Assessment of Corneal Biomechanics in Cases of Glaucoma before and after Control: A Prospective Study

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Abstract

Purpose: To compare corneal hysteresis (CH), corneal resistance factor (CRF), corneal-compensated KW (IOPcc), and Goldmann-correlated KW (IOPg) in normal eyes and open angle glaucoma before and after treatment.

Study Design: Prospective, hospital based, observational study.

Methods: 282 consecutive subjects were divided into two main groups; normal control group (group 1, 141 cases and glaucoma group II, comprised of 141 cases). Group II was subdivided into controlled glaucoma group A under medical treatment (119 cases); and controlled glaucoma group after trabeculectomy (group B, 22 cases). Full ophthalmological examination and assessment of corneal biomechanical properties using the Ocular Response Analyzer were done. All results were expressed as mean±SD. Analysis of variance (ANOVA) with post hoc comparisons and students t-test with Bonferroni correction were used to assess differences in groups and between groups. Pearson correlation was done to detect correlation between tested variables.

Results: Mean IOPcc did not differ significantly from the mean IOPg in all groups. In group IIA, IOPg was significantly higher than IOPg in control group (p=0.001). After medical treatment, the IOPg was significantly reduced (p=0.001). Corneal hysteresis increased significantly from 8.73±2.40mm Hg before treatment to 9.52±1.68mm Hg. (p=0.037). CRF was significantly higher in group IIA than group I (p=0.001) and it was significantly reduced after medical treatment. In group IIB, IOPg and IOPcc were significantly reduced but the CH and CRF did not show significant difference from the control group I. In all groups, CH showed significant negative correlation with IOPg and IOPcc (p=0.0001). Meanwhile, CRF showed strong positive correlation with IOPg and IOPcc (p=0.0001).

Conclusion: The corneal biomechanical factors (CH and CRF) showed association with the IOP. After treatment whether medical or surgical, the recovery of CH and CRF values suggested that these factors could be used as a measuring for the accuracy of treatment.

Key Words: Corneal biomechanics — Glaucoma — Hysteresis.

Introduction

The diagnosis of glaucoma is based on combination of factors; intraocular pressure (IOP) measurement, fundus examination to evaluate the cup/disc ratio, Visual field examination, retinal nerve fiber layer measurement by optical coherent tomography (OCT) and gonioscopy. Recently, measuring corneal biomechanics was mentioned to help in early diagnosis of cases of glaucoma, especially in cases of low tension glaucoma. Corneal hysteresis (CH) was mentioned to be significantly lower in glaucoma patients than in control subjects. Also, lower CH was found to associate with progressive visual field worsening. Similarly, corneal biomechanical properties can influence the measured value of IOP. A low CH value was found to be responsible for the underestimation of IOP when measured with Goldman applanation tonometry.

The Ocular Response Analyzer (ORA); is a new, noninvasive device that analyzes corneal biomechanical properties simply and rapidly. It is designed to improve the accuracy of IOP measurement. The ORA estimates corneal-compensated IOP measurements (IOPcc), IOP Goldman (IOPg), corneal hysteresis (CH) and corneal resistance (CRF). Whether CH is an inherent property of the cornea which reflect the elasticity of the globe and the optic disc, or it is a changeable value with various levels of IOP is a matter of debate in many studies. The dynamics between IOP and corneal biomechanical properties may impact clinical management of glaucoma, especially in the light of recent reports that eyes with primary open-angle glaucoma (POAG) have a lower CH compared with those with ocular hypertension. It has also been proposed that differences in corneal biomechanical properties may explain why some eyes are more susceptible than others to glaucomatous optic nerve damage.
The aim of this hospital-based study was to compare between the values of CH and CRF in cases of uncontrolled, and controlled glaucoma whether medically or surgically controlled and compare it to normal volunteers. We were looking to see whether corneal mechanical factors were stable factors in the cornea or they would change with IOP.

Patients and Methods

This was an observational prospective, hospital-based study that was designed to investigate corneal biomechanical characteristics in open angle glaucoma patients. Glaucomatous group was first studied before IOP-lowering therapy or surgery. After antiglaucoma medications and/or surgery to lower IOP, biomechanical properties were again recorded.

This study was done in Memorial Institute of Ophthalmology during 2012. It was approved by the ethical committee and an informed consent was obtained. Inclusion criteria were patients over 18 years of age, with clear cornea, clear ocular media and a minimum best-corrected visual acuity (BCVA) of 20/40. The refractive error was within ±5.0 diopter (D) and astigmatism ±3.0D. Only one eye of each patient was included in the study. If both eyes were eligible for inclusion, the right eye was enrolled.

Patients were divided into two main groups:

- Normal control group (group I, 141 cases): It included normal patients with normal cornea, normal IOP, normal fundus and no history of ocular surgeries.

- Glaucoma group with no treatment (group II, comprised of 141 cases): It included patients with high IOP, open angle with clinically abnormal disc as confirmed by visual perimetry. They were prospectively followed, examined two weeks after medical and surgical treatment and further subdivided into:
  a- Group A, comprised of 119 cases, it was controlled glaucoma group under medical treatment with the following inclusion criteria: Patients who are on treatment for glaucoma (controlled IOP with clinically abnormal disc confirmed by visual perimetry).
  b- Group B, controlled glaucoma group after trabeculectomy, comprised of 22 cases.

All groups underwent complete ophthalmological examination including assessment of best corrected visual acuity, assessment of corneal biomechanical properties by the Ocular Response Analyzer (ORA, Reichert Ophthalmic Instruments, Buffalo, New York, USA), autorefraction, automated perimetry (24-2, Sita Standard Strategy, Humphrey Visual Field Analyzer 750i, Humphrey Instruments, Dublin, CA), Central corneal thickness (CCT) by Pentacam (Oculus (Oculus, Germany) and IOP by Goldmann applanation tonometry (GAT; Haag-Streit, Koenz, Switzerland). Slitlamp examination of the anterior segment, evaluation of the retina, and dynamic gonioscopy (Goldman 3-mirror gonioscope; Ocular Instruments Inc, Bellevue, WA).

Exclusion criteria for this analysis were cases with history of other intracocular surgery, refractive surgery, high myopes >-5 D, patients with advanced glaucoma (mean deviation >-12dB) and presence of corneal abnormalities such as keratoconus, corneal scarring.

Statistical analysis: Results were expressed as mean±SD and analyzed using SPSS for Windows software, Version 10.0 (SPSS Inc, Chicago, Illinois, USA). Analyses of variance (ANOVA) with post hoc comparisons and students t-test with Bonferroni correction were used to assess differences in groups and between groups. Pearson correlation was done to detect correlation between tested variables. p-value less than 0.05 was considered significant.

Results

Demographic, IOP, CH and CRF data for normal, glaucomatous eyes are shown in Table (1) for the 282 patients included in the study. Group I comprised of 141 cases (50%), Group II comprised of 141 cases (50%), group IIA (119 cases, 84.3%) and group JIB (22 cases, 15.7%). 154 cases (53.6%) were females, 128 were males (45.4%). The mean age of included subjects was 45.68±14.12 years. There was no significant difference in age between groups.

Among examined groups, mean IOPcc did not differ significantly from the mean IOPg (p=0.196, Anova test). In group IIA before treatment, the mean IOPg was 28.76±7.82mm Hg which was significantly higher than IOPg in control group I (p=0.001, t-test). After the IOP-lowering medications (group IIA post-therapeutic), for two weeks, the IOPg was significantly reduced to 16.06±3.37mm Hg as compared to premedication level (p=0.001; paired t-test). Corneal hysteresis increased significantly from 8.73±2.40mm Hg before treatment to 9.52±1.68mm Hg. (p=0.037; paired t-test). Post therapeutic CH showed no significant difference from the control group I (p=0.13, t-test). In contrast, CRF was significantly higher in group
IIA pre-therapeutic than group I (p=0.001, t-test). Posttherapeutic CRF (group IIA) was significantly reduced with no significant difference from group I (p=0.64, t-test).

In group IIB, after surgical treatment, IOPg and IOPcc were significantly reduced with significant difference from the presurgical values (p=0.01 and 0.008, t-test, respectively). The CH, after surgery, did not differ significantly from the pre-surgical value (p=0.89, t-test) and it did not show significant difference from the control group I (p=0.09, t-test). The CRF was significantly reduced as compared to presurgical values (p=0.02, t-test), with no significant difference from the control group I (p=0.87, t-test) Table (1).

In general, CH showed significant negative correlation with IOPg (r=-0.54, p=0.0001, Pearson correlation) and IOPcc (r=-0.33, p=0.0001). CRF showed strong positive correlation with IOPg (r=0.225, p=0.0001) and IOPcc (r=0.426, p=0.0001, Pearson correlation). There was no significant association between the age and CH (r=0.06, p=0.34, Pearson correlation). Also, a non significant association was seen between CRF and age, (r=-0.3, p=0.6). Non significant association was seen between CH, CRF and CCT for all groups Table (2).

Table (2) shows the results of correlations between the IOPg, IOPcc, CH, CRF and CCT among all cases.

Discussion

Our findings suggested that there were no differences in corneal hysteresis and CRF between normal (group I) and controlled glaucomatous patients (group II, A and B) reflecting no structural difference between their corneas. As well as, we confirmed the dependence of CH and CRF on IOP. CH values in patients with high IOP (group II, before treatment) were significantly lower than the other groups, while CRF was higher. These findings were also described by Ang et al., who suggested that increased corneal stiffness in cases of chronic glaucoma caused high CRF and low CH [7]. Also, Kotecha et al., found that CH tended to decrease with high IOP; possibly due to a remodeling response of the cornea to IOP elevations.
Another explanation was that at high IOP levels, corneal collagen fibers could be stretched to the mechanical extreme and might not yield further; thus CH would become very low.

The present study agreed to the previous work suggesting that patients with successful lowered IOP medically (group IIA) showed full recovery of their CH values [12]. But the recovery of CH in group IIB, postsurgical, did not differ from presurgical level which suggested that the surgical incision could be responsible for the incomplete recovery of CH. An incision in the eye could weaken the strength of the eyeball, resulting in lower CH. This was Contradictory to Sun et al., [12] and Mitsuko Shimuo [12], who mentioned CH recovered back to the normal range within hours after trabeculectomy.

The effect of CCT on CH and CRF was a matter of debate. It was found that glaucoma patients with low CH had greater backward bowing of the lamina cribrosa in response to transient IOP elevation, meanwhile low CCT did not show such association. [14] In our study, no significant relationship was detected between CH, CRF and CCT. Our findings agreed partially with Morita et al. [2], who found no significant relation between CCT and CRF. Meanwhile, other researchers found that the relationship between CCT and CH was strong for normal patients and only moderate for treated glaucomatous patients [15]. The explanation for this might be due to variation in population or the effect of long term medical treatment on the cornea.

Similar to our study, Kirwan et al., suggested that there was no correlation between CH, CRF and age [16]. However, it was suggested that the decrease of CH with aging was independent of changes in CCT or IOP [17].

There were several limitations to our study. First, our sample size was relatively small. Second, we did not evaluate the effect of severity of glaucoma on corneal biomechanical properties. Third, the potential effect of topical medications on corneal biomechanical properties was not assessed. Another limitation was that we relied exclusively on corneal biomechanical properties as assessed by the ORA. No studies have yet validated ORA parameters against actual measurements of corneal physical properties. Future studies should be designed to elucidate the relationship between CH and CRF and susceptibility to glaucoma damage.

In conclusion, CH was significantly lower in OAG patients, and recovery occurred after successful IOP-lowering therapy. After surgical trabeculectomy the CH showed incomplete recovery which suggested the weakening effect of scleral incision on corneal biomechanics. The recovery of these biomechanical parameters after medical or surgical treatment suggested that these parameters did not represent an innate character of the corneal collagen and it may add a guide test to how effective is the treatment.

References


