Optometry and Vision Science
THE UNIVERSITY OF NEW SOUTH WALES

Posterboard number: 6090 - C0025

CHARACTERIZING CORNEAL CHANGES INDUCED BY ORTHOKERATOLGY USING HIGH RESOLUTION OCT: 1998 REVISITED

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INTRODUCTION

- Orthokeratology (OK) involves overnight wear of reverse geometry rigid contact lenses that temporarily reshape the anterior cornea to correct mild to moderate degrees of myopia[1]
- Early research, conducted in the late 1990s, suggested that corneal curvature changes induced by OK lens wear resulted from reorganisation of anterior corneal tissue (primarily thinning of central epithelium and thickening of paracentral stroma) rather than overall corneal bending[2-4]
- Based on Munnerlyn's formula[5] it was proposed that refractive changes induced by overnight OK can be completely explained by these topographical changes in corneal thickness[2]
- This conventional view of OK refractive effects was based on the superseded technology of optical pachometry, and has been challenged by some who consider that stromal bending may play a significant role in OK effects
- Therefore, we sought to re-investigate this conventional explanation of OK effects using advanced technology that allows high-resolution imaging of corneal tissue across a large scan width

PURPOSE

- To investigate changes in epithelial and stromal corneal thickness along the horizontal and vertical corneal meridians after overnight OK lens wear using a high resolution Tomey CASIA optical coherence tomographer (OCT)

METHODS

SUBJECTS

- 28 young adult subjects (age range 18-26 years)
- Inclusion criteria
  - -1.00 to -5.00DS and ≤-1.50DC
  - No prior rigid gas-permeable contact lens wear
  - Good ocular health and no contraindications for OK lens wear
- Both eyes fitted with OK lenses (Paragon CRT; Paragon Vision Sciences Inc., USA) made from HDS 100 material
- Measurements taken at baseline and after 4 weeks overnight OK lens wear within 2-3 hours after lens removal

MEASUREMENTS

- Distance LogMAR visual acuity (VA) (Test Chart Pro, Thomson Software Solutions; UK)
- Central objective refraction (Shin-Nippon NVision K-5001 autorefractor; Japan)
  - Average of 5 measurements, converted to vector components M, J_{180} & J_{45}
- Corneal topography (Medmont E-300; Australia)
  - Average of 4 measurements
- Anterior eye OCT (Tomey CASIA, Japan)
  - 16mm scan width, 2048 scans per measurement
  - 3 cross-sectional corneal measurements taken along the horizontal & vertical meridians
  - Epithelial, stromal and total corneal thickness measurements at center (visual axis), and ±2, ±2.5, ±3, ±3.5 and ±4mm from center

STATISTICAL ANALYSIS

- Data taken from one eye only
- Linear Mixed Model analysis, RM-ANOVA or Friedman test with post-hoc t-tests to analyze changes in vision, central refraction, and epithelial, stromal and full corneal thickness. Critical p-value <0.05

RESULTS

DISTANCE VA

- There was no significant difference between best corrected distance VA measured at baseline (-0.06 ± 0.05) and after 4 weeks of OK lens wear (-0.05 ± 0.07; p=0.787)

CENTRAL REFRACTION

- Central refraction at baseline and after 4 weeks of OK lens wear is shown in Table 1. There was a significant hyperopic M shift and no change in astigmatism

CORNEAL TOPOGRAPHY

- Apical radius of curvature (R_0), and Flat and Steep K before and after OK lens wear are shown in Table 2
- There was significant corneal flattening reflected by a significant increase in R_0, and decrease in both Flat K and Steep K values.

	M	J_{180}	J_{45}
Baseline	-2.16 ± 1.06	-0.01 ± 0.23	0.01 ± 0.11
OK	-0.29 ± 0.62	-0.01 ± 0.21	-0.02 ± 0.19
P-value	<0.001	0.937	0.964

Table 1. Central refraction (D; mean ± SD) before and after OK

	R_0	Flat K	Steep K
Baseline	7.85 ± 0.24	42.66 ± 1.32	43.70 ± 1.31
OK	8.22 ± 0.27	41.07 ± 1.36	42.08 ± 1.30
P-value	<0.001	<0.001	<0.001

Table 2. Apical radius of curvature (mm; mean ± SD), Flat and Steep K (D; mean ± SD) before and after OK.

EPITHELIAL THICKNESS CHANGES

- OK lens wear induced significant changes in epithelial thickness across both the horizontal and vertical meridians
- There was significant thinning of the epithelium in the central cornea and epithelial thickening in the paracentral cornea (Figure 1)

STROMAL THICKNESS CHANGES

- There were significant changes in stromal thickness across the horizontal and vertical meridians
- There was significant thickening of the stroma as shown in Figure 2

TOTAL CORNEAL THICKNESS CHANGES

- Significant changes in overall corneal thickness along the horizontal and vertical meridians are shown in Figure 3
- There was significant decrease in central corneal thickness and increased thickness in the paracentral cornea

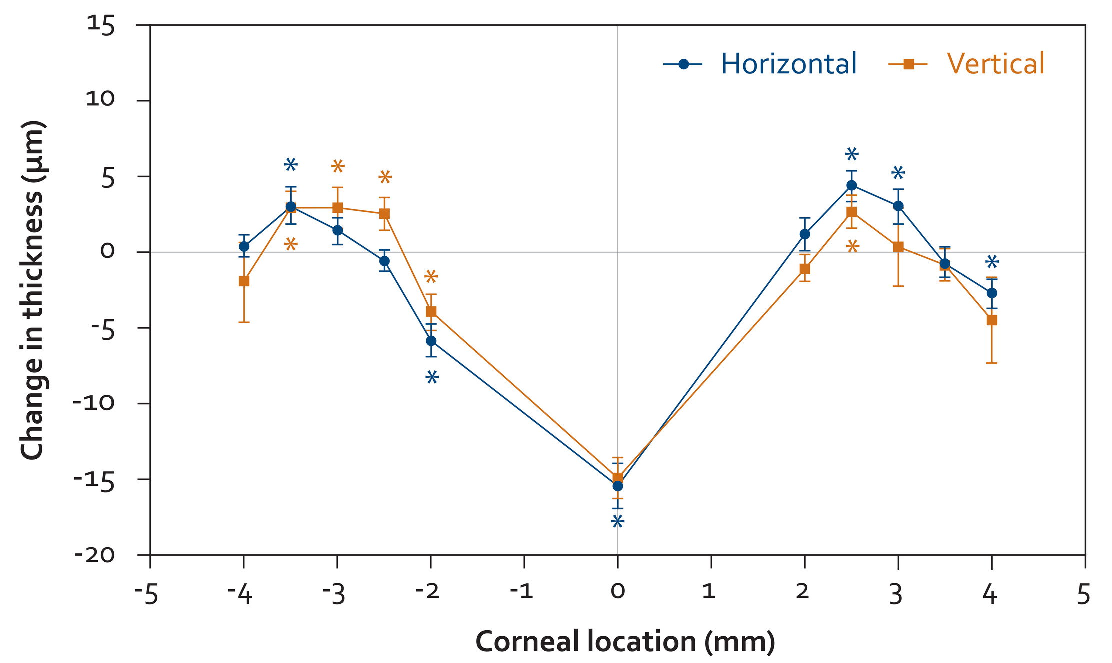

Figure 1. Epithelial thickness changes along the horizontal and vertical corneal meridians. Error bars represent the standard error of the mean. Negative values represent the temporal and inferior cornea while positive values represent the nasal and superior cornea. Asterisks indicate locations of significant change from baseline.

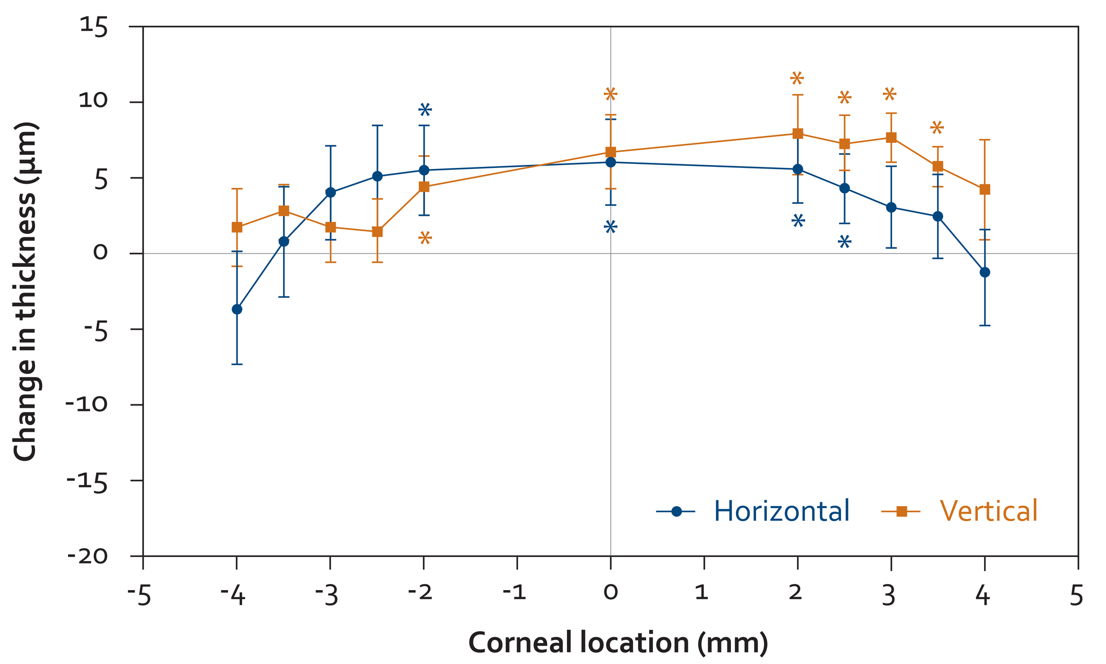

Figure 2. Stromal thickness changes along the horizontal and vertical corneal meridians. Error bars represent the standard error of the mean. Negative values represent the temporal and inferior cornea while positive values represent the nasal and superior cornea. Asterisks indicate locations of statistically significant change from baseline.

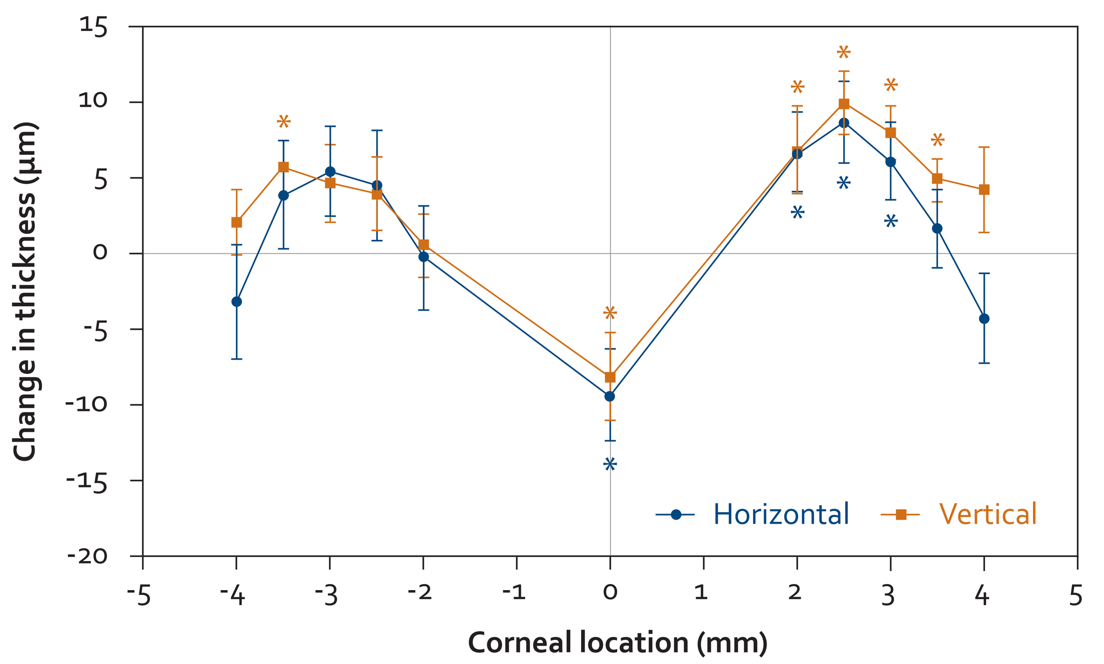

Figure 3. Full corneal thickness changes along the horizontal and vertical corneal meridians. Error bars represent the standard error of the mean. Negative values represent the temporal and inferior cornea while positive values represent the nasal and superior cornea. Asterisks indicate locations of significant change from baseline.

DISCUSSION

- In agreement with previous studies, overall corneal thickness decreased in the center and increased in the paracentral cornea along both the horizontal and vertical meridians[2, 4, 7]
- Decrease in central corneal thickness is mostly due to thinning of the central epithelium and increase in paracentral corneal thickness is due to increase in both epithelial and stromal thickness[2-4,7,8]
- Some studies have found stromal thickening centrally[3,9] while others have reported no change.[2,10] Increase in stromal thickness across the cornea is likely to be a result of residual hypoxic edema
- Applying Munnerlyn's formula[5] to corneal sag height change (15.98µm) measured across a 5mm corneal chord and a corneal refractive index of 1.377, the anticipated refractive power change was 1.93D. This is very similar to the measured refractive power change (1.87D) indicating that corneal sagittal height change due to corneal thickness changes can account for refractive changes induced by OK

CONCLUSIONS

- Central corneal thinning induced by OK was mostly due to epithelial thinning
- Mid-peripheral corneal thickening was a combination of epithelial and stromal thickening
- Central corneal thickness changes can account for refractive changes, further supporting the hypothesis that OK induces its refractive effects through anterior corneal changes rather than overall corneal bending

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ACKNOWLEDGEMENTS

- This research was funded through the Australian Research Council Linkage Project Scheme with support from industry partners Bausch + Lomb Boston (Wilmington, MA), BE Enterprises Pty Ltd (Brisbane, Australia) and Capricornia Contact Lens Pty Ltd (Brisbane, Australia).
- Lenses were supplied by Paragon Vision Sciences (USA) and contact lens solutions were provided by Bausch + Lomb (Australia)

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