Author Response: Biomechanical Responses of Lamina Cribrosa to Intraocular Pressure Change Assessed by Optical Coherence Tomography in Glaucoma Eyes

Our recent publication\(^1\) noted several features of change in anterior lamina depth (ALD) with change in intraocular pressure (IOP) in glaucoma patients. ALD changed more in the lower ranges of IOP than at higher ranges, which represents the expected increased stiffening of biomaterials in regions of higher stress. Some eyes exhibited movement of the lamina out of the eye at lower IOP—a behavior that is more likely when the peripapillary sclera is more compliant. This was more common in eyes with less glaucoma damage. The regions of the lamina that moved more were in its vertical poles, above and below, as suggested by the lower density of connective tissue in the lamina there. Within an individual optic nerve head (ONH), there was greater displacement with IOP change in clock hours that retained more normal nerve fiber layer in the correspond- ing peripapillary nerve fiber layer. Compliance of ALD may be a relevant and practical biomarker for glaucoma susceptibility by noninvasive imaging. None of these findings are affected by the issue discussed in the Letter to the Editor.

The letter by Rebolleda et al.\(^2\) discusses the reference plane for images in optical coherence tomography (OCT) of the optic nerve head. In past work in this field, Bruch’s membrane opening (BMO) has been the standard reference plane, and our paper used it as well, both for consistency with the literature and because we recognize that it is the best of three alternatives: BMO, choroidal–scleral interface (CSI), or RPE.

The reasons that BMO position is the best reference are as follows: (1) it is visible in 100% of scans; (2) it can be detected by automated software without human “marking”; (3) it does not change in size or shape with moderate shifts in IOP (documented in our paper); and (4) the putative change in its position with IOP change due to choroidal thickness change as suggested by Rebolleda et al. is not a significant issue. It is important to distinguish choroidal thickness in the immediate peripapillary area from that of the choroid underlying the macula. Rebolleda et al. refer to choroidal thickness changes in two cited references (their references 6 and 7), but these investigations (one of them by our group) studied change in choroidal thickness with IOP change in the macular area, not near the disc. The peripapillary choroid tapers down to become much thinner in most eyes directly underlying the edge of BMO. Therefore, the change in BMO position at that site due to choroidal thickness change is trivially small compared with the hundreds of micrometers of movement that we measured in ALD with change in IOP. Any movement of BMO due to change in the thin choroid at the disc margin is within the margin of error on repeat measurements at the same IOP. Likewise, using a choroidal thickness measurement 3.5 mm from the disc center, as Rebolleda et al.\(^2\) did, is not “peripapillary” and is not indicative of change in choroidal thickness immediately under the edge of BMO.

The weaknesses of using the CSI as reference are many. (1) As we and others have published, 20% of eyes have no clearly identifiable CSI using present technology. (2) The position of CSI has not been accurately automated and its subjective marking by human observers has a variance very far greater than any putative movement of BMO. (3) CSI is not a smooth curve, so that selecting one arbitrary location along it (as Rebolleda et al. have done) can give rise to significant variability from image to image. (4) The eye changes in axial length and curvature at the CSI with IOP change, so the claim that it is “better” ignores the fact that CSI is equally and potentially more mobile with IOP change than BMO. (5) In some eyes, the CSI reference position chosen by Rebolleda et al. (3.5 mm from the disc center) leads to a reference line that practically runs right through the anterior lamina border, making its depth essentially zero when it clearly is posterior to the BMO inlet. In these eyes, a CSI reference plane would (artifactitiously) produce huge changes in ALD as a percent of baseline. (6) We measured and published choroidal thickness change in the macular zone of many of the patients in the present study. There is macular choroidal thickening of 2 to 3 μm/mm Hg lowering of IOP. By contrast, our peripapillary measurements of choroidal thickness at the BMO showed minor and variable change compared with those of the macular zone.

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References


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