Central and Peripheral Changes in Anterior Corneal Topography in Short-Term Orthokeratology

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Abstract: Purpose: This study aimed to investigate the changes in topography of the front corneal surfaces with orthokeratotomy for correcting myopia. Methods: Thirty young wore orthokeratology lenses for correction of myopia spherical equivalent. The values of front corneal surfaces were derived with a corneal topographer (Medmont E300) before and at least 3 months after each treatment. Measurement was conducted in the center of the cornea and four points to each side of the horizontal meridian at 1 mm intervals. Results: This study included 60 eyes from 30 patients with a mean age of 12.05 ± 2.88 years (range = 10 to 18 years). Mean values and standard deviation for the pre- and post-treatment of the selected patients are listed for each of the variables. The equivalent sphere of pretreatment was -4.05 ± 1.99 D, and OS was -4.30 ± 1.58 D. The Jo of OD was -0.26 ± 0.649 D, and J45 was -0.32 ± 0.54 D. The Jo of OS was -0.39 ± 0.52 D, and J45 was -0.26 ± 0.19 D. The change in refractive power after orthokeratology on the front surface at the central region, the nasal 1–3 mm and temporal 1–3 mm distance became negative and significantly decreased. Discussions: The results of this study confirmed previous studies that have reported a decrease in the power and curvature of the cornea, indicating the different features of the geometrical nature of the cornea.

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1. Introduction

Orthokeratology refers to the uses of rigid contact lenses to temporarily change corneal shape and reduce refractive error [1-3]. Orthokeratology is a non-surgical procedure mainly achieved by flattening the central cornea with an overnight lens. After modifying the shape of the front corneal curvature, light entering the eye can precisely focus on the retina without encountering wear amid any instrument [4-6]. As in other topography systems, the corneal topographer enables the measurement of several parameters of both front and back corneal surfaces.

This study primarily aimed to conduct corneal topography in preoperative and postoperative evaluations of ongoing overnight orthokeratology. Although numerous studies have focused on changes in central curvature, the present study compared the values of the central and peripheral curvature of cornea data to identify the pre- and post-treatment differences.

2. Materials and methods

2.1. Subjects and inclusion criteria

This study collected the clinical records of 30 patients recruited to participate in this study after undergoing orthokeratology using corneal refractive therapy. Patients with myopia between -2.00 and -7.00 D and refractive astigmatism of less than -1.25 D were included. All patients do not have any history of ocular disease or trauma and have not undergone previous ocular surgery. A minimum of 12 months after treatment was required to ensure stability of the topography of cornea.

Table 1 lists the inclusion criteria for this study. Only children aged 10–18 years with spherical equivalent refraction of at least less than 4.00 D and myopia were recruited.

2.2. Visual acuity

Distant uncorrected visual acuity and best corrected visual acuity (BCVA) were measured using the Snellen chart. All visual acuity measurements were conducted under normal room illumination.

2.3. Orthokeratology lens characteristics

The lens specifications and solutions used are shown in Table 2. The orthokeratology lenses used were manufactured by the Hiline Optical Company (Taipei, Taiwan) using Boston XO materials (ISO/Fatt Dk 100; Rochester, NY, USA) with the following parameters: total diameter, 10.6 mm; BOZD, 6.0 mm; and center thickness, 0.22 mm.

TABLE 1. Inclusion criteria

Age	10-18 yr of age
Refractive errors	Spherical equivalent refraction ≦-4.50 D Myopia -2.00D~-7.00D
Ocular health	No binocular vision problems No ocular diseases that might affect vision No contraindications for overnight orthokeratology lens wear
General health	No systemic diseases that might affect vision
Others	No undergo myopic treatment (e.g., refractive surgery) Willing to wear orthokeratology lenses in accordance with instructions if assigned to partial reduction orthokeratology group

TABLE 2. Specifications of orthokeratology lens

Orthokeratology lens (Procornea Ltd., Netherlands)	
Material	Boston XO materials
Design	4-zone (BOZR, RC, AC, and PC) Spherical
Oxygen permeability	100
Back optic zone radius	7.20Y9.50 mm (0.05-mm step)
Optic zone diameter	6.0 mm
Total diameter	10.6mm
Lens central thickness	0.22mm.
Wearing modality	Overnight orthokeratology
Replacement period	1 yr

2.4. Corneal topography

Corneal topography was measured using the Medmont E300 Corneal Topographer Version 4.9.0.0 (Medmont, Camberwell, Victoria, Australia). Three images were captured, and data from the associated map displays were averaged on every measurement instance. Topographic data were collected from the center of corneal topography (C). The corneal locations included in the analysis were those within the central 6 mm of the cornea because this was the optical zone for all patients. Thus, focus was given on analyzing the central, 1, 2, 3, and 4 mm chord areas. The topography of the examined cornea is shown in Figure 1, which indicates the area, central curvature, and measurements along the center to the peripheral 4 mm.

2.5. Statistical analysis

For statistical analysis, the SPSS software package v. 17 (SPSS Inc., Chicago, IL, USA) was used. The paired-sample *t* test was performed to analyze the correlations between refractive and topographical changes and the statistical significance of topographic changes, respectively. For statistical purposes, $P < 0.05$ was considered statistically significant.

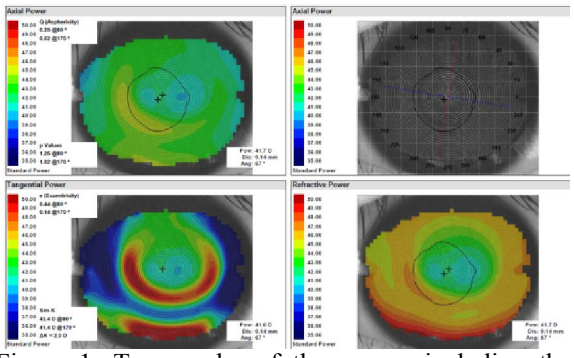

Figure 1: Topography of the cornea including the central curvature; the center to the periphery measures 4 mm.

3. Results

This study included 60 eyes from 30 patients with a mean age of 12.05 ± 2.88 years (range = 10–18). Table 3 shows the pre- and post-treatment data for spherical equivalent and astigmatism. Mean values and standard deviation (SD) for the pre- and post-treatment of the selected patients are listed for each of the variables. The equivalent sphere of pretreatment was -4.05 ± 1.99 D, and OS was -4.30 ± 1.58 D. The *Jo* of OD was -0.26 ± 0.649 D, and *J45* was -0.32 ± 0.54 D. The *Jo* of OS was -0.39 ± 0.52 D, and *J45* was -0.26 ± 0.19 D.

Table 3. Descriptive statistics for population data collection

	M (D)		*J*0 (D)		*J*45 (D)		BCVA(log MAR)	
	OD	OS	OD	OS	OD	OS	OD	OS
Baseline	-4.05±1.99	-4.30±1.58	-0.26±0.64	-0.39±0.52	-0.32±0.54	-0.26±0.19	0.018	0.009
12 months	-1.02±0.85	-0.82±0.74	-0.75±0.38	-0.63±0.53	-0.51±0.24	-0.24±0.17	0.014	0.023

Table 4 shows the mean, SD, and statistical significance for the corneal topography differences between the pre- and post-treatment stages separately presented for each technique.

The change in refractive power after orthokeratology on the front surface at the central region, as well as the nasal 1–3 mm and temporal 1–3 mm distance, became negative and significantly decreased. The refractive power of elevation became positive in the nasal 3,4 and temporal 3,4 mm region.

Table 4. Pre- and post-treatment values of eye

	Baseline	12 months	
	Mean ± SD	Mean ± SD	*p*
N1	43.34±1.21	40.37±1.54	0.00
N2	43.55±1.02	41.25±1.20	0.02
N3	43.78±0.99	45.02±0.84	0.12
N4	43.51±1.32	44.22±0.96	0.125
C	43.92±0.83	40.43±1.01	0.00
T1	43.51±0.96	40.18±0.97	0.00
T2	43.94±0.85	41.82±1.04	0.01
T3	44.62±1.12	44.76±1.25	0.261
T4	45.14±1.37	45.64±0.95	0.391

4. Discussions

Topography is the most common method for peripheral curvature examination [7], particularly in LASIK and non-surgical evaluations [8, 9]. The data of this study showed the different alterations in the power of the anterior corneal surface from the center toward the peripheral cornea after the orthokeratomy lens. Results also demonstrated changes after days of lens wear. A previous study has reported that full corneal and visual changes occur and stabilize throughout waking hours after 1 week of orthokeratology.

The change in refractive error was also not associated with BCVA. The pre-treatment BCVA was not statistically significant by day 30 for evening measurements. In a previous study, the mean unaided VA significantly improved from a mean of 0.49 log MAR units (20/60) at baseline to -0.02 log MAR units (20/20) after just one night of overnight OK lens wear [10].

Based on a hypothesis that the periphery of the cornea becomes steep after orthokeratology [11], we assumed that the decrease in refractive was due to tissue recombination from the center to the periphery regardless of the treated zones that decreased the power between the central treated and peripheral non-treated zones [12]. As expected, quantitative analysis of the change in refractive power between pre- and post-treatment orthokeratology procedures presented remarkable differences.

Nevertheless, the present study did not analyze the different time points and back surface curvature. Another study has focused on changes in the corneal curvature obtained using other instruments such as Orbscan II and Pentacam and then evaluated the posterior elevation after surgery [13]. This result showed the overestimation of the peripheral thickness of the cornea by Orbscan II compared with that using ultrasound pachometry [14].

In conclusion, the results of this study confirmed previous ones that have reported a decrease in the power and curvature of the cornea, indicating the different features of the geometrical nature of the cornea. Previous reports of treated zones that decrease the power between the central treated and peripheral non-treated zones were also confirmed [15]. Overall, our results supported the current hypothesis that the orthokeratology refractive effect was primarily achieved through remodeling of the front surface corneal without overall corneal bending.

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