Evaluation of Corneal Biomechanical Properties following Scleral Buckling Using the Ocular Response Analyzer

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Abstract

***Purpose*:** To evaluate corneal visco-elasticity and intraocular pressure (IOP) changes measured by an Ocular Response Analyzer (ORA) after scleral buckling

***Methods*:** Fifty-six eyes with history of scleral buckling surgery three months ago were included in the study. Corneal hysteresis (CH), corneal resistance factor (CRF), corneal-compensated IOP (IOPcc) and Goldmann-correlated IOP (IOPg) were measured by ORA 3 month postoperatively. In each group, unoperated (normal) eye was the control eye and operated eye was the case eye.

***Results*:** Twenty-seven eyes underwent buckling with encircling elements (group 1) and 29 eyes with segmental sponge (group 2). The mean (±SD) CRF in group 1 was 8.74±2.05 in operated eyes and 9.19±1.96 in control contralateral eyes, with no significant difference between them (p=0.412). In group 2 the mean (±SD) CRF was 8.14±1.95 in contralateral eyes and 9.38±2.1 in control eyes and the difference was statistically significant (p=0.024). In group 1 there was no significant difference between mean CH of cases and controls (p=0.286), but statistically significant difference between mean CH of cases and controls in group 2 (p=0.044). There were no significant differences between IOPg and IOPcc of cases and controls in two groups.

***Conclusion*:** Mean CRF and CH measurements were significantly lower after scleral buckling with segmental sponge, but no significant change in encircling procedure was observed. Also no significant change in IOPg and IOPcc in any kind of scleral buckling technique occurred postoperatively. It seems that hysteresis and CRF may measure different biomechanical aspects of ocular rigidity and are likely to be useful additional measurements in the assessment of ocular rigidity when measuring IOP.

***Keywords*:** Corneal Visco-Elasticity, Intraocular Pressure, Ocular Response Analyzer, Scleral Buckling, Encircling Band, Segmented Buckle

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Introduction

The Ocular Response Analyzer (ORA) (Reichert Ophthalmic Instruments, Buffalo, NY) performs in vivo measurements of the biomechanical properties of the cornea including corneal hysteresis (CH) and corneal resistance factor (CRF), as well as corneal-compensated intraocular pressure (IOPcc) and Goldmann-correlated intraocular pressure (IOPg). CH is in fact a measure of the viscous damping of the cornea, and is found to be correlated with the viscoelastic resistance of the cornea. The CRF, on the other hand, is an indicator of corneal elasticity.

The CH and CRF, although related to biomechanical properties of the cornea, can be affected by other factors as well.[1]

Ocular rigidity is another measurable parameter which is an indicator of the elasticity of the globe. Measuring ocular rigidity may be of clinical importance because it seems to affect certain other parameters such as IOP, and is in turn affected by scleral buckling.[2] Ocular rigidity could influence corneal responses to stress and deformation, as well as parameters measured by the ORA. The purpose of this study was to assess the effect of scleral buckling on CH, CRF, IOPcc, and IOPg as measured by the ORA.

Methods

Fifty-six eyes that had previously undergone scleral buckling surgery (encircling elements or segmental sponge) for unilateral rhegmatogenous retinal detachment were included in this study. The surgeries were carried out by the same surgeon (M RE). In each group, unoperated (normal) eye was the control eye and operated eye was the case eye. Twenty-seven eyes underwent buckling with encircling elements (group 1) and 29 eyes with segmental sponge (group 2).

All patients provided informed consent. Patients with previous ophthalmic surgery and subjects with refractive errors such as myopia>2 diopters, hypermetropia>1 diopter or astigmatism>1 diopter were excluded from the study. After a routine ophthalmic examination including visual acuity (VA), slit-lamp biomicroscopy, tonometry, and fundoscopy, the CH, CRF, IOPcc, and IOPg were measured by the ORA (ORA, Reichert Ophthalmic Instruments, Buffalo, NY) three months postoperatively. The ORA examination was performed at least three times. Disqualified scale values were deleted, repeat measurements taken, and the average values recorded. SPSS 16 software was used for analysis. Analytic tests such as paired *t* test were used to compare parameters between cases and controls. The level of significance was considered p-value<0.05.

Results

The mean patients age was 45.8±19.1 years (range, 13-80 years), and 33 of the patients were male (58.9%).

Table 1 shows CRF and CH values in two groups .The mean (±SD) CRF in group 1 was 8.74±2.05 in cases and 9.19±1.96 in controls, with no significant difference between them (p=0.412). In group 2 the mean (±SD) CRF was 8.14±1.95 in cases and 9.38±2.1 in controls and the difference was statistically significant (p=0.024). Also, in group 1 there was no significant difference between mean CH of cases and controls (p=0.286), but statistically significant difference between mean CH of cases and controls in group 2 was observed (p=0.044).

Table 2 shows the changes in IOPg and IOPcc in two groups. There were no significant differences between cases and controls in two groups.

Table 1. Comparison of the mean Ocular Response Analyzer parameters (in cases and controls groups)

		Corneal resistance factor			Corneal hysteresis		
		Mean±SD	**Range**	**p**	**Mean±SD**	**Range**	**p**
Scleral buckle							
	Case	8.74±2.05	5.1 to 14.5	0.412	8.56±1.74	5.5 to 13.9	0.286
	control	9.19±1.96	4.8 to 13		9.02±1.4	5.7 to 12	
Sponge							
	Case	8.14±1.95	4.3 to 12.1	0.024	8.26±1.79	4.4 to 11.6	0.044
	control	9.38±2.1	5 to 13.2		9.17±1.56	6.2 to 11.8	

Table 2. Comparison of the mean Ocular Response Analyzer parameters (in cases and controls groups)

		Corneal-compensated intraocular pressure			Goldmann-correlated intraocular pressure		
		Mean±SD	Range	p	Mean±SD	Range	p
Scleral buckle							
	Case	17.73±3.86	13.2 to 32.8	0.681	15.19±4.16	9.7 to 29.6	0.905
	control	17.34±2.99	13.2 to 32.8		15.32±3.8	9 to 23	
Sponge							
	Case	17.03±3.41	13.2 to 32.8	0.726	14.02±3.56	7.2 to 22.3	0.123
	control	17.33±2.9	13.2 to 32.8		15.53±3.76	9.3 to 23.3	

Discussion

The cornea is a viscoelastic structure, and thus exhibits both static and dynamic components of resistance. The corneal response to external forces such as the pressure exerted during tonometry depends on the power of the force and its changes. As explained by Goldmann and Schmidt,[3] since corneal deformation during Goldmann applanation tonometry (GAT) is slow and short (about 2 seconds), thus, the static resistance is considered the main component.

Non-contact tonometers such as ORA applanate 4 µm of the cornea with air over a very short time. Changes in the corneal reflex are assessed with optical systems, and IOP is calculated based on the time necessary to applanate the surface, which is extremely shorter (less than 5 milliseconds) than the 2 seconds required for GAT, and thus, the dynamic component of corneal resistance plays the main role. This dynamic resistance is mainly related to the elastic properties of the cornea and changes in the CH.[4]

The ORA also measures two other corneal biomechanical properties which vary in different individuals: the CH and the CRF. During measurement, the cornea absorbs part of the energy of the first air pulse. Therefore, the measured pressure is lower with the second applanation. The difference between these two is displayed as the CH, which appears to be a reflection of the corneal viscoelasticity or viscous-damping capacity.[5] This parameter can be of clinical importance and some investigators believe increased damping enables the eye to withstand potentially harmful IOP fluctuations. Theoretically speaking, this buffer effect can reduce the stress on the optic nerve and the peripapillary scleral tissues, and protect them from the damage caused by glaucoma.[6]

The CH and CRF, although related to the biomechanical properties of the cornea, they can be affected by other factors as well; the whole globe acts as one unit,[1] and even intraocular changes can directly influence these two indices.

Ocular rigidity is a physical property related to ocular elasticity. It is defined as the change in IOP as an effect of changes in intraocular volume. It is influenced by myopia, use of miotic agents, intraocular injection of gas, and scleral buckling. Buckled eyes are less rigid compared to normal eyes, and the higher the buckle, the lower the ocular rigidity. Changes in rigidity are secondary to changes in the shape and the distribution of stress in the scleral shell; they are related to the elasticity of the encircling element only to some extent.[2] Thus, a buckled eye may be less sensitive to IOP fluctuations because it is less rigid. This observation may be concordant with the protective effects of high CH and explain why we found no significant change in CH in the first group when compared to the control group, while the second group demonstrated a significant reduction in CH after surgery which can be attributed to the absence of the buffering effect of the encircling element.

Corneal biomechanics, including CH and CRF have recently been studied in cases such as keratoconus, anterior segment pathologies and glaucoma, as well as postoperative cases such as LASIK and cataract. CH has been reported to decrease in keratoconus and immediately after cataract surgery using a clear corneal incision.[7-12] Ascaso et al investigated the effects of encircling scleral buckle (SB) on corneal biomechanical properties and its morphological parameters and they concluded SB surgery leads to a change in the corneal biomechanical properties without altering corneal morphological parameters.[13]

In our study, mean CH and CRF of operated eyes were lower than controls in both groups but differences in the first group (encircling) were not statistically significant.

This study has several limitations in terms of the small number of eyes studied and not considering central corneal thickness (CCT) in cases and controls (because hysteresis and CRF measured by the ORA have a positive but moderate correlation to CCT) and no access to preoperative data.

In addition, this study is a cross-sectional study. A prospective, controlled study with a large number of patients is needed to further characterize corneal biomechanical changes following buckling procedures.

Our study revealed that mean CRF and CH measurements were significantly lower after scleral buckling with segmental sponge, but no significant change was observed in encircling procedure. Also no significant change in IOPg and IOPcc were observed postoperatively in any kind of scleral buckling techniques. Although the CH and CRF relate to the biomechanical properties of the cornea, they are not the only factors, because the globe reacts as a whole and intraocular changes specially in ocular rigidity can also indirectly affect these parameters. It seems that hysteresis and CRF may measure different biomechanical aspects of ocular rigidity and are likely to be useful additional measurement in the assessment of ocular rigidity when measuring IOP.[14] This may be of particular importance when trying to correct IOP measurements for increased or decreased ocular rigidity.

Conclusion

Mean CRF and CH measurements were significantly lower after scleral buckling with segmental sponge, but not significant change in encircling procedure. Also no significant change in IOPg and IOPcc postoperatively was observed.

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