Increased Scleral Stiffness in Diabetes with Retinopathy than in Diabetes without Retinopathy

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Posterboard#: B0499

Abstract Number: 2065 - B0499

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Purpose

To compare corneal and scleral stiffness from air puff induced deformation in Diabetes without retinopathy (DIA) and Diabetes with Retinopathy (DR) including when diabetic but prior to developing retinopathy (dia-DR), and normal controls (NRL).

Methods

A total of 78 right eyes of 78 DIA, 84 right eyes of 84 DR, and 107 right eyes of 107 age-matched normal control subjects were prospectively enrolled. Demographic and ophthalmic diagnostic device data were recorded, including the Corvis ST. For diabetic subjects, nearest HbA1c, average HbA1c over time (HbA1c-mean), maximum HbA1c (HbA1c-max), and length of diabetes diagnosis (LoD) were taken from the medical records. Biomechanical parameters included two stiffness parameters (SP) calculated as load over displacement, from undeformed state to first applanation (SP-A1) for cornea stiffness, and from applanation to highest concavity (SP-HC) for sclera stiffness, as well as corneal stress-strain index (SSI) developed from finite element modeling. ANOVA was performed to compare groups by age, IOP from Dynamic Contour Tonometry and central corneal thickness (CCT). ANCOVA was performed on SP-HC, SP-A1, and SSI using results of ANOVA as covariates. HbA1C parameters and LoD were compared between DIA and DR using t-tests. Statistical significance threshold was set to $p<0.05$.

Results

DIA had 18% Type I and 82% Type II diabetes, while DR had 26% Type I and 74% Type II diabetes. Only CCT was different between groups so was single covariate. SP-HC was significantly greater in DR than both DIA ($p = 0.0113$) and NRL ($p = 0.0298$), while DIA and NRL were not different from each other ($p = 0.5630$). No differences in SP-A1 or SSI ($p > 0.05$). LoD was significantly longer ($p< 0.0001$) for DR-dia (19.2 ± 9.9 years) than DIA (8.2 ± 7.5 years). For diabetic subjects, HbA1c, HbA1c-mean, and HbA1c-max were significantly greater ($p < 0.0005$) in dia-DR (8.5 ± 2.0, 8.8 ± 1.9, 11.0 ± 2.6, respectively) than DIA (7.4 ± 1.8, 7.0 ± 1.3, 9.1 ± 2.7, respectively).

Conclusions

Diabetic subjects with retinopathy at enrollment had significantly stiffer scleral response and greater HbA1c parameters than diabetic subjects without retinopathy at enrollment, which had similar scleral stiffness to age-matched subjects without diabetes. Scleral stiffness may be a cumulative indicator of chronic hyperglycemia as shown in Figure 1.