Effect of Accommodation on Corneal Topography

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Purpose: To investigate the effect of accommodation on corneal topography in healthy subjects.

Methods: Using a Nidek OPD-Scan ARK-10000, corneal topographic images, images of the iris, and the refraction of 18 eyes of 10 normal subjects with a mean age of 26.3 ± 7.1 years (median, 24 years; range, 19–41 years) were simultaneously obtained before and during fixation of a near target in the Department of Ophthalmology, Istanbul Medeniyet University Medical Faculty, Istanbul, Turkey. At baseline, iris landmarks, such as nevi and crypts, were identified on each iris image that were on opposite sides of the pupil and 180 degrees apart. A line was drawn on the iris images between these 2 landmarks. The same landmarks were identified on the iris images obtained when the eye was fixating at the near target. A line was drawn between the landmarks. The angular rotation of the lines relative to the vertical meridian was measured to assess cyclotorsion of the eyes during accommodation.

Results: At baseline, the mean spherical equivalent refraction of the eyes was −0.78 ± 0.38 diopters (D) (range, −0.25 to −1.67 D) with <0.5 D of astigmatism. During a mean accommodative amplitude of −4.55 ± 2.04 (median, −4.25 D; range, −1.75 D to −8.12 D), there was no apparent difference in corneal topography and no statistical difference in mean keratometry ($P = 0.26$) or cyclotorsion ($P = 0.74$).

Conclusions: During accommodation, the cornea does not change curvature and the eye does not appear to significantly cyclotort.

Key Words: accommodation, convergence, cornea, topography

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In 1801, Young[1] demonstrated that the cornea does not affect accommodative amplitude with his famous eyecup experiment. Since then, there have been numerous publications supporting and contradicting his conclusion. Using keratometers, Kohlrausch[2] in 1870 and Löpping and Weale[3] in 1965 did not find significant changes in corneal curvature during accommodation, whereas Fairmaid[4] in 1959 found a decrease in corneal refractive power of up to 1.5 diopters (D) in the horizontal meridian and 0.5 D in the vertical meridian after convergence and accommodation. More recent studies using corneal topographers also showed controversial results.[5–10] Yasuda et al[5,6] and He et al[7] observed steepened corneal curvatures during accommodation; however, Buehren et al,[8] Read et al,[9] and Tarutta et al[10] reported that the cornea does not significantly change shape during accommodation. The aim of this study was to investigate the effect of accommodation on corneal topographic maps in healthy nonpresbyopic adults.

METHODS

Using a Nidek OPD-Scan ARK-10000, corneal topographic images, images of the iris, and the refraction of 18 eyes of 10 normal subjects (6 women and 4 men) with a mean age of 26.3 years (SD, ±7.1 years; median, 24 years; range: 19–41 years) were simultaneously obtained before and during fixation at a near target. The subjects had normal corneas, and none had been wearing contact lenses. All the subjects were in good physical and ocular health with no history of ocular disease, surgery, or trauma. None of them had presbyopic complaints. Their best-corrected visual acuities were 20/20 or better.

At baseline, the subjects fixated the internal target of the Nidek device, and using automatic fogging, the distance refraction, corneal topography, and images of the iris were obtained separately from the right and left eyes. Then, a 2.5-mm-diameter circular sticker was placed at the center of the Placido disc of the Nidek device for the subjects to fixate at near. The approximate distance of the sticker from the subject's cornea was 19 cm. The sticker was small enough that it did not interfere with the ability of the device to automatically measure refraction and to obtain corneal topography and iris images when the subjects fixated separately at the near target with each eye. The accommodative amplitude was determined by subtracting the baseline refraction from the near refraction. The topographic images at baseline and during accommodation were visually compared, and the mean keratometric and astigmatic readings of the unaccommodated and accommodated states of the eyes were statistically analyzed (Fig. 1).

In addition, at baseline, iris landmarks, such as nevi and crypts, were identified on each iris image that were on opposite sides of the pupil and 180 degrees apart. A line was drawn on the iris images between these 2 landmarks. After accommodation, the same landmarks were identified on the iris images of the accommodated eyes, and a line was again drawn between the landmarks. The angular rotation of the

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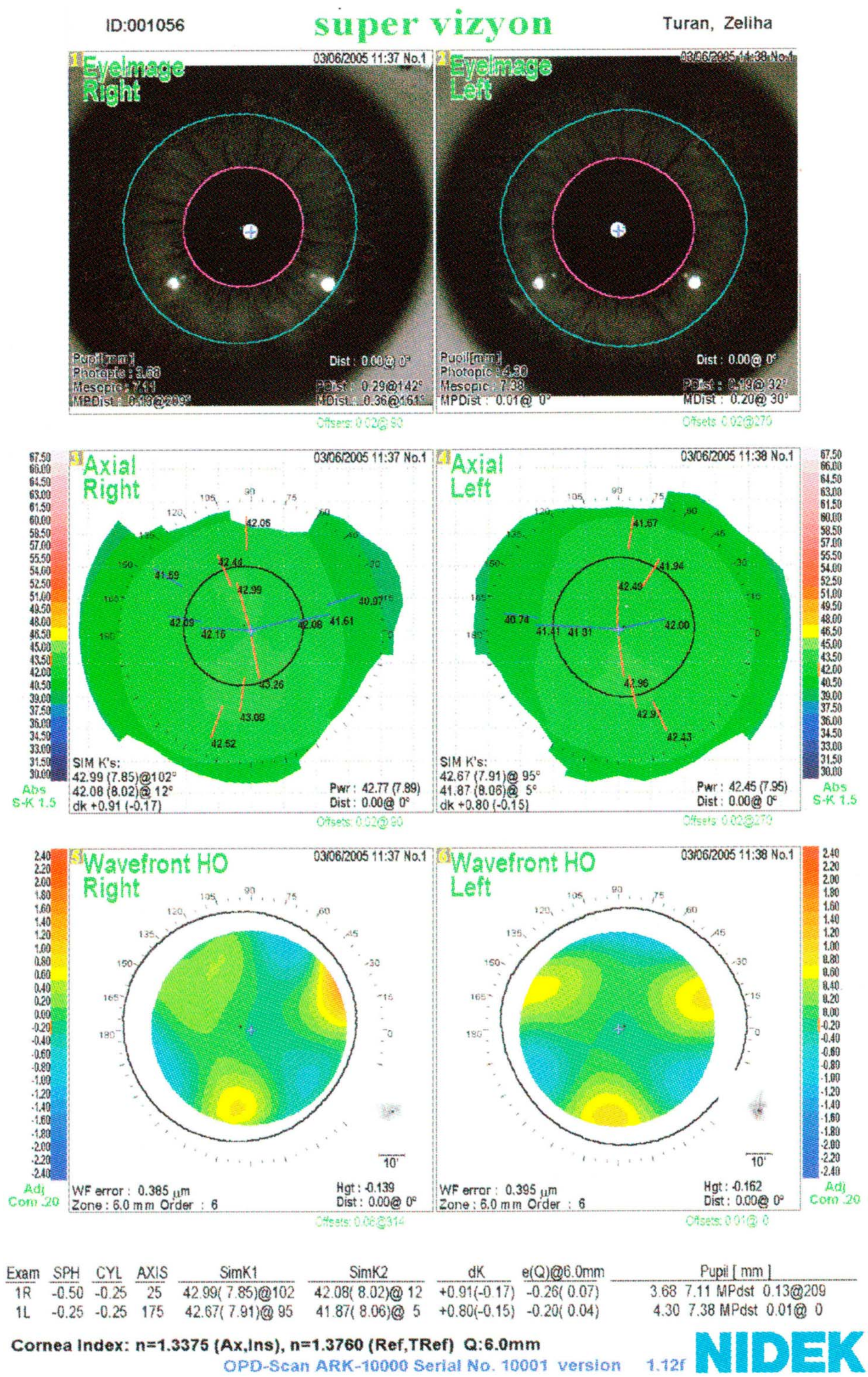

FIGURE 1. Corneal topographic measurements of subject 4 without accommodation.

lines relative to the vertical meridian was measured to assess cyclotorsion of the eyes during accommodation (Fig. 2). Statistical analyses were performed with SPSS Statistics 20. Because all groups were distributed normally, parametric tests were used. A P value less than 0.05 was considered statistically significant.

RESULTS

Two eyes of 2 subjects were not included in the study because the measurements could not be obtained confidently enough (because of a sign of error of the autorefractometric measurements on the printout of the images). The mean spherical equivalent refraction of the 18 eyes was -0.78 ± 0.38 D (range,

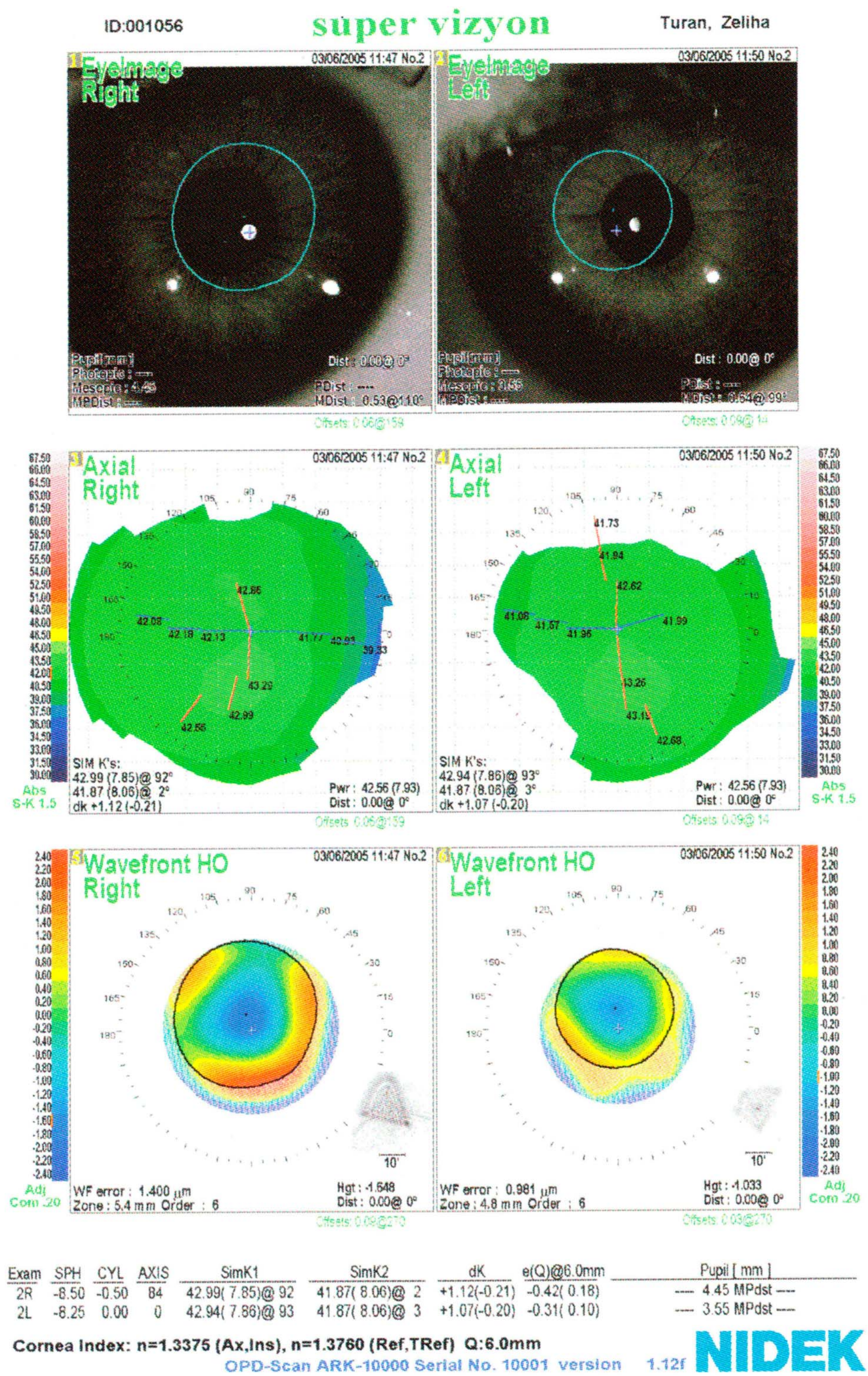

FIGURE 2. Corneal topographic measurements of subject 4 with accommodation. Note that there are no significant corneal topographic changes observed despite a huge amount of accommodation levels (−8.12 D for the right eye and −7.87 D in the left eye).

−0.25 to −1.67 D). The mean accommodative amplitude was −4.55 ± 2.04 D (median, −4.25 D; range, −1.75 D to −8.12 D). The mean keratometric measurements at baseline and during accommodation were 43.35 ± 1.90 D and 43.29 ± 1.94 D, respectively; that is, during accommodation, there was a nonsignificant ($P = 0.255$, paired t test) mean decrease in keratometry of 0.063 ± 0.228 D (median, −0.14 D; range, −0.35 to +0.62), which did not correlate with the magnitude of accommodation ($r^2 = 0.14$). The corneas of 14 eyes flattened and 4 eyes steepened (Figs. 1, 2). There was no significant cyclotorsion accompanying with accommodation (median, 0; mean, −0.17 ± 2.06 excyclotorsion). Four eyes slightly incyclotorted, 5 eyes

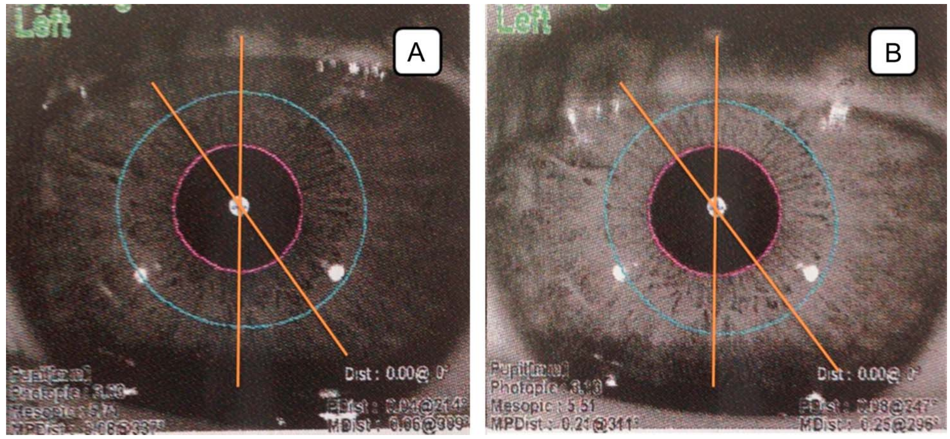

FIGURE 3. Iris images of the left eye of subject 9 in an unaccommodated (A) and accommodated (B) state with lines drawn. A line intersecting the pupillary center and the middle of 2 iris nevi placing at about 5-o'clock position was drawn in addition to the vertical meridian on both figures. Note that, in panel (B), no significant angular rotation exists relative to the vertical meridian in comparison to panel (A).

negligibly excyclotorted, and 9 eyes did not show any cyclotorsion (Fig 3).

DISCUSSION

Independent of the method used to measure the cornea, there have been contradictory published reports on whether the cornea changes shape during accommodation.[1–10] Using a modern corneal topographer, Yasuda et al[5] found a 0.62 D steepening of the cornea during accommodation; however, when they repeated the experiments, only a clinically meaningless change of 0.13 + 0.17 D was observed.[6]

In the present corneal topographic study, the cornea did not statistically significantly change curvature during accommodation. Similar to the studies by Buehren et al[8] and Read et al,[9] which also did not show a change in corneal curvature during accommodation, fixed landmarks were used for image correspondence of the unaccommodated and accommodated corneal topographic images. This ensured that the effects of eye movement on keratometry were minimized. We, like Buehren et al[8] and Read et al,[9] observed only minimal cyclotorsion during accommodation. These small eye movements probably account for the small insignificant corneal flattening of 0.063 $\pm$ 0.228 D observed. The present study reaffirms the original observation of Young[1] that the cornea does not affect accommodative amplitude nor does it change shape during accommodation as stated by Schachar.[11]

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