Comparison of eye-rubbing effect in keratoconic eyes and healthy eyes using Scheimpflug analysis and a dynamic bidirectional applanation device

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Purpose: To compare the effect of eye rubbing on Scheimpflug imaging parameters and corneal biomechanics in eyes with keratoconus and healthy eyes.

Setting: Oftalmosalud Instituto de Ojos, Lima, Peru.

Design: Prospective cohort study.

Methods: The study included healthy and keratoconus patients who attended the institution between January 2017 and July 2017. Eye rubbing was performed for 1 minute followed by a 5-second break, followed by further rubbing for 1 minute. Baseline tests were performed before rubbing; post-rubbing tests were performed immediately after (0 minutes), and then again at 7 minutes and 14 minutes. Parameters related to anterior and posterior curvature and elevation, pachymetry, and corneal biomechanics obtained from tomography with a rotating Scheimpflug camera (Pentacam HR) and a dynamic bidirectional applanation device (Ocular Response Analyzer) were measured and compared between healthy and keratoconic eyes.

Results: The study included 30 healthy eyes and 31 keratoconic eyes. In the healthy group, the immediate mean changes in steeper anterior keratometry, posterior astigmatism, anterior chamber volume (ACV), flattest posterior keratometry, and Goldmann-correlated intraocular pressure (IOPg) after eye rubbing were 0.07 diopters (D) $\pm$ 0.15 (SD), –0.01 $\pm$ 0.08 D, 0.03 $\pm$ 7.06 mm^3, $-$0.001 $\pm$ 0.04 mm, and $-$1.21 $\pm$ 1.99 mm Hg, respectively, whereas the mean changes in the keratoconus group were $-$0.03 $\pm$ 0.32 D, 0.14 $\pm$ 0.50 D, $-$5.09 $\pm$ 8.45 mm^3, 0.03 $\pm$ 0.06 mm, and –1.61 $\pm$ 1.41 mm Hg, respectively. There were statistically significant differences between the preoperative and postoperative eye-rubbing values of posterior astigmatism, ACV, and IOPg in the keratoconus group (P = .03, P = .0003, and P = .001, respectively) but not in the healthy group (P = .65, P = .85, and P = .23, respectively).

Conclusions: Unlike the healthy eyes group, the keratoconus group experienced significant changes in ACV, IOP, and corneal posterior astigmatism after eye rubbing.

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Having a genetic predisposition and altered biomechanics are not necessarily precursors to develop keratoconus or for the disease to progress; at least, this is the explanation offered for patients with asymmetric or unilateral keratoconus.[1–6] A positive correlation between eye rubbing and aggravation of keratoconus has been previously described.[7,8] Recently, it was suggested that keratoconus might never occur in the absence of repeated mechanical trauma, such as that seen in vigorous eye rubbing.[8]

In healthy patients, the impact of eye rubbing has been previously described. Eye rubbing reduces epithelial thickness,[9] alters surface regularity and surface asymmetry indices,[10] decreases the tear-film breakup time,[10] causes

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Table 1. Pre- and post-eye-rubbing values of the Scheimpflug device and the dynamic bidirectional applanation device parameters analyzed at 0, 7, and 14 minutes.

	Pre-evaluation		Minute 0	
Variable	Mean ± SD	Range	Mean ± SD	Range
Healthy eyes				
IOPg	13.96 ± 3.68	5.9, 9.9	12.75 ± 3.16	7.0, 21.7
IOPcc	13.91 ± 2.63	9.1, 21	12.76 ± 2.99	7.5, 24.4
CH	11.18 ± 1.66	8.1, 14.8	11.16 ± 1.59	7.5, 14.4
CRF	10.44 ± 2.35	6.2, 15.3	10.24 ± 1.76	6.7, 14.3
Waveform score	6.31 ± 1.50	5.0, 12.0	6.07 ± 1.03	5.0, 8.9
Anterior flattest K	42.97 ± 1.44	40.5, 45.6	43.09 ± 1.40	40.5, 45.6
Anterior steeper K	44.31 ± 1.44	41.5, 46.7	44.37 ± 1.42	41.4, 46.7
Anterior astigmatism	1.25 ± 0.59	0.3, 2.6	1.30 ± 0.59	0.4, 2.7
Anterior asphericity	−0.37 ± 0.14	−0.61, −0.12	−0.38 ± 0.14	−0.67, −0.14
Maximum K	44.80 ± 1.40	41.7, 47.4	44.88 ± 1.45	41.6, 47.4
ACD	2.87 ± 0.27	2.4, 3.38	2.87 ± 0.26	2.39, 3.41
Anterior elevation TP	2.07 ± 1.36	1.0, 15.0	1.87 ± 1.25	0.0, 5.0
Posterior elevation TP	5.90 ± 3.71	1.0, 15.0	5.33 ± 3.94	0.0, 14.0
CCT	557.07 ± 27.96	499, 620	558.03 ± 27.67	511, 621
Pachymetry at TP	550.6 ± 28.22	489, 608	551.27 ± 28.75	502, 612
RMS LOAs	1.47 ± 0.45	0.67, 2.41	1.51 ± 0.50	0.75, 2.63
RMS HOAs	0.40 ± 0.08	0.22, 0.55	0.41 ± 0.12	0.25, 0.76
Posterior flattest K	−6.26 ± 0.26	−6.7, −5.8	−6.26 ± 0.25	−6.7, −5.8
Posterior steeper K	−6.61 ± 0.29	−7, −6	−6.2 ± 2.33	−7, 6.1
Posterior astigmatism	0.36 ± 0.12	0.2, 0.6	0.35 ± 0.13	0, 0.6
Posterior asphericity	−0.418 ± 0.13	−0.75, −0.22	−0.43 ± 0.14	−0.82, −0.24
Cornea volume	63.31 ± 3.56	56.5, 70.5	63.20 ± 3.41	57.7, 70.4
ACV	151.10 ± 27.98	112, 216	151.13 ± 29.82	108, 225
Keratoconic eyes				
IOPg	11.24 ± 3.36	2.8, 18.4	9.63 ± 3.19	2.2, 15.1
IOPcc	13.52 ± 2.56	8.5, 18.7	12.35 ± 2.66	7.5, 17.9
CH	9.27 ± 1.34	7.0, 12.0	9.07 ± 1.47	6.6, 12.2
CRF	7.98 ± 2.03	3.5, 12.1	7.53 ± 1.79	3.9, 11.5
Waveform score	5.32 ± 1.55	0.7, 9.2	5.24 ± 1.43	0.6, 8.4
Anterior flattest K	45.71 ± 3.21	40.8, 58.1	45.67 ± 3.24	40.7, 58.4
Anterior steeper K	49.63 ± 4.29	44.4, 63.1	49.60 ± 4.33	44.5, 63.7
Anterior astigmatism	3.91 ± 2.49	0.4, 9.2	3.94 ± 2.40	0.4, 9.6
Anterior asphericity	−0.37 ± 0.43	−1.72, −0.4	−0.70 ± 0.33	−1.76, −0.26
Maximum K	52.52 ± 6.14	44.9, 73.4	52.53 ± 6.41	45.0, 76.6
ACD	3.25 ± 0.26	2.95, 4.12	3.26 ± 0.27	2.95, 4.18
Anterior elevation TP	14.27 ± 8.73	−1.0, 41.0	13.60 ± 8.53	−1.0, 41.0
Posterior elevation TP	32.83 ± 17.99	−1.00, 81	31.54 ± 19.49	0.0, 89.0
CCT	481.39 ± 39.48	364, 557	482.19 ± 39.61	362, 562
Pachymetry at TP	472.38 ± 38.72	363, 552	473.16 ± 39.03	361, 555
RMS LOAs	6.07 ± 3.65	0.87, 16.65	6.07 ± 3.66	0.99, 17.98
RMS HOAs	1.40 ± 0.91	0.30, 4.04	1.39 ± 0.87	0.28, 4.27
Posterior flattest K	−6.74 ± 0.64	−9.1, −6.0	−6.71 ± 0.63	−9.1, −6.0
Posterior steeper K	−7.51 ± 0.78	−9.8, −6.5	−7.56 ± 0.85	−10.5, −6.5
Posterior astigmatism	0.78 ± 0.39	0.3, 1.8	0.92 ± 0.59	0.3, 3.1
Posterior asphericity	−0.77 ± 0.35	−1.73, −0.25	−0.76 ± 0.37	−1.84, −0.19
Cornea volume	58.51 ± 2.73	53.7, 66.4	58.67 ± 2.72	53.6, 64.8
ACV	181.68 ± 23.15	125, 234	176.58 ± 22.84	121, 233

ACD = anterior chamber depth; ACV = anterior chamber volume; CCT = central corneal thickness; CH = corneal hysteresis; CRF = corneal resistance factor; HOAs = higher-order aberrations; IOPcc = corneal-compensated intraocular pressure; IOPg = Goldmann-correlated intraocular pressure; K = keratometry; LOAs = lower-order aberrations; RMS = root mean square; TP = thinnest point of the cornea
*Statistically significant

flattening as seen using anterior keratometry,[11] produces changes in lower-order aberrations,[11] and has been associated with a trend toward against-the-rule astigmatism.[11]

The possible causal links between keratoconus formation and eye rubbing could include increased corneal temperature,[12] epithelial thinning,[12] increased concentrations of

Table 1. (Cont.)

Minute 7		Minute 14		
Mean ± SD	Range	Mean ± SD	Range	*P* Value
13.14 ± 3.45	6.0, 19.0	12.93 ± 2.90	6.8, 19.1	.233
13.29 ± 2.65	8.5, 18.4	13.32 ± 2.79	8.4, 19.8	.215
10.96 ± 1.57	8.5, 15.6	10.83 ± 1.57	6.9, 14.2	.257
10.17 ± 2.02	6.0, 15.6	10.00 ± 1.70	6.2, 13.4	.041*
6.17 ± 1.06	5.0, 8.4	5.70 ± 0.66	5.0, 7.7	.357
43.09 ± 1.40	40.4, 45.6	43.06 ± 1.41	40.4, 45.6	.726
44.34 ± 1.42	41.4, 46.7	44.35 ± 1.46	41.5, 46.7	.014*
1.27 ± 0.64	0.3, 2.7	1.50 ± 1.24	0.1, 6.9	.275
−0.38 ± 0.15	−0.66, −0.16	−0.37 ± 0.14	−0.61, −0.12	.568
44.84 ± 1.44	41.8, 48.0	44.84 ± 1.48	41.8, 47.7	.442
2.87 ± 0.27	2.38, 3.43	2.88 ± 0.28	2.37, 3.42	.559
1.97 ± 1.40	0.0, 5.0	1.87 ± 1.04	0.0, 4.0	.558
5.70 ± 3.60	0.0, 16.0	5.56 ± 3.22	1.0, 13.0	.712
557.96 ± 29.32	503, 623	558.23 ± 28.09	501, 618	.361
551.13 ± 29.72	492, 612	550.63 ± 29.27	492, 607	.289
1.56 ± 0.45	0.93, 2.65	1.55 ± 0.57	0.70, 3.47	.459
0.44 ± 0.12	0.25, 0.78	0.42 ± 0.10	0.26, 0.73	.301
−6.25 ± 0.27	−6.7, −5.8	−6.26 ± 0.27	−6.7, −5.8	.783
−6.63 ± 0.28	−7.1, −6.1	−6.61 ± 0.28	−7, −6.1	.231
0.37 ± 0.14	0.1, 0.7	0.34 ± 0.13	0.1, 0.6	.658
−0.44 ± 0.15	−0.79, −0.23	−0.42 ± 0.14	−0.8, −0.2	.113
63.24 ± 3.71	56.8, 70.3	63.44 ± 3.45	56.8, 70.0	.429
151.07 ± 27.97	110, 220	150.67 ± 27.58	111, 213	.854
9.91 ± 3.30	2.5, 15.7	10.06 ± 3.09	3.1, 16.6	<.0001*
12.43 ± 2.47	7.3, 16.6	12.57 ± 2.34	7.3, 18.7	<.001*
9.25 ± 1.33	6.8, 13.0	9.21 ± 1.33	6.7, 13.5	.741
7.75 ± 1.83	4.5, 12.6	7.78 ± 1.76	4.9, 13.3	.049*
5.35 ± 1.42	0.9, 7.9	5.24 ± 1.39	0.5, 8.2	.992
45.69 ± 3.29	40.7, 58.7	45.79 ± 3.29	40.7, 58.6	.678
49.55 ± 4.30	44.3, 63.8	49.59 ± 4.23	44.4, 62.7	.725
3.89 ± 2.36	0.4, 9.3	3.91 ± 2.32	0.3, 9.0	.561
−0.69 ± 0.34	−1.76, −0.21	−0.68 ± 0.33	−1.73, −0.23	.091
52.27 ± 5.96	44.8, 73.0	52.56 ± 6.04	44.9, 73.1	.168
3.26 ± 0.27	2.94, 4.09	3.26 ± 0.26	2.95, 4.06	.872
12.51 ± 11.75	−34.0, 40.0	13.27 ± 8.41	0.0, 40.0	.458
30.48 ± 21.56	−32.0, 84.0	30.45 ± 17.41	2.0, 83.0	.712
482.39 ± 38.39	355, 555	465.67 ± 85.53	52, 551	.149
472.16 ± 38.50	354, 544	471.77 ± 38.42	349, 544	.292
5.91 ± 3.37	1.03, 15.14	6.05 ± 3.51	0.98, 16.12	.108
1.36 ± 0.82	0.267, 3.61	1.37 ± 0.84	0.21, 3.77	.417
−6.73 ± 0.68	−9.3, −6.0	−6.73 ± 0.64	−9.1, −6.0	.033*
−7.51 ± 0.79	−9.9, −6.5	−7.52 ± 0.78	−10, −6.6	.324
0.79 ± 0.44	0.2, 1.9	0.77 ± 0.38	0.3, 1.8	.031*
−0.76 ± 0.36	−1.75, −0.21	−0.74 ± 0.36	−1.75, −0.23	.158
58.39 ± 2.80	50.9, 63.6	58.53 ± 2.33	53.6, 63.8	.661
176.61 ± 23.01	133, 236	176.55 ± 22.98	111, 233	.0003

inflammatory mediators,[12] and changes to keratocytes because of mechanical trauma.[12] However, the impact of eye rubbing on the biomechanics and anterior segment in keratoconic eyes is uncertain, and assuming that keratoconic corneas are weaker than those in healthy eyes,[13] we hypothesized that the response of a keratoconic cornea would be different from the response of a healthy cornea to eye rubbing.

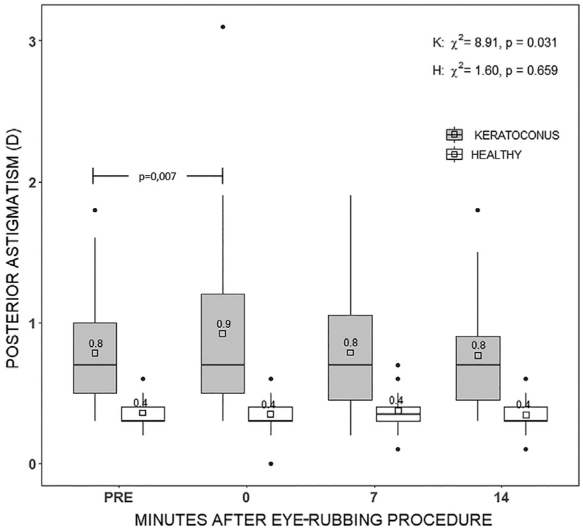

Figure 1. Pre- and post-eye rubbing values for posterior astigmatism in keratoconic eyes and healthy eyes.

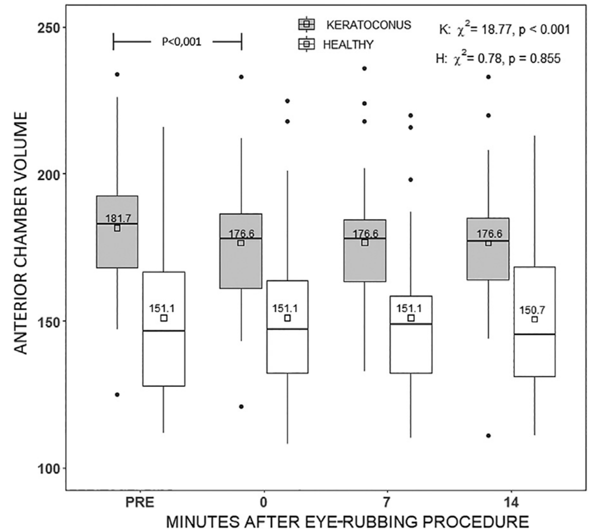

Figure 2. Pre- and post-eye rubbing values for anterior chamber volume in keratoconic eyes and healthy eyes.

The aim of this study was to compare the effect of eye rubbing on Scheimpflug imaging parameters and corneal biomechanics in keratoconic eyes and healthy eyes.

PATIENTS AND METHODS

This prospective cohort single center study included 30 healthy eyes and 31 keratoconic eyes between September to November 2017 at the Oftalmosalud Instituto de Ojos, Lima, Peru. The study complied with the Declaration of Helsinki. The ethics committee of the Oftalmosalud approved the study and written informed consent was obtained from all participants.

Inclusion criteria in the control group were patients who attended the clinic for an annual examination, age older than 18 years, no ocular symptoms or ocular pathology, no atopy, no irregular corneal patterns, no previous ocular surgery, refractive error lower than 1.5 diopters (D), not having used contact lenses in the previous 3 months, no use of any topical drops, no clinical or tomographic signs of keratoconus or scissoring on retinoscopy, and a corrected distance visual acuity of 20/20 or better. Patients were included regardless of whether they proceeded to undergo corrective refractive surgery. Only one randomly selected eye per patient was included in the study.

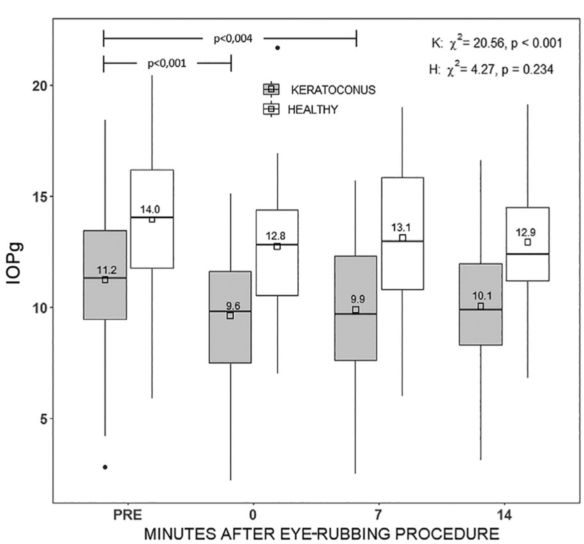

Figure 3. Pre- and post-eye-rubbing values for IOPg in keratoconic eyes and healthy eyes (IOPg = Goldmann-correlated intraocular pressure).

Inclusion criteria in the keratoconus group were a new keratoconus diagnosis defined by the presence of one or more clinical signs (corneal stromal thinning, Fleischer ring, scissoring of the red reflex, or oil droplet sign) and topographic/tomographic signs including an increased area of corneal power surrounded by concentric areas of decreasing power, inferior–superior power asymmetry, and skewing of the steepest radial axes above and below the horizontal meridian[13]; patients who reported a habit of rubbing their eyes at home in their history; no use of contact lenses in the previous 3 months; and no use of any topical drops. Exclusion criteria in the keratoconus group were the presence of Vogt striae and a nonclear cornea. In addition, patients were informed of the adverse effects of eye rubbing on the cornea and only those patients who agreed with the study protocol were included. Volunteers were read a detailed sheet about the nature of the study and were shown a video of the eye-rubbing procedure (Video 1, available at http://jcrsjournal.org). A rotating Scheimpflug camera (Pentacam HR, OCULUS Optikgeräte GmbH) was used for the tomography and a dynamic bidirectional applanation device (Ocular Response Analyzer, version 3.01, Reichert Ophthalmic Instruments) was used for recording corneal biomechanics. Two episodes of eye rubbing were chosen because the biomechanical properties of the cornea are more affected after two episodes than after one according to Liu et al.[14] Eye rubbing was performed by the same researcher (M.C.), who was blinded to the patient's group for 1 minute followed by a 5-second break and a further 1-minute rubbing using the index finger of the right hand in a circular, clockwise motion over the closed eyelid, according to the procedure described by Chervenkoff et al.,[11] while applying approximately the same rubbing force (approximately between 5 and 6 newton) to each of the patients who were positioned at primary gaze. Patients were then seated at the Scheimpflug device and were advised to look straight ahead. To minimize the duration between the rotating Scheimpflug camera and the dynamic bidirectional applanation device scan, both machines were placed side by side, with a moving chair. For each patient, the eye was then rubbed as per the protocol, and immediately after, the eye assessed with Scheimpflug imaging first and then with the dynamic bidirectional applanation device.

To test the eye-rubbing effect, the dynamic bidirectional applanation device test was taken after Scheimpflug corneal topography test. However, the two examinations could not be taken together, and were taken no longer than 1 minute apart. After the eye rubbing, patients were tested immediately with both devices and recorded as time "zero" minutes. The next examinations were taken at 7 minutes and 14 minutes after the eye rubbing with both devices.

From the Scheimpflug device, the posterior corneal elevation measurements were used with a best-fit sphere as the reference surface, with the float option over an 8.0 mm fit. From these maps, the posterior elevation at the thinnest point of the cornea was measured as the maximum value above the best-fit sphere at the thinnest point of the cornea. A pachymetry map was recorded and the pachymetry at the apex of the cornea and pupil center (apex and pupil, respectively) and thinnest point of the cornea were obtained. From the refractive maps (cornea front), the flattest, steepest, and maximum keratometry (K) values were obtained from the rear surface of the cornea. Flatter K and steeper K were also recorded. Regarding the anterior and posterior surface of the cornea, astigmatism and asphericity, root mean square of lower-order aberrations, RMS of higher-order aberrations, anterior chamber depth, and anterior chamber volume (ACV) were measured. Regarding the dynamic bidirectional applanation device,[15] the following parameters were analyzed: Goldmann-correlated intraocular pressure (IOPg), corneal-compensated IOP (IOPcc), central corneal thickness, corneal resistance factor, waveform score, and corneal hysteresis.

STATISTICAL ANALYSIS

Statistical analysis was performed using R version 3.4.3,[A] a free available statistical software under the terms of the Free Software Foundation's general public license. Changes within each group (keratoconic and healthy) with respect to time were evaluated using the Friedman test. Post hoc testing using criterium Fisher least-significant-difference test was performed when the Friedman test indicated statistically significant differences. For the comparison between the two groups, the changes were calculated for each case and the Wilcoxon rank-sum test was performed to establish whether the differences were statistically significant. All tests were performed with a type I error equal to 0.05. For the correlations between pre-eye-rubbing metrics and variables that demonstrated statistically significant changes, the Spearman rank-correlation coefficient test was used.

RESULTS

Sixty-one eyes from 61 patients were included; 30 were included in the healthy group (14 [46.67%] were in men) and 31 eyes in the keratoconus group (18 were in men [58.06%]). The mean age was 27.2 ± 3.45 years old (range 22 to 34 years) in the healthy group and 27.88 ± 3.99 years (range 20 to 33 years) in the keratoconus group, with no statistically significant difference between groups ($P = .382$). Table 1 shows pre- and post-eye-rubbing values of the Scheimpflug device and the dynamic bidirectional applanation device parameters analyzed at 0, 7, and 14 minutes.

There was a significant increase of 0.07 D in the anterior steepest K in healthy eyes at 0 minutes ($P = .01$ after post hoc analysis), returning to pre-eye-rubbing values after 7 minutes ($P = .66$).

The keratoconic eyes exhibited a significant increase in posterior corneal astigmatism (Table 1). The post hoc analysis revealed that the difference was significant at 0 minutes ($P = .007$), returning to values not significantly different from those at the pre-eye rubbing at 7 minutes. Healthy eyes did not show statistically significant changes in posterior astigmatism. Figure 1 shows the induced changes of posterior corneal astigmatism in healthy eyes and keratoconic eyes after eye rubbing.

The keratoconic eyes showed a significant decrease is ACV (Table 1). The post hoc analysis revealed that the difference was significant at 0 minutes ($P < .001$), returning to values not significantly different from those at the pre-eye rubbing at 7 minutes. Healthy eyes did not show any significant differences at any post-eye-rubbing times. Figure 2 shows the pattern of the induced changes in ACV in healthy eyes and keratoconic eyes after eye rubbing.

The keratoconic eyes exhibited a significant decrease in IOPg (Table 1). The post hoc analysis revealed that difference was significant at 0 and 7 minutes ($P < .001$ and $P = .004$, respectively). Healthy eyes did not show any significant difference at any post-eye-rubbing time. Figure 3 shows the induced changes in IOPg in healthy and keratoconic eyes after eye rubbing.

Of the 31 keratoconic eyes included in the study, 5 eyes underwent Scheimpflug analysis after the eye-rubbing tests at a mean follow-up time of 8.8 months ± 2.68 (SD), of which, 2 eyes exhibited signs of progression.

Correlations between pre-eye-rubbing metrics and variables that demonstrated statistically significant changes (posterior astigmatism, ACV, IOPg, and IOPcc) were calculated. A significant positive correlation was found between pre-eye-rubbing maximum K and the change in posterior astigmatism ($r = 0.37$, $P = .043$). No significant correlations were found between the pre-eye-rubbing variables and ACV, IOPg, or IOPcc.

DISCUSSION

Our study examined the relationship between eye rubbing and consequent induced changes in anterior segment parameters in eyes with keratoconus in comparison to healthy control eyes. Multiple studies have reported changes after eye rubbing in healthy eyes; however, to the our knowledge, this is the first study to evaluate anterior segment parameters in keratoconic eyes after eye rubbing. We found significant changes in posterior astigmatism, IOP, and ACV in keratoconic eyes that were not found in the control eyes.

In our study, posterior astigmatism was significantly increased in keratoconic eyes and not in healthy eyes. Consistent with our results, no significant change in the posterior cornea of healthy eyes after eye rubbing has been described.[11] The most important finding of our study is that, different from healthy eyes, keratoconic eyes exhibited a significant increase in posterior corneal astigmatism. Consistent with our results, no significant change in the posterior cornea of healthy eyes after eye rubbing has been described.[11]

Keratoconic eyes had weaker corneas than healthy eyes, supported by the lower corneal hysteresis and corneal resistance factor metrics observed in the pre-eye-rubbing evaluation. There was a significant reduction in the ACV, IOPg, and IOPcc immediately after eye rubbing only in the keratoconic eyes. Concerning the changes in IOP, a greater change in IOPg (1.61 mm Hg, $P < .0001$) than in IOPcc (1.17 mm Hg, $P < .001$) was seen in the keratoconic eyes. It is believed that IOPcc is less affected by corneal biomechanical properties than IOPg.[14] In accordance with these results, healthy eyes, which had higher pre-eye-rubbing metrics with respect to corneal hysteresis and corneal resistance factor than keratoconic eyes, showed a similar change in both IOPg (1.21 mm Hg) and IOPcc (1.15 mm Hg); interestingly, the change in IOPcc was similar to that observed in keratoconic eyes. However, a confounding factor in our study setup might be the fact that mechanical forces exerted onto the globe, similar to those reported for the application of Honan balloons before cataract surgery, could result in transitory changes in IOP, which might affect IOPg and IOPcc measurements.[16]

From this study, it is impossible to determine the impact of this finding in cases where chronic and intense eye rubbing is performed; however, the fact that change in the posterior cornea after eye rubbing is different from that seen in healthy eyes is notable. The changes in the posterior cornea might be explained by the weaker cornea because of the underlying pathology of keratoconus. Our finding of the induced changes in the posterior cornea could explain, in part, the effects of chronic eye rubbing and could contribute to the theory that postulates eye rubbing as the trigger for this multifactorial disease, as suggested in reported cases of unilateral keratoconus, very asymmetrical keratoconus, or recurrent keratoconus in patients with compulsive eye rubbing.[1–6]

Chervenkoff et al.[11] found a significant change in the anterior cornea in healthy eyes, where the anterior flatter K showed significant further flattening and a trend toward against-the-rule astigmatism, postulating that the changes in the anterior corneal curvature preceded the changes in posterior corneal curvature after eye rubbing. However, their study was performed in healthy eyes and it did not include patients with keratoconus. In our study, we found a significant change in the steeper anterior K immediately after eye rubbing in healthy eyes, whereas the keratoconus group did not exhibit any statistical change in either steeper or flattest anterior K. These changes could be explained by the fact that healthy eyes did not experience a significant decrease in the IOP, which makes them more prone to show induced changes on the anterior cornea surface, whereas anterior K results in keratoconus patients might be affected by the significant reduction in IOP and ACV that they experienced.

From our study, we know that keratoconic eyes respond differently than healthy eyes to eye-rubbing force, and this knowledge could be potentially useful in elucidating the pathogenesis of the disease. However, future studies would be required to determine whether these changes are clinically significant or relevant to disease progression. These would likely have to be in vitro, because it would not be ethically permissible for patients to undergo a chronic and standardized eye-rubbing procedure.

A limitation of our study is that measurements in patients with keratoconus show greater variability when compared with healthy eyes. This might indeed lower the chances of detecting significant differences. Our results, as to be expected, showed more variability in measurements performed in keratoconus eyes than in healthy eyes. However, despite this limitation, significant results were found in post hoc tests, which give the findings greater support in statistical terms. One way to achieve greater reliability would be to carry out repeated measurements as repeatability studies are conducted. However, performing several tests could potentially eliminate the immediate response of the cornea to eye rubbing, which was the main focus of the study. Further analysis comparing both groups with several measurements of each parameter and a larger sample size could further support our findings.

In conclusion, this study shows that after eye rubbing, keratoconic eyes, unlike healthy eyes, undergo changes in the posterior cornea. After eye rubbing, keratoconic eyes demonstrated a significant increase in posterior astigmatism and significant decrease in ACV and IOP, suggesting that the impact of eye rubbing in the keratoconus eyes is different from healthy eyes.

WHAT WAS KNOWN

- Eye rubbing in healthy eyes can alter surface regularity and surface asymmetry indices, decrease tear-film breakup time, flatten anterior keratometry, produce changes in lower-order aberrations, and has been associated with a trend toward against-the-rule astigmatism.
- The effect of eye rubbing on the biomechanics and anterior segment of the keratoconus eyes have not been studied.

WHAT THIS PAPER ADDS

- Compared with healthy eyes after eye rubbing, keratoconic eyes showed significant changes in posterior astigmatism, IOP, and ACV. The changes were more evident immediately after the eye-rubbing force was applied.

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