Commentary: The utility of water-drinking test and corneal biomechanics in glaucoma

The water-drinking test (WDT) is known to increase the IOP by approximately 1–2 mm Hg from baseline in healthy adults and by 3–5 mm Hg (~30% of baseline) in treated glaucoma patients.[1,2] Although the exact mechanism of this is unclear (increased episcleral venous pressure or expansion of choroidal volume), the ability of the eye to recover would depend on the aqueous outflow facility. The WDT may be an indirect evaluation of the aqueous outflow capacity.[2] Reports of lower WDT-IOP peaks in patients treated with prostaglandin analogs add credence to this observation.[2,3] Another prospective study reported a strong correlation between IOP peaks during the WDT and modified diurnal tension curve (r = 0.780, $P < 0.0001$) in POAG patients without anti-glaucoma medication.[4] This study demonstrates its utility in predicting the diurnal IOP change as performing a modified diurnal tension curve is labor-intensive. The water-drinking test has also been found to cause other short-term ocular changes besides IOP rise. Read *et al*.[1] reported significant increases in the IOP and ocular pulse amplitude and a decrease in the axial length (due to a nonsignificant increase noted in choroidal thickness?), the change being more significant among myopes. This indicates a broader ocular change occurring due to hydration requiring further evaluation.

Ocular biomechanics refers to the science concerning the origin and effects of forces that act on the eye. The estimation of IOP is one such measurement related to biomechanics. Due to the limited accessibility of the posterior chamber, the IOP is typically measured via the cornea. The cornea is considered a viscoelastic structure. Viscoelasticity is a term used for materials whose deformation in response to an applied force (loading) differs from its response to removing that force (unloading). The difference in the loading and unloading forces is a measure of the damping effect of the material, called hysteresis, which reflects its ability to absorb and dissipate energy. The collagen fibrils contribute to the elastic element, and the viscous element is primarily the stromal glycosaminoglycans and water. However, biomechanical measurement is complicated because the cornea is spatially inhomogeneous to lateral span and depth and is directionally anisotropic in its response to loading.[5]

Measurement of the IOP is affected by the central corneal thickness (CCT) and corneal biomechanical properties. Corneal biomechanical properties may be a stronger predictor of IOP measurement error than CCT. They have also been shown to predict the risk of glaucoma development and progression. This may be because the sclera and cornea are composed of an integrated connective tissue layer, and by extension, are biomechanically related. Therefore, an eye with a more deformable cornea is likely to have a lamina cribrosa that is less able to dampen pressure changes and suffer glaucomatous damage from an elevated IOP. A vast majority of studies evaluating the role of corneal biomechanics in glaucoma that were performed on the ocular response analyzer (ORA; Reichert Ophthalmic Instruments, Depew, NY, hereafter ORA) show the corneal hysteresis (CH) to be a strong predictor of the development and progression of glaucoma. However, the exact nature of what the CH measures are unclear. The changes in CH may indirectly reflect changes in the peripapillary ring and lamina cribrosa structure.[6] The ORA also reports a corneal-compensated IOP (IOPcc), which uses the measured biomechanical properties to report IOP values less affected by changes associated with LASIK and other refractive surgeries. The Corvis ST (Oculus, Wetzlar, Germany, hereafter Corvis ST) offers a few advantages over the ORA: two-dimensional imaging, isolating corneal deflection from whole-eye motion, and a consistent air puff pressure between measurements.[5] It also provides a corneal biomechanical index (CBI), tomographic biomechanical index (TBI), and biomechanically compensated IOP (bIOP) comparable to true IOP in *ex vivo* tests. Thus, preliminary data utilizing the Corvis ST to study IOP and biomechanical changes, such as from the current study, are welcome additions to the literature.[7] Another promising new composite metric, the Dresden biomechanical glaucoma factor (DBGF), which weighs bIOP, pachymetry data, and several Corvis ST metrics of corneal biomechanics to improve early detection of normal-tension glaucoma, has recently been introduced.[8] Other new technologies in development offering advantages of spatially sensitive measurements of corneal biomechanics are optical coherence elastography (OCE), Brillouin imaging, and phase-decorrelation OCT (PhD-OCT).[5]

While the role of evaluating corneal biomechanics in corneal surgery (refractive surgery) and pathology (corneal ectasias) cannot be overemphasized, its place in the glaucoma decision tree remains under-represented. To this end, future studies similar to the current one,[7] observing the effect of other physiological factors and pathological conditions affecting IOP and biomechanics, may be extremely valuable. Given the available evidence, we recommend utilizing biomechanical measures for stratifying patients as high-risk or low-risk for the development and progression of glaucoma. This may be particularly useful in determining therapy in monocular patients, borderline IOP, inconclusive fields, and a strong family history of glaucoma.

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Quick Response Code:

Website:
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DOI:
10.4103/ijo.IJO_3029_21

Cite this article as: Behera G, Kaliaperumal S. Commentary: The utility of water-drinking test and corneal biomechanics in glaucoma. Indian J Ophthalmol 2022;70:1229-30.