Original Article

Corneal biomechanics after rigid gas permeable contact lens wear in keratoconus eyes

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Background: Evaluation of corneal biomechanical properties 3 months after using rigid gas permeable (RGP) contact lenses in keratoconus.

Methods: In this prospective trial study, cases were 32 keratoconic eyes with no history of RGP lens wear. All eyes were examined with the Ocular Response Analyzer (ORA) and the Corneal Visualization Scheimpflug Technology (CORVIS-ST) to measure corneal hysteresis (CH), corneal resistance factor (CRF), deformation amplitude (DA), applanation velocity (AV) 1 and 2, applanation length (AL) 1 and 2, and peak distance before and 3 months after fitting aspheric RGP lenses. The effect of the correlation between contralateral eyes and maximum keratometry were controlled for in the analysis. Results were compared using repeated measures analysis of covariance.

Results: At 3 months, neither the increases in mean CH (0.14±2.77 mmHg, P=0.789), CRF (0.41±4.35 mmHg, P=0.612), AV1 (0.03±0.17 m/s, P=0.301), AV2 (0.11±0.59 m/s, P=0.299), AL1 (0.44±1.56 m/s, P=0.118), AL2 (1.16±5.06 m/s, P=0.211), and peak distance (0.19±1.29 m/s, P=0.409), nor the decrease in mean DA (0.03±0.17 mm, P=0.402) was statistically significant.

Conclusions: Results in our series of patients indicated that 3 months of RGP lens wear had no significant impact on corneal biomechanics, and perhaps non progression of keratoconus. Therefore, RGP lenses can be regarded safe and appropriate in keratoconic patients.

Keywords: Keratoconus; corneal biomechanics; rigid gas permeable lens (RGP lens)

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Introduction

Corneal biomechanical properties provide important indicators when evaluating treatment results and monitoring progression of disease such as keratoconus (1,2), and can be helpful for the detection of keratoconus even before common topographic signs of disease develop (3). Current devices available for the measurement of corneal biomechanical properties include the Ocular Response Analyzer (ORA; Reichert, USA) and the Corneal Visualization Scheimpflug Technology (CORVIS-ST; Oculus Optikgeräte GmbH, Germany). The ORA measures corneal hysteresis (CH) and the corneal resistance factor (CRF) (4). CORVIS-ST shows corneal deformations in response to air puff pressures. Measured indices with this device, including the deformation amplitude (DA), the velocity of the first and second applanation velocity (AV1 and AV2), the length of

the first and second applanation (AL1 and AL2), and the peak distance can complete ORA results to assess structural changes, stability or no change in the corneal status, and the appropriateness of the treatment method (5).

In patients with keratoconus, visual acuity is commonly improved using rigid gas permeable (RGP) lenses (6). There are many unanswered questions regarding RGP lens-induced changes in corneal biomechanical properties, and studies in the area are very few. It is suggested that such changes in the optical and structural parameters of the cornea could depend on baseline biomechanical properties and certain fitting parameters (7). To our knowledge, no studies are available concerning RGP lens-induced changes in biomechanical properties of the cornea in keratoconus patients as measured with the ORA and CORVIS-ST. This study was conducted to better understand how corneal biomechanical properties may change with RGP lens wear.

Methods

The target of this before-after study was patients with mild to severe keratoconus referring to the Contact Lens Clinic. All patients had already had a complete ophthalmic evaluation by a cornea sub-specialist, based on which the diagnosis of keratoconus was made and confirmed through imaging. The Ethics Committee of Iran University of Medical Sciences approved the study. Objectives and methods of the study were explained to patients, and they all signed informed consents before participation in the study.

Inclusion criteria were age between 19 and 35 years and being eligible for fitting RGP spherical lenses. Patients with a history of RGP lens use, corneal scarring, infectious or inflammatory ocular diseases, corneal graft surgery, or ring implantation, and those referred for fitting mini-scleral and ClearKone lenses were excluded.

After enrollment, patients had complete visual examinations including the measurement of visual acuity using a Snellen chart (Nidek-34605-6004-LCD Chart) at 4 meters, objective refraction with a streak retinoscope (HEINE BETA 200, Germany) and an auto refractometer (Nidek, Japan), and subjective refraction with a trial lens set and frame. The Pentacam (Oculus Optikgeräte GmbH, Germany) was used to measure and record maximum keratometry and the central corneal thickness.

The appropriate aspherical RGP (Lens Gostar, Tehran, Iran) lens was prescribed using the diagnostic lens fitting method (8). On slit-lamp examination, good tear exchange was verified by observing the fluorescein pattern with mild apical clearance over the corneal cone and slight edge and midperipheral clearance (9). The ORA and CORVIS-ST were used to measure indices related to the biomechanical properties of the cornea. Testing with ORA was done first, and measurements with CORVIS were done after at least 1 hour. Both were done in the same room by the same technician. Before testing, patients' blinking pattern was noted if necessary. Both devices were checked and calibrated before use.

Recorded biomechanical indices included CH and CRF, as measured with the ORA and DA, AV1, AV2, AL1, AL2 and peak distance, as measured with the CORVIS-ST. All examinations were repeated 3 months after daily use of the RGP lens.

The results were compared using repeated measure analysis of variance. P values less than 0.05 were considered significant.

Results

In this before-after study, 32 eyes of 19 patients with keratoconus who met the inclusion criteria were enrolled. Patients were 7 women and 12 men, with an age range of 19–35 years (27.9±4.30 years). Based on Rabinowitz/McDonnell criteria (10), 15 eyes were in the early stage of keratoconus, 3 were in the moderate stage, and 14 were categorized as having advanced keratoconus. Mean spherical equivalent refraction was –4.13±3.16 diopter (D) and mean LogMAR visual acuity was 0.81±0.46 without contact lenses and 0.01±0.02 with lenses.

Mean maximum keratometry reading was 53.34±6.93 D at baseline and 53.87±6.97 D at 3 months (P=0.368) and mean central corneal thickness was 455.76±33 µm and 452.33±47.32 µm, respectively (P=0.80).

At 3 months, neither the increases in mean CH (0.14±2.77 mmHg), CRF (0.41±4.35 mmHg), AV1 (0.03±0.17 m/s), AV2 (0.11±0.59 m/s), AL1 (0.44±1.56 m/s), AL2 (1.16±5.06 m/s), and peak distance (0.19±1.29 m/s), nor the decrease in mean DA (0.03±0.17 mm) was statistically significant (all P>0.05). *Table 1* shows ORA and CORVIS-ST indices at baseline and 3 months after RGP lens wear.

Discussion

This study showed that corneal biomechanical properties were stable after 3 months RGP lens wear. The ORA has been used in a number of studies with contrasting results;

Table 1 Descriptive statistics indices of the ORA and CORVIS-ST parameters in the studied keratoconus patients at baseline and at 3 months after wearing rigid gas permeable contact lenses

Device	Biomechanical parameters	Baseline	3 months	P value
ORA	Corneal hysteresis (mmHg)	7.84±1.93	8.10±3.23	0.789
	Corneal resistance factor (mmHg)	6.91±2.30	7.48±4.68	0.612
CORVIS-ST	Deformation amplitude (mm)	1.09±0.13	1.06±0.17	0.402
	Applanation velocity 1 (m/s)	0.13±0.03	0.16±0.17	0.301
	Applanation velocity 2 (m/s)	–0.43±0.09	–0.54±0.50	0.299
	Applanation length 1 (mm)	1.68±0.27	2.13±1.48	0.118
	Applanation length 2 (mm)	1.76±0.49	2.89±4.96	0.211
	Peak distance (mm)	1.05±0.18	1.05±0.19	0.409

ORA, Ocular Response Analyzer; CORVIS-ST, Corneal Visualization Scheimpflug Technology.

some believe its measurements in keratoconus add little value to the routine workup (11-13). The ORA lacks the ability to measure dynamic deformation in real time, and certain indices such as velocity (14). A study in 2014 introduced the CORVIS as an appropriate method for measuring corneal biomechanical parameters. In their study, two groups of normal and keratoconic corneas were compared, and DA was reported as the best parameter with a sensitivity of 81.7%. Results indicated increased DA, AV1, and AV2, and decreased AL1 and AL2 in keratoconus patients. Moreover, DA was introduced as a reliable parameter for corneal biomechanical evaluation with emphasis on the necessity of more studies in this regard (14). In another study, DA was the most repeatable parameter, and it appeared to be higher in thinner corneas, which could be important in light of progressive thinning in keratoconus patients (15).

Comparison of the results of the two devices in normal and keratoconic individuals showed decreased elasticity and resistance of the keratoconic corneas as measured with the ORA (16) and an increase in DA and velocity (14,15) as measured with the CORVIS in line with the structural weakness of the cornea.

RGP lens wear is an efficient method for improving visual acuity. To our knowledge, our study is the first to examine the effect of RGP lens wear on corneal biomechanics, and 3 months after fitting RGP lenses in keratoconus patients. We found no significant change in any of the studied variables including the central corneal thickness and maximum keratometry reading (*Table 1*). This is in favor of the safety of RGP lenses for the treatment of keratoconus patients, or even a halting effect on the progression of the disease. Further studies with appropriate controls are required to elucidate this mater.

In conclusion, prescribing RGP lenses is a safe approach with minimal short-term effects on the corneal biomechanics. This finding is important for practitioners and patients on account of concerns about lens-induced changes in the corneal surface or structure. Further studies with longer follow-up periods are suggested to obtain long-term results.

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The Ethics Committee of Iran University of Medical Sciences approved the study. Objectives and methods of the study were explained to patients, and they all signed informed consents before participation in the study.

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