

# Comparison of cyclopentolate versus tropicamide on corneal topography in emmetropic and myopic eyes

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## Research article

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# Abstract

**Background:** To compare the effect of cyclopentolate versus tropicamide eye drops on anterior surface corneal parameters using Keratograph 4 in myopic and emmetropic individuals.

**Methods:** Fifty-eight participants included 29 emmetropic and 29 myopic individuals, were recruited, according to inclusion and exclusion criteria. At baseline visit, anterior surface corneal parameters were measured using Keratograph 4 in the right eye. All measurements were repeated at two separate visits, one week apart, after administration of tropicamide 1% and cyclopentolate 1% at similar conditions.

**Results:** Of 58 participants who completed the study, 29 (24 women, 5 men, age:  $23.82 \pm 2.78$  years) were emmetropic and 29 (21 women, 8 men, age:  $23.66 \pm 2.76$  years) were myopic. Baseline mean spherical equivalents were  $-0.23 \pm 0.23$  D and  $-2.45 \pm 1.03$  D in emmetropic and myopic groups, respectively. The analysis of the data showed a significant hyperopic shift following instillation of both cycloplegic eye drops in both refractive groups. However, tropicamide results was statistically insignificant in comparison with cyclopentolate ( $p=0.49$ ). The assessment of data revealed no statistically significant differences in anterior surface corneal parameters in baseline, tropicamide and cyclopentolate instillation in each refractive group, except IHD value with tropicamide in myopic group ( $p=0.02$ ). The further analysis between refractive groups also showed no significant differences in anterior surface corneal parameters in each session.

**Conclusions:** Present study indicates that cyclopentolate and tropicamide do not appear to affect corneal topographic parameters and hence can be trusted to capture topography data.

## Background

The topically applied cycloplegic drops inducing both mydriasis and cycloplegia are widely used for detailed fundus examinations and cycloplegic refraction in outpatient clinic [1]. Cyclopentolate and tropicamide are the most commonly applied cycloplegic drops in clinics. They influence on muscarinic receptors in iris sphincter and ciliary muscles that result in pupil dilation and ciliary muscle relaxation [2]. With relaxation of the ciliary muscle following topically applied cycloplegic drops, the tension on the scleral spur is removed and therefore the corneal characteristics may change. The main distinctions of these drops are the mechanism, onset duration, function recovery and cycloplegia depth as well as probable side effects [3]. Cyclopentolate has an onset of action of 30–45 minutes that persist for up to 24 hours, however, tropicamide has an onset of action of 15–30 minutes with duration of action of 4–6 hours [2].

Corneal topography is an appropriate tool for evaluating the anterior surface of the cornea, as a predominant refractive component of the eye. It is valuable for both diagnostic and therapeutic purposes including contact lens fitting [4], diagnosis and management of Keratoconus [5, 6], refractive surgery planning [7] and detection of any pathological abnormalities following refractive surgeries [8].

According to the wide clinical application of cycloplegia and different cycloplegic mechanisms of cyclopentolate and tropicamide drops and also the sensitivity of topographic data in refractive surgery planning, it is critical to determine how the commonly used cycloplegic drops influence the topographic

parameters. To the best of knowledge, there is no evidence on the direct comparison of the influence of these cycloplegic eye drops on corneal topographic parameters. Therefore, the present study aimed to compare the effect of cyclopentolate and tropicamide on corneal topographic parameters in myopic and emmetropic individuals.

## Methods

### Study population

Fifty-eight participants included 29 emmetropic and 29 myopic individuals (age range between 18 to 30 years) were recruited in this cross-sectional study. Emmetropia was defined as a mean spherical equivalent equal and between +0.50 to -0.50 D. Myopia was defined as a spherical equivalent of -0.75 D or worse.

Comprehensive eye examinations including refraction, best corrected visual acuity, intraocular pressure and assessment of corneal and tear film health were performed to rule out ineligible subjects. Individuals with intraocular pressure greater than 21 mm Hg, any history of angle closure glaucoma, any history of corneal diseases including pingecula, pterygium and keratoconus, any history of systemic diseases such as diabetes mellitus and hyperthyroidism and any history of ocular surgery were excluded from the study. Participant also had no history of contact lens application for at least two weeks prior to the study. Astigmatism power more than -1.5 D was considered as an exclusion criterion.

### Procedure

Anterior surface corneal parameters were evaluated using Keratograph 4 (OCULUS, Wetzlar, Germany) corneal topography. It is an advanced, placido disc-based corneal topographer that consists of 22 rings and measures 22000 points. Several studies have reported that Oculus Keratograph 4 provides repeatable measurements of corneal topography parameters in healthy eyes [9, 10]. Participants were asked to fix at the yellow circle and instructed to blink to provide a uniform tear film over the cornea and then the device recorded corneal parameters automatically.

After baseline anterior surface corneal parameters assessment, all measurements were repeated under two cycloplegic eye drops conditions as follows:

- At 30 minutes after the instillation of two drops of tropicamide 1% with 5 minutes intervals [11].
- At 45 minutes after the instillation of two drops of cyclopentolate 1% with 10 minutes intervals [11].

The two procedures were separated by one week. Data were recorded on right eye in all visits. All examinations were performed by the same experienced examiner.

### Anterior surface corneal parameters definition:

- Steep (Ks) and flat keratometry readings (Kf)
- ISV (Index of Surface Variation): The corneal surface irregularity [12].

- IVA (Index of Vertical Asymmetry): The value of curvature symmetry, with respect to the horizontal meridian [12].
- KI (Keratoconus Index): The ratio between upper and lower segment mean radius values [12].
- CKI (Central Keratoconus Index): The ratio between mean radius values in a peripheral ring divided by a central ring [12].
- IHA (Index of Height Asymmetry): The degree of symmetry of height data with respect to the horizontal meridian [12].
- IHD (Index of Height Decentration): The degree of decentration in the vertical direction, on a ring with radius 3 mm [12].
- R Min (Minimum Radius Curvature): The smallest radius of sagittal corneal curvature [12].
- Asphericity: Variation in radius of curvature from center to the periphery [13].
- Eccentricity

### Statistical analysis:

Statistical analyses were performed using the SPSS software version 11.5 (SPSS Inc., Chicago, IL). Descriptive statistics are reported as mean  $\pm$  SD. Repeated measures Analysis of Variance (ANOVA) was performed to compare anterior surface corneal parameters between baseline, tropicamide and cyclopentolate for each refractive group. Independent student t-test employed to detect differences between emmetropic and myopic groups.  $P < 0.05$  was considered statistically significant.

## Results

Of a total of 58 participants who completed the study, 29 (24 females, 5 male) were emmetropic and 29 (21 females, 8 males) were myopic. The mean age of subjects was  $23.82 \pm 2.78$  years in emmetropic and  $23.66 \pm 2.76$  years myopic groups ( $p=0.81$ ). Mean spherical equivalent (MSE) refractive errors were  $-0.23 \pm 0.23D$ ,  $0.30 \pm 0.16D$  and  $0.33 \pm 0.23D$  in emmetropic group and  $-2.45 \pm 1.03D$ ,  $-2.26 \pm 0.11D$  and  $-2.10 \pm 0.90D$  in myopic group at baseline, tropicamide and cyclopentolate instillation, respectively ( $p < 0.0001$ ). As expected, the analysis of the data showed a significant hyperopic shift following instillation of both cycloplegic eye drops in two refractive groups. However, tropicamide results was statistically insignificant in comparison with cyclopentolate in both emmetropic and myopic groups ( $p=0.49$ ,  $p=0.06$ , respectively).

Repeated measures ANOVA showed significant differences in steep ( $K_s$ ) and flat ( $K_f$ ) keratometry readings, central corneal astigmatism and astigmatism axis following instillation of either cyclopentolate or tropicamide in both refractive groups. Moreover, no significant differences were illustrated in abovementioned parameters between emmetropic and myopic groups in each procedure.

The assessment of data revealed no statistically significant differences in anterior surface corneal parameters between baseline, tropicamide and cyclopentolate instillation for both refractive groups, except IHD value with tropicamide in myopic group ( $p=0.02$ ). The further analysis between refractive groups also revealed no meaningful differences in anterior surface corneal parameters in each session. The results are shown in Table 1.

**Table 1: Anterior surface corneal parameters in baseline measurement, tropicamide and cyclopentolate administration in emmetropic and myopic groups.**

	Emmetropia				Myopia			
	Baseline	Tropicamide	Cyclopentolate	P	Baseline	Tropicamide	Cyclopentolate	p
<b>Ks</b>	43.64±1.61	43.62±1.53	43.63±1.59	0.814	44.40±1.63	44.37±1.66	44.41±1.60	0.889
<b>Kf</b>	42.81±1.57	42.78±1.52	42.80±1.54	0.468	43.53±1.52	43.50±1.56	43.53±1.55	0.782
<b>ISV</b>	20.75±6.46	21.24±6.58	20.96±6.53	0.680	20.10±5.86	19.58±6.19	19.86±5.68	0.630
<b>IVA</b>	0.13±0.06	0.14±0.06	0.013±0.06	0.067	0.12±0.06	0.11±0.06	0.12±0.06	0.497
<b>KI</b>	1.01±0.02	1.01±0.02	1.01±0.02	0.768	1.01±0.01	1.01±0.01	1.01±0.01	0.495
<b>CKI</b>	1.007±0.004	1.007±0.005	1.008±0.005	0.175	1.007±0.004	1.007±0.004	1.007±0.006	0.800
<b>Rmin</b>	7.63±0.30	7.61±0.29	7.62±0.26	0.591	7.49±0.27	7.49±0.29	7.49±0.27	1
<b>IHA</b>	7.45±4.49	8.56±6.03	7.30±4.72	0.140	5.87±4.87	7.00±5.35	6.53±4.13	0.172
<b>IHD</b>	0.005±0.003	0.005±0.003	0.005±0.003	0.095	0.004±0.002	0.005±0.002	0.004±0.002	<b>0.010</b>
<b>Ecc</b>	0.55±0.09	0.55±0.10	0.55±0.11	0.651	0.53±0.11	0.52±0.11	0.53±0.09	0.679
<b>Qm</b> <b>5mm</b>	-0.23±0.10	-0.22±0.12	-0.22±0.10	0.698	-0.21±0.10	-0.17±0.16	-0.21±0.11	0.314
<b>Qm</b> <b>6mm</b>	-0.25±0.09	-0.26±0.10	-0.23±0.15	0.381	-0.23±0.09	-0.20±0.17	-0.22±0.13	0.507
<b>Qm</b> <b>7mm</b>	-0.29±0.09	-0.30±0.10	-0.27±0.15	0.299	-0.28±0.09	-0.24±0.18	-0.25±0.17	0.510

All data has normal distribution. Bold text indicates a statistically significant value.

Kf: lat keratometry, Ks: steep keratometry, ISV: index of surface variation, IVA: index of vertical asymmetry, KI: keratoconus index, CKI: central keratoconus index, Rmin: minimum radius curvature, IHA: index of height asymmetry, IHD: index of height decentration, Ecc: eccentricity, Qm: asphericity.

## Discussion

Tropicamide and cyclopentolate are the most commonly applied cycloplegic drops with common mydriatic and cycloplegic actions but different strength and depth of action. The aim of the present experiment was to

compare cyclopentolate versus tropicamide effects on anterior surface corneal parameters in emmetropes and myopes captured by Keratograph 4 corneal topographer.

Findings showed, as expected, a significant hyperopic shift after each cycloplegic drops in both refractive groups. However, tropicamide outcomes were not statistically significant in comparison to cyclopentolate. The analysis of anterior surface corneal parameters exhibited no significant differences between baseline measurement, tropicamide and cyclopentolate administration in both refractive groups.

Consistent with our results, a previous study on the cycloplegic effect of cyclopentolate 1% and tropicamide 1% in adults' refractive outcomes also revealed no significant differences between cycloplegic effects of these two drops [14]. The influence of cycloplegic eye drops on corneal curvature was also assessed in previous studies [15-21]. The assessment of tropicamide influence on corneal topography in adults showed no significant changes in corneal radius, power and astigmatism after administration [15]. Also, investigation of cyclopentolate eye drop administration on corneal parameters using pentacam showed that cyclopentolate has no significant effect on keratometry measurements [16]. Evaluation of biometric parameters following cycloplegia using Lenstar and IOLMaster biometers also revealed no significant differences in axial length and corneal curvature measurements with and without cycloplegia with both devices [17]. However, there is evidence that homatropine 2% administration (6 drops with 10 minutes intervals) was accompanied with a flattening of the cornea by mean of  $+0.13 \pm 0.11$ mm and increase in the central corneal radius curvature and consequently corneal power reduction [18]. The difference between our findings and this aforementioned study [18] might be attributed to the difference in the cycloplegic agent type and the dosage applied. Application of six drops of homatropine 2% might have acted stronger than two drops of cyclopentolate 1% or tropicamide 1%. Another study also showed a flattening in corneal curvature and a reduction in posterior corneal curvature after administration of tropicamide-phenylephrine hydrochloride in young participants with a range of +0.25 to -6.00 D refractive error [19].

Based on our finding, corneal eccentricity and asphericity showed no significant changes after tropicamide and cyclopentolate instillation in both refractive groups. Further analysis between refractive groups also revealed no meaningful difference of these parameters in each session. Keratoconic indices also did not show any change before and after instillation of either cycloplegic eye drops. The only significant change was in IHD parameters following instillation of tropicamide in myopic group.

## Conclusions

The results of the current study suggest that using either tropicamide 1% or cyclopentolate 1% for cycloplegic refraction in examinations before refractive surgery would give the same results in young patients between 18-30 years of age. These findings, however, may be applicable in myopic patients between -0.750 to -4.00 D. Present study indicates that cycloplegic drops do not appear to affect corneal topographic parameters and hence topography data can be trusted after using cyclopentolate or tropicamide.

It should be noted that refractive status may not have an impact on topography parameters, however our study lacked hyperopic patients. Another limitation to consider in future investigations is posterior corneal curvature evaluation and corneal thickness as these parameters are also essential in refractive surgery.

However, the keratography 4 provides accurate information only from the anterior corneal surface. Therefore, it is recommended that a larger study with the addition of hyperopic group, and using other cycloplegic drops such as homatropin performed by instrument such as Pentcam that be able to evaluate both anterior and posterior corneal parameters.

## **Abbreviations**

MSE: Mean Spherical Equivalent; Ks: Steep Keratometry; Kf: Flat Keratometry; ISV: Index of Surface Variation; IVA: Index of Vertical Asymmetry; KI: Keratoconus Index; CKI: Central Keratoconus Index; R Min: Minimum Radius Curvature; IHA: Index of Height Asymmetry; IHD: Index of Height Decentration; Ecc: Eccentricity; Qm: Asphericity.

## **Declarations**

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### **Authors' contributions**

EG proposal development and data collection. NMS and EA data analysis and manuscript Preparation. AE and HOM proposal review, supervision during data collection and manuscript review. All authors have read and approved the final manuscript.

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### **Availability of data and materials**

The datasets used and analyzed in this study are available from the corresponding author on reasonable request.

### **Ethics approval and consent to participate**

The study followed the tenets of the Declaration of Helsinki and approved by the Research Ethics Committee of Mashhad University of Medical Sciences. An informed written consent was obtained from all participants after explanation of the nature and possible consequences of the study.

### **Consent for publication**

Not applicable.

### **Competing interests**

The authors declare that they have no competing interests.

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