Optic Nerve Head Biomechanical Strain as a Potential Biomarker for Progression in High and Pathologic Myopia

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Purpose:
To determine if biomechanical changes in the optic nerve head (ONH) (i.e. strains or deformations) following adduction, abduction, and IOP elevation in healthy and highly myopic eyes (with and without pathologies) can serve as a biomarker for progression.

Methods:
18 eyes of 18 subjects, which comprised of 6 low myopia or emmetropic subjects (LM), 6 highly myopia (HM: axial length > 26 mm) and 6 pathologic myopia (PM). Macular and ONH SD-OCT scans were obtained with eyes in: (1) primary gaze, (2) 20° adduction, (3) 20° abduction, and (4) primary gaze with acute IOP elevation (to ~40 mmHg) achieved through ophthalmodynamometry (ODM). For each OCT volume, we automatically segmented the prelaminar tissue (PLT) and the lamina cribrosa (LC) using deep learning. We also digitally-aligned the OCT volumes obtained from (2)-(4) to the baseline volume (1) before performing digital volume correlation (DVC) analysis to quantify IOP- and gaze-induced PLT and LC displacements for all scenarios. The resulting displacement fields obtained from the DVC analysis were then used to calculate the effective strain (a local measure of tissue deformation) that was compared across groups.

Results:
ODM induced abnormally high strains (6.6 ± 1.9%) in PM eyes as compared to HM eyes (3.4 ± 1.0%) and LM eyes (2.6 ± 0.8%). The same trend was also observed for eye movements. Interestingly, PM eyes experienced similar strains (no significance difference, p > 0.05) under IOP elevation (6.6 ± 1.9%) and adduction (6.4 ± 2.1%). In one subject with high axial anisometropia, the average strain in the PLT of the PM right eye (7.4 ± 2.3%) was much higher than that the LM left eye (4.3 ± 1.5%) under IOP elevation (p < 0.05).

Conclusions:
We found that HM eyes tend to be more sensitive to IOP elevation as compared to LM eyes. PM eyes experienced abnormally high strains and they were equally influenced by IOP elevation and adduction. These preliminary results may indicate that ONH strain differs significantly between LM, HM and PM eyes and has the potential to serve as a biomarker for progression.