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The Proportion of Individuals Likely to Benefit from Customized Optic Nerve Head Structure–Function Mapping

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Purpose: Interindividual variance in optic nerve head (ONH) position, axial length, and location of the temporal raphe suggest that customizing mapping between visual field locations and ONH sectors for individuals may be clinically useful. Herein we quantify the proportion of the population predicted to have structure–function mappings that markedly deviate from "average," and thus would benefit from customized mapping.

Design: Database study and case report.

Participants: Population database of 2836 eyes from the Beijing Eye Study and a single case report of an individual with primary open-angle glaucoma.

Methods: Using the morphometric fundus data of the Beijing Eye Study for 2836 eyes and applying a recently developed model based on axial length and ONH position relative to the fovea, we determined for each measurement location in the 24-2 Humphrey (Carl Zeiss Meditec, Dublin, CA) visual field the proportion of eyes for which, in the customized approach as compared with the generalized approach, the mapped ONH sector was shifted into a different sector. We determined the proportion of eyes for which the mapped ONH location was shifted by more than 15°, 30°, or 60°.

Main Outcome Measures: Mapping correspondence between locations in visual field space to localized sectors on the ONH.

Results: The largest interindividual differences in mapping are in the nasal step region, where the same visual field location can map to either the superior or inferior ONH, depending on other anatomic features. For these visual field locations, approximately 12% of eyes showed a mapping opposite to conventional expectations.

Conclusions: Anatomically customized mapping shifts the map markedly in approximately 12% of the general population in the nasal step region, where visual field locations can map to the opposite pole of the ONH than conventionally considered. Early glaucomatous damage commonly affects this region; hence, individually matching structure to function may prove clinically useful for the diagnosis and monitoring of progression within individuals. *Ophthalmology 2017;■:1–8 © 2017 by the American Academy of Ophthalmology*

Both anatomic and functional measures are key to contemporary glaucoma diagnosis and management. Typically, these are measured separately; hence, to relate these 2 different clinical measures intelligently, it is necessary to have a mapping between the structural parameters (for example, the location on the optic nerve head [ONH] or peripapillary retinal nerve fiber [RNF] layer position) and locations in visual space. Different approaches to such mapping have been proposed, including models derived from hand tracing and visualization of RNF bundle trajectories,[1,2] from models derived by visualization of the absence of RNF bundles in established glaucoma using retinal photography,[3] from geometrical principles,[4–6] or from correlations between structural and functional abnormalities in clinical databases.[7,8] The advent of high-resolution ocular imaging with the capacity to assess ocular biometric parameters readily and quantitatively has seen an increased clinical and scientific interest in the interindividual differences in key ocular anatomic parameters that are considered to contribute to this mapping.[2,9–11]

There are several key anatomic features that influence the mapping between structure and function in glaucoma. These include the position of the ONH relative to the fovea, the position of the temporal raphe, and axial length. Although it is well established that axial length shows significant variance between individuals,[12] published data on the population variance of other key parameters is relatively recent. Chauhan and Burgoyne[13] provided a histogram of the distribution of ONH positions relative to the fovea in a population of 222 patients with ocular hypertension or glaucoma and showed that the position of the center of the ONH (center of Bruch's membrane opening) relative to the fovea could differ by up to 25°. A larger population distribution from the Beijing Eye Study showed a distribution from 6.3° to 28.9°.[14] The temporal raphe is now visible directly using high-resolution optical coherence tomography (OCT)[15,16] and adaptive optics.[17] The sample size of studies that have visualized and mapped the raphe are relatively small (approximately 20 people); however, the

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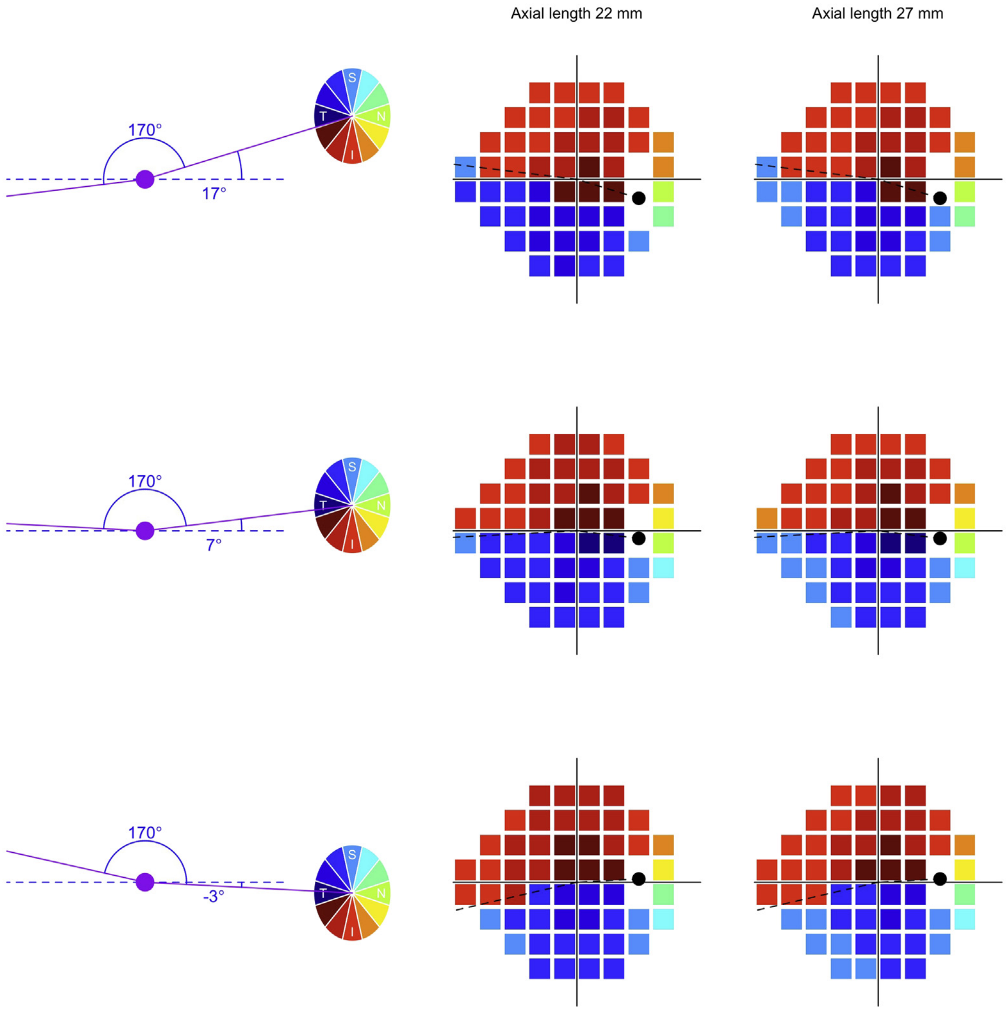

Figure 1. Schematic illustration of customized mapping from 30° sectors of the optic nerve head to the 24-2 locations in visual field space in right eye format. The left column shows 3 different positions of the optic nerve relative to the fovea. Corresponding maps for both shorter and longer axial lengths are illustrated in the middle and right columns.

angle of the temporal raphe seems to vary among individuals by up to 10°, with an on-average positioning of approximately 170° from the ONH-to-fovea angle.[15,16] Variation in the position of the temporal raphe has been confirmed by studies that have used lower-resolution clinical OCT to look for divisions between superior and inferior hemifields in macular cube data.[18] The temporal raphe is a key landmark dividing the superior and inferior retina, and many analysis procedures for glaucoma (e.g., the glaucoma hemifield test[19]) assume a horizontal boundary between the superior and inferior visual field. Hence, if the temporal raphe deviates significantly from horizontal, there is the potential for very atypical mapping between visual field locations in the nasal visual field and the optic nerve, and possibly misinterpretation of clinical analytics that assume a strictly horizontal divide between the superior and inferior hemifields.

The observation of significant population variance in these key anatomic features predicts that custom, personalized mapping between structure and function may have clinical usefulness.[4,9,15] For example, personalized mapping may be important to detect early, spatially localized signs of progression (for example, mapping pointwise visual field change to sectoral change of neuroretinal rim tissue or RNF layer) or to enable customized functional testing that is spatially directed by structural abnormalities observed on OCT.[20] To date, although customized mapping has been proposed,[2,4] there has been fairly limited exploration of when and for whom it is likely to be useful. Danthurebandara et al[21] compared the strength of correlations between structure and function for individually customized mapping[4] with a commonly used population-based map[3] and found that performance of the 2 mapping schema was similar. Hood et al[11] considered individual differences in the position of the ONH relative to the fovea and similarly found that, on average, between-group estimates of the strength of correlation between structure and function were not improved. These outcomes are hardly surprising given that most individuals within a population will have fairly average anatomy, and therefore, the customized approach and noncustomized approach will produce very similar maps for