

The Literature

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ASSOCIATION BETWEEN CORNEAL BIOMECHANICAL PROPERTIES AND GLAUCOMA SEVERITY

Mansouri K, Leite MT, Weinreb RN, et al¹

ABSTRACT SUMMARY

Mansouri et al used structural and functional testing to evaluate the association between corneal hysteresis (CH) and the severity of glaucoma.¹ The observational cross-sectional study included 299 eyes of 191 participants who were either glaucoma suspects (n = 151 eyes) or patients with confirmed glaucoma (n = 148 eyes). The researchers measured two corneal biomechanical properties—CH and corneal resistance factor (CRF)—with the Ocular Response Analyzer (Reichert Ophthalmic Instruments). They measured disease severity according to two functional parameters: visual field mean deviation and pattern standard deviation. In addition, they measured the thickness of the retinal nerve fiber layer with the GDx scanning laser polarimeter (Carl Zeiss Meditec, Inc.) with enhanced corneal compensation and spectral-domain optical coherence tomography.

According to Mansouri et al, results of the multivariable linear regression model suggested a weak overall association between corneal biomechanics and disease severity. Despite an independent association between CRF and mean deviation, a similar association was not seen between CH and mean deviation. With regard to structural changes and corneal biomechanics, there appeared to be no independent association between corneal biomechanical parameters and retinal nerve fiber layer thickness.

DISCUSSION

What is the relationship between corneal biomechanical properties and the severity of glaucoma?

For many years, glaucoma specialists have known that central corneal thickness (CCT) plays an important role in glaucoma risk assessment. Several recent studies have suggested that corneal biomechanical properties other than CCT, specifically CH, could be a predictor of glaucoma.^{2,3} CH is a viscoelastic property of the cornea characterized by its ability to absorb and dissipate energy. Previous studies have demonstrated that CH may be an independent

“Corneal hysteresis is a viscoelastic property of the cornea characterized by its ability to absorb and dissipate energy.”

risk factor for the progression of glaucoma.^{4,5} Some researchers have hypothesized that differences in corneal biomechanics between glaucomatous and healthy patients may reflect overall structural differences between eyes.⁶ As such, decreased CH might be a proxy for vulnerability at the level of the lamina cribrosa and might help to explain why some patients are more susceptible to optic nerve damage from elevated IOP than others.

According to the investigators, this study is the first to evaluate the association between corneal biomechanical parameters and both structural and functional changes to the optic nerve. The authors report that, although an association between corneal biomechanics and glaucomatous disease exists, it appears to play only a minor role in determining disease severity. These conclusions differ from those of several other published studies that have evaluated corneal biomechanics with respect to visual field defects.⁷ Given the potential of corneal biomechanical parameters to aid the diagnosis and management of glaucoma, the authors concluded that a longitudinal prospective study is needed to elucidate the relationship between glaucomatous progression and corneal biomechanics.

RELATIONSHIP BETWEEN CORNEAL BIOMECHANICAL PROPERTIES, CENTRAL CORNEAL THICKNESS, AND INTRAOCULAR PRESSURE ACROSS THE SPECTRUM OF GLAUCOMA

Kaushik S, Pandav SS, Banger A, et al⁸

ABSTRACT SUMMARY

Kaushik et al evaluated the differences in CH, CRF, corneal-compensated IOP, and Goldmann-correlated IOP in Indian eyes. The investigators studied the relationship between these variables and

“Although corneal hysteresis may prove to be an additional risk factor for glaucoma, whether it is a pressure-independent risk factor is still up for debate.”

CCT and Goldmann applanation tonometry (GAT) measurements.⁸ The prospective observational study included normal subjects (n = 71); patients with ocular hypertension (OHT; n = 38); subjects with discs suspicious for glaucoma but normal visual fields (n = 38); and patients with primary angle-closure glaucoma, (n = 59), primary open-angle glaucoma (POAG; n = 36), and normal-tension glaucoma (NTG; n = 18). None of the study's participants had received treatment.

The investigators found that CH measurements were significantly lower in eyes with POAG ($P = .034$) and NTG ($P = .030$) compared with normal subjects, regardless of the patients' IOP. The CRF was significantly less in eyes with NTG and most prevalent in eyes with POAG and OHT. Regression analysis with CH as the dependant variable showed a significant association with GAT and CRF ($P < .001$) but not CCT (adjusted $R^2 = 0.483$). GAT correlated strongly with Goldmann-correlated IOP on the Ocular Response Analyzer ($r = 0.82$, $P < .001$), but the limits of agreement between the measurements were poor.

Kaushik and colleagues concluded that CH and CRF may constitute a pressure-independent risk factor for glaucoma. CRF appears to influence GAT IOP measurements more than CCT. IOP measurements from the Ocular Response Analyzer, however, are not currently interchangeable with, and are unlikely to replace, GAT.

DISCUSSION

How do corneal biomechanical properties differ across the spectrum of glaucoma?

When the investigators compared differences in biomechanical measurements based on clinical diagnoses, they found that CH was lower in POAG and NTG than the other groups. CRF, a measure of overall corneal resistance, was higher in OHT and POAG and lower in NTG. Although the researchers did not thoroughly explore this idea with a predictive model, they hypothesized that CRF might be a better correcting factor for IOP than CCT.

What is the relationship between corneal biomechanical properties and Goldmann-correlated IOP?

When controlled for other variables, CH appears to be inversely related to Goldmann-correlated IOP. This finding is consistent with the decreased CH in POAG, but it appears to conflict with the low CH measurements in NTG as well as the high CH measurements in OHT. These findings suggest that the relationship between CH and IOP is more complicated than a simple linear inverse association.

What is the relationship between corneal biomechanical properties and CCT?

The authors found that CH was not associated with CCT, which suggests that CH may be an independent risk factor for glaucoma.

Although CH may prove to be an additional risk factor for glaucoma, whether it is a pressure-independent risk factor is still up for debate. This article suggests a complex relationship between CCT, IOP, and corneal biomechanical factors that the glaucoma community is only beginning to understand. Additional questions regarding the role of CH in the diagnosis and management of glaucoma need to be answered before physicians can incorporate these measurements into their clinical practice. ■

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1. Mansouri K, Leite MT, Weinreb RN, et al. Association between corneal biomechanical properties and glaucoma severity. *Am J Ophthalmol*. 2012;153(3):419-427.e1.
2. Congdon NG, Broman AT, Bandeen-Roche K, et al. Central corneal thickness and corneal hysteresis associated with glaucoma damage. *Am J Ophthalmol*. 2006;141(5):868-875.
3. Mangouritis G, Morphis G, Mourtoukos S, Feretis E. Association between corneal hysteresis and central corneal thickness in glaucomatous and non-glaucomatous eyes. *Acta Ophthalmol*. 2009;87(8):901-905.
4. Abitbol O, Bouden J, Doan S, et al. Corneal hysteresis measured with the Ocular Response Analyzer in normal and glaucomatous eyes. *Acta Ophthalmol*. 2010;88(1):116-119.
5. Kotecha A, Elsheikh A, Roberts CR, et al. Corneal thickness- and age-related biomechanical properties of the cornea measured with the Ocular Response Analyzer. *Invest Ophthalmol Vis Sci*. 2006;47(12):5337-5347.
6. Wells AP, Garway-Heath DF, Poostchi A, et al. Corneal hysteresis but not corneal thickness correlates with optic nerve surface compliance in glaucoma patients. *Invest Ophthalmol Vis Sci*. 2008;49(8):3262-3268.
7. Anand A, De Moraes CG, Teng CC, et al. Corneal hysteresis and visual field asymmetry in open angle glaucoma. *Invest Ophthalmol Vis Sci*. 2010;51(12):6514-6518.
8. Kaushik S, Pandav SS, Banger A, et al. Relationship between corneal biomechanical properties, central corneal thickness and intraocular pressure across the spectrum of glaucoma. *Am J Ophthalmol*. 2012;153(5):840-849.e2.