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Bruch's Membrane Opening Minimum Rim Width and Retinal Nerve Fiber Layer Thickness in a Normal White Population

A Multicenter Study

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Purpose: Conventional optic disc margin-based neuroretinal rim measurements lack a solid anatomic and geometrical basis. An optical coherence tomography (OCT) index, Bruch's membrane opening minimum rim width (BMO-MRW), addresses these deficiencies and has higher diagnostic accuracy for glaucoma. We characterized BMO-MRW and peripapillary retinal nerve fiber layer thickness (RNFLT) in a normal population.

Design: Multicenter cross-sectional study.

Participants: Normal white subjects.

Methods: An approximately equal number of subjects in each decade group (20–90 years of age) was enrolled in 5 centers. Subjects had normal ocular and visual field examination results. We obtained OCT images of the optic nerve head (24 radial scans) and peripapillary retina (1 circular scan). The angle between the fovea and BMO center (FoBMO angle), relative to the horizontal axis of the image frame, was first determined and all scans were acquired and analyzed relative to this eye-specific FoBMO axis. Variation in BMO-MRW and RNFLT was analyzed with respect to age, sector, and BMO shape.

Main Outcome Measures: Age-related decline and between-subject variability in BMO-MRW and RNFLT.

Results: There were 246 eyes of 246 subjects with a median age of 52.9 years (range, 19.8–87.3 years). The median FoBMO angle was -6.7° (range, 2.5° to -17.5°). The BMO was predominantly vertically oval with a median area of 1.74 mm^2 (range, 1.05–3.40 mm^2). Neither FoBMO angle nor BMO area was associated with age or axial length. Both global mean BMO-MRW and RNFLT declined with age at a rate of -1.34 μm/year and -0.21 μm/year, equivalent to 4.0% and 2.1% loss per decade of life, respectively. Sectorially, the most rapid decrease occurred inferiorly and the least temporally; however, the age association was always stronger with BMO-MRW than with RNFLT. There was a modest relationship between mean global BMO-MRW and RNFLT ($r = 0.35$), whereas sectorially the relationship ranged from moderate ($r = 0.45$, inferotemporal) to nonexistent ($r = 0.01$, temporal).

Conclusions: There was significant age-related loss of BMO-MRW in healthy subjects and notable differences between BMO-MRW and RNFLT in their relationship with age and between each other. Adjusting BMO-MRW and RNFLT for age and sector is important in ensuring optimal diagnostics for glaucoma. *Ophthalmology 2015;122:1786-1794 © 2015 by the American Academy of Ophthalmology.*

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Spectral-domain optical coherence tomography (OCT) has become an important imaging method in the diagnosis and follow-up of glaucoma and retinal diseases. Furthermore, OCT has permitted important anatomic insights into the optic nerve head (ONH) structures that correspond to the clinically perceived optic disc margin[1,2] and visualization of deep ONH structures, such as the anterior laminar surface[3,4] and the termination of the Bruch's membrane–retinal pigment epithelium complex within the ONH.[2–4]

Optic disc margin-based indices that quantify the neuroretinal rim, such as cup-to-disc ratio and rim area, lack a solid anatomic and geometrical rationale.[2,5] Conventional funduscopy and disc photography do not permit clinicians to visualize critical anatomic features that delineate the outer edge of the rim, principally because of extensions of Bruch's membrane well inside the clinical disc margin that are present in variable amounts in all eyes[2] and that yield critical errors in rim estimates.[5]

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Recently, we and other investigators[5–8] have proposed an anatomically and geometrically accurate neuroretinal rim parameter, which is one aspect of an OCT-based paradigm change in the clinical assessment of the ONH.[9] This parameter, Bruch's membrane opening minimum rim width (BMO-MRW),[5] measures the rim from a logical outer border of the neuroretinal rim, that is, BMO, which represents the maximum aperture at the level of the ONH through which retinal ganglion cell axons can pass. It also is a geometrically accurate measurement because it measures the minimum rim width from BMO to the internal limiting membrane, and not conventionally along or parallel to the fixed plane of the disc margin or BMO. Recent publications have shown a higher diagnostic accuracy for glaucoma with BMO-MRW[10–12] and a stronger relationship with the visual field compared with conventional rim parameters.[12–14]

The orientation of the fovea relative to BMO impacts the accuracy of sector-based rim measurements of the ONH and of peripapillary and macular retinal nerve fiber layer thickness (RNFLT).[9] Although the mean angle between the fovea and BMO center (termed the FoBMO angle) is approximately $-7°$, relative to the horizontal axis of the image frame, it can vary from $6°$ to $-17°$ among individuals.[15] As a result, the current strategy of assigning sectors relative to the fixed horizontal and vertical axes of the imaging device could result in artificially large variability among individuals (Fig 1) and could decrease diagnostic accuracy. It also results in significant differences in BMO-MRW in most clock hour sectors compared with computation according to the FoBMO axis.[15] For these reasons, we recently proposed that both image acquisition and analysis be performed according to the individual subject's FoBMO axis.[9]

Incorporating BMO-MRW into clinical devices requires a robust description of BMO-MRW and the parameters that could influence it, including age and BMO area, to phenotype the normal ONH and construct prediction intervals to determine the likelihood that a test result is within normal limits. The objective of this research was to provide such a description of BMO-MRW in data acquired and analyzed according to the eye-specific FoBMO axis in a multicenter study with a white population.

Methods

Participants

Study participants of self-identified white descent were recruited in 5 centers: 1 in Canada, 2 in the United States, and 2 in Germany.

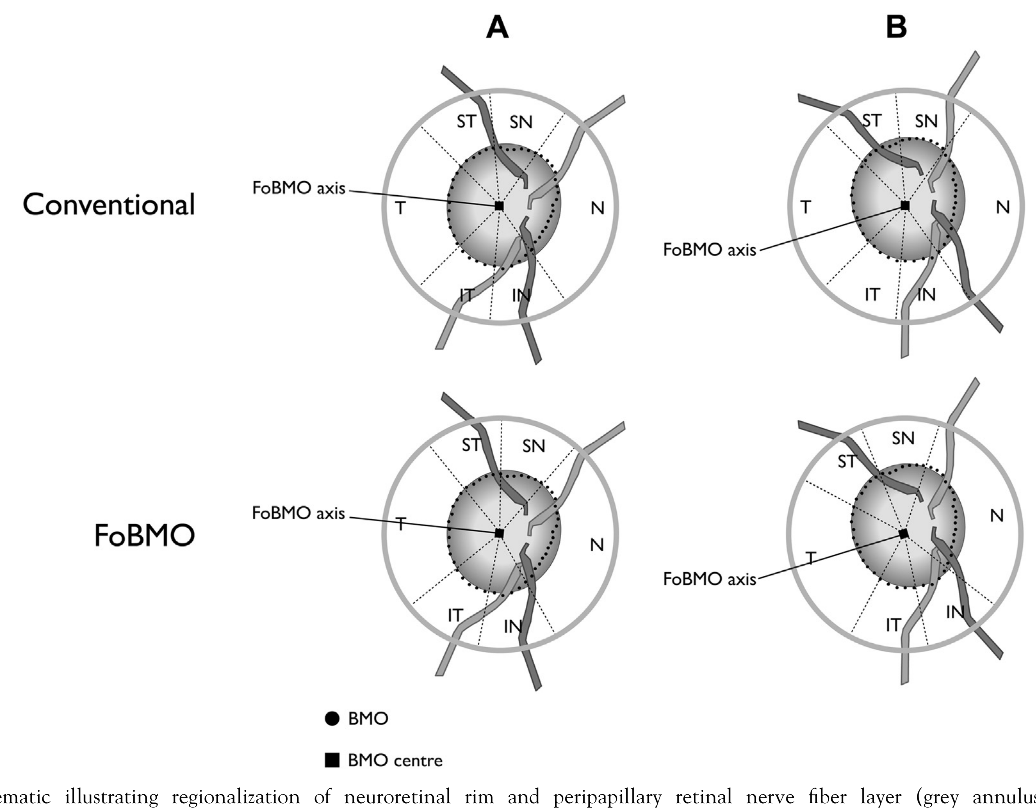

Figure 1. Schematic illustrating regionalization of neuroretinal rim and peripapillary retinal nerve fiber layer (grey annulus) sectors. With current conventional methods, data acquisition and regionalization is relative to the horizontal axis of the imaging frame with the assumption that sectors contain the same anatomic locations. In 2 cases (**A** and **B**), the orientation of the lines connecting the fovea to the Bruch's membrane opening (BMO) center (FoBMO axis) varies by 20°; hence, the sectors contain measurements from different anatomical locations. In FoBMO acquisition and regionalization, sectors contain data from the same anatomic locations. IN = inferonasal; IT = inferotemporal; N = nasal; SN = superonasal; ST = superotemporal; T = temporal.