMO-MRW and RNFL thickness. The pAUC was higher for the BMO-MRW compared with DM-RA ($P < 0.001$), but similar to RNFL thickness ($P > 0.5$). Sectoral values of BMO-MRW tended to have a higher, but nonsignificant, pAUC across all sectors compared with RNFL thickness.

Conclusions: Bruch's membrane opening MRW is more sensitive than DM-RA and similar to RNFL thickness for the identification of glaucoma in myopic eyes and offers a valuable diagnostic tool for patients with glaucoma with myopic optic discs. *Ophthalmology 2016;123:1181-1189 © 2016 by the American Academy of Ophthalmology.*

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The diagnosis of primary open-angle glaucoma relies on the clinician's ability to identify structural abnormality of the optic disc.[1] In myopia, identification of glaucomatous optic disc changes often poses a diagnostic challenge[2] because atypical optic disc morphology, including substantial peripapillary atrophy,[3] varying degrees of disc tilt,[4–6] and abnormally large[7,8] or small optic disc size, often is present.[5] Furthermore, individuals with myopia can have visual field defects that mimic glaucomatous loss.[6,9,10]

Myopia is a significant risk factor for the development of primary open-angle glaucoma,[11–13] and there is strong supporting evidence for an increase in the prevalence of myopia, particularly in urban areas.[14,15] As these myopic individuals age, clinicians likely are to be increasingly faced with the challenge of diagnosing glaucoma in myopic eyes, requiring more sensitive and specific methods for diagnosis.

Automated imaging devices, such as confocal scanning laser tomography (CSLT) and optical coherence tomography, give an objective and reproducible measure of optic nerve head or retinal nerve fiber layer (RNFL) structure.[16] However, the utility of these devices has been limited in myopic eyes because of low diagnostic accuracy.[17–19] At 90% specificity, CSLT has been reported to have a sensitivity of approximately 50% in these eyes.[18]

In clinical settings, CSLT has been used widely for neuroretinal rim measurement for quantifying the likelihood of glaucoma[20] and its progression.[21] Neuroretinal rim measurements from CSLT are based on the clinically

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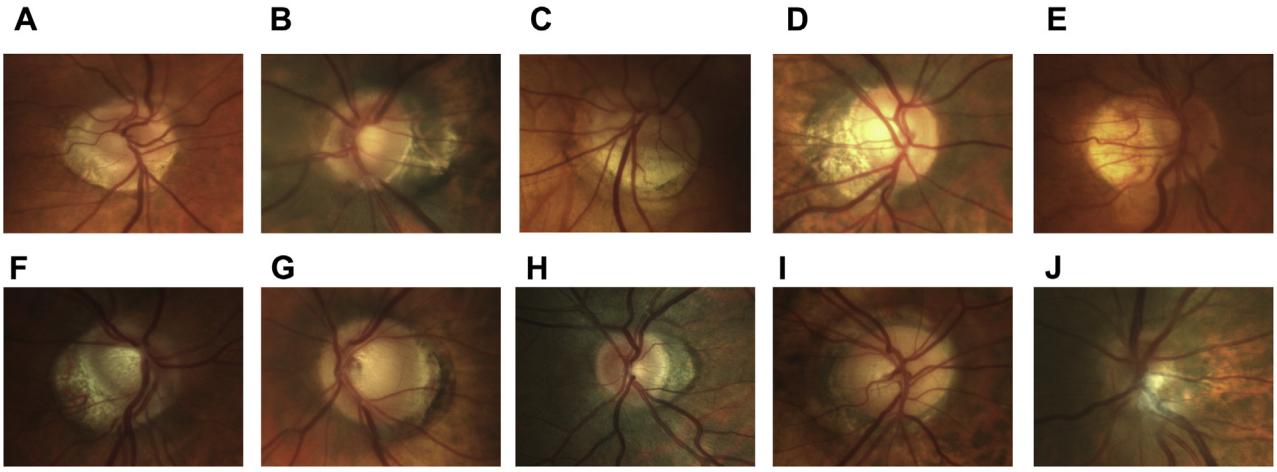

Figure 1. Optic disc photographs of eyes in the control group, selected at random. **A**, Right eye of 72-year-old man with spherical equivalent (SE) of −3.25 diopters (D). **B**, Left eye of 53-year-old man with SE of −9.38 D. **C**, Left eye of 70-year-old man with SE of −6.25 D. **D**, Right eye of 59-year-old woman with SE of −7.11 D. **E**, Right eye of 67-year-old woman with SE of −4.50 D. **F**, Right eye of 37-year-old man with SE of −7.50 D. **G**, Left eye of 78-year-old man with SE of −7.25 D. **H**, Left eye of 37-year-old man with SE −7.12 D. **I**, Right eye of 62-year-old woman with SE of −9.00 D. **J**, Left eye of 63-year-old man with SE of −3.50 D.

identifiable optic disc margin (DM). However, recent findings with optical coherence tomography have challenged the validity and accuracy of conventional DM-based measures.[22] Alternative anatomically and geometrically accurate rim parameters,[23,24] based on the Bruch's membrane opening (BMO), have been proposed. A new parameter measuring the minimum distance between the BMO and the internal limiting membrane, termed "BMO-minimum rim width" (BMO-MRW), seems to provide a better representation of the amount of neuroretinal rim tissue than conventional DM-based parameters. Previous studies have demonstrated better diagnostic accuracy[24] and greater correlation with other structural and functional parameters[25,26] of BMO-MRW than conventional DM-based rim measures.

The primary aim of this study was to compare the diagnostic accuracy of BMO-MRW with DM-based rim assessment from CSLT and RNFL thickness measurements to separate individuals with myopic optic disc morphology with glaucoma (myopic glaucoma) from those without glaucoma (myopic controls). Secondarily, we also explored the sensitivity of these measures on a sectoral basis.

Methods

Participants

Study participants included myopic patients with glaucoma and healthy controls with myopic optic disc morphology (defined later). Patients with glaucoma and myopia were recruited prospectively from the glaucoma clinic at the Eye Care Centre, Queen Elizabeth II Health Sciences Centre, Halifax, Canada. Myopic participants without glaucoma were recruited consecutively from a local optometry practice. Typical myopic optic disc morphology (Fig 1) was defined as the presence of significant beta type of peripapillary atrophy, characterized by complete loss of retinal pigment epithelium, adjacent to the optic disc.[27] Beta peripapillary atrophy usually was present sectorally, mostly temporally, associated with the direction of the optic disc tilt, but could also be present circumferentially around the optic disc. Optic disc tilt also is part of the typical myopic optic disc morphology, but its presence was not necessary for inclusion in this study.

For both groups, additional inclusion criteria were best-corrected visual acuity of ≥20/40, myopia greater than −2 diopters (D) (spherical equivalent refraction), cylinder correction within 4 D, absence of retinal disease (including degenerative myopia) or optic nerve disease other than glaucoma, and willingness to participate in the study. If both eyes were eligible, 1 eye was randomly selected for analysis.

The study was approved by the Ethics Review Board of Capital Health and followed the tenants of the Declaration of Helsinki. All subjects provided written informed consent.

Study Definition of Patients with Glaucoma and Myopic Controls

The diagnosis of myopic glaucoma or myopic control was defined by consensus among 3 fellowship-trained glaucoma subspecialists who evaluated the visual fields and optic disc photographs from all participants independently and were masked from all other demographic and clinical information. To minimize bias and maintain an independent reference standard for evaluating the diagnostic accuracy of structural tests, visual field appearance was primarily used for deciding the diagnostic group of the participants. Individuals were included in the myopic control group if their visual field was graded as normal or with abnormalities consistent with myopia, but not glaucoma, independently by all 3 clinicians, regardless of the grading given to their optic disc. If all 3 clinicians graded the visual field as having glaucomatous abnormalities, the participant was included in the myopic glaucoma group. In cases of disagreement in visual field grading, the clinicians used the optic disc evaluation to obtain a consensus decision to place the participant in the glaucoma or control group (examples given in "Results").

Study Procedures

Study subjects had a variety of diagnostic tests (described later) performed in 1 study visit. For individuals who were perimetrically

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