



Outcomes of orthokeratology: a nine-year retrospective review from a university-based optometry clinic in Malaysia

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ABSTRACT

Background: Orthokeratology (Ortho-K) is a non-surgical approach to myopia management that uses specially designed gas-permeable lenses to reshape the cornea temporarily and improve vision. While its efficacy is established, real-world data from diverse clinical settings remain limited. In this study we aimed to support evidence-based, individualized Ortho-K practice in routine optometric care by evaluating corneal and visual outcomes, lens designs, and treatment costs at a university-based optometry clinic in Malaysia.

Methods: In this retrospective study, we analyzed clinical records of individuals fitted with Ortho-K lenses at SEGi EyeCare, SEGi University, between January 2015 and October 2024. Eligible individuals were identified via electronic health records and included if they completed key follow-up visits at 1-night, 1–2-weeks, and 1–3-months post-dispensing. Exclusion criteria included incomplete records or missed follow-up visits. Data extracted included unaided distance visual acuity (UADVA) in logarithm of the minimum angle of resolution (logMAR), corneal topography (flat and steep keratometry, eccentricity), pupil size, treatment-zone diameter, age, lens design, and total treatment cost. Measurements were obtained using the Tomey TMS-5 topographer. For each patient, both eyes were analyzed independently.

Results: Data from 30 eyes of 15 patients (mean age and standard deviation [SD]: 23.3 [9.1] years) were analyzed. Significant improvements in corneal curvature and UADVA were observed across follow-up visits (all $P < 0.05$). Mean (SD) steep keratometry decreased from 43.79 (1.87) D to 42.08 (2.17) D, and flat keratometry from 42.40 (1.61) D to 40.59 (2.31) D at the final visit (both $P < 0.05$). UADVA improved from 0.93 (0.36) logMAR to 0.23 (0.24) logMAR ($P < 0.05$) at the final visit. Pupil size and treatment-zone diameter remained stable (both $P > 0.05$), indicating consistent lens centration. The mean (SD) Ortho-K cost per patient was RM3736.67 (514.25), equal to USD 846.20.

Conclusions: Ortho-K treatment at this university-based optometry clinic significantly improved corneal curvature, refractive error, and UADVA, with most clinical changes stabilizing within the first month of lens wear. The stability of pupil size and treatment-zone diameter suggests consistent lens performance. These findings affirm the effectiveness of Ortho-K as a non-surgical option for myopia management in real-world practice. Future studies should incorporate axial length measurements and extended follow-up to validate treatment efficacy in slowing myopia progression.

KEYWORDS

orthokeratology, corneal reshaping, treatment zone size, contact lens, corneal topographies, pupils, optometries, cost, malay federation

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INTRODUCTION

Orthokeratology (Ortho-K) is a non-surgical intervention in which specially designed rigid gas-permeable contact lenses are used to reshape the cornea temporarily, thereby reducing refractive errors [1]. They are safe to use owing to their high oxygen permeability and can improve the field of vision [2]. Measuring the changes in the shape of the cornea that are induced by Ortho-K can help to predict the success of the treatment [3]. Over the past decade, Ortho-K has gained increasing attention clinically, particularly in the management of childhood myopia, owing to its dual benefits in vision correction and in potentially slowing myopia progression [4, 5]. A recent study conducted by Ouzzani et al. [6] at a national referral contact lens clinic in Algeria has shown Ortho-K to be safe and effective, with a high success rate in initial fittings [6].

In Malaysia, the safety and effectiveness of Ortho-K among children and young adults have been examined in several studies [7-10]. A study involving young Malay adults reported central corneal thinning, without significant morphological changes in the mid-periphery, after 6 months of Menicon Z Night lens wear [7]. Among school-aged children in Kuala Lumpur, Ortho-K was found to improve vision-related quality-of-life significantly, supporting its utility as a myopia-control strategy in routine optometric care [8]. Recent magnetic resonance imaging-based investigations in Malaysian children with myopia children have also suggested that Ortho-K induces peripheral eye elongation, exceeding axial length changes, which contributes to a more oblate retinal shape [9]. This enhances peripheral myopic defocus, which is a mechanism believed to underlie the effect of Ortho-K in controlling myopia progression [9]. Furthermore, a study involving Malaysian schoolchildren aged 7-17 years has reported marked improvements in uncorrected visual acuity and reductions in corneal curvature in eyes with low and high myopia, yielding meaningful outcomes even in those with refractive errors up to -8.25 diopters (D) [10].

While these findings are valuable, these prior studies from Malaysia have largely been limited by narrow age ranges, single lens designs, and a relatively restricted set of clinical endpoints [7-10]. Thus, a more comprehensive evaluation is needed to reflect the diversity and complexity of Ortho-K use in real-world settings.

In this study, we sought to provide a more holistic understanding of Ortho-K practice in Malaysia to support individualized lens fitting decisions, by building upon existing evidence by examining Ortho-K outcomes across a broader demographic and a wider spectrum of refractive errors. We conducted longitudinal analyses of unaided distance visual acuity (UADVA), corneal topography parameters, pupil size, treatment-zone characteristics, lens brand/design, and associated treatment costs, thereby integrating clinical, optical, and economic data.

METHODS

This was a retrospective study with a longitudinal observational design, in which we analyzed clinical records of individuals who were fitted with Ortho-K lenses at SEG EyeCare, Faculty of Optometry and Vision Sciences, SEG University, Malaysia, between January 2015 and October 2024. Ethics committee approval was obtained for the study. The study adhered to the tenets of the Declaration of Helsinki. Informed consent was obtained from all individuals prior to Ortho-K lens fitting.

Eligible individuals were identified through electronic health record searches, based on the criterion of having been dispensed Ortho-K lenses at SEG EyeCare and having completed all scheduled follow-up visits. A list of Ortho-K lens purchases was obtained from SEG EyeCare, and the corresponding clinical records and corneal topography data were reviewed to confirm patient eligibility for enrollment. For inclusion, patients were required to have attended three key follow-up appointments: the first visit after the initial overnight lens wear, the second follow-up (between 1 and 2 weeks), and the third follow-up (between 1 and 3 months) after fitting. Exclusion criteria included incomplete clinical records, loss to follow-up, or having been dispensed Ortho-K lenses at SEG EyeCare without subsequent clinical evaluation at the same facility.

Relevant clinical and demographic data were extracted and compiled from patient records. The parameters recorded for each individual included age, Ortho-K lens design and brand, total treatment cost, UADVA (logarithm of the minimum angle of resolution [logMAR]), corneal topography readings, pupil size, and treatment-zone size. All types and brands of Ortho-K lenses were included to enhance the generalizability of the findings. UADVA was measured at each follow-up visit by using a computerized logMAR chart displayed on a calibrated LCD system. Comprehensive anterior and posterior segment examinations were conducted under a slit-lamp by an experienced optometrist. Topographic imaging, pupil size, and treatment-zone size were assessed using the Tomey TMS-5 Scheimpflug and Corneal Topographer system (Tomey Corporation, Nagoya, Japan).

Pupil size was measured based on a black circle with a central cross (Figure 1), while treatment-zone size was determined from the differential topography map, represented by a dotted line within the pupil boundary (Figure 2). For instance, in a representative case, the pupil diameter was 3.75 mm (Figure 1), and the treatment-zone size was 3.39 mm (Figure 2).

We also analyzed Ortho-K lens cost to provide insights associated with the therapy. All costs were reported in Malaysian Ringgit (MYR) and were converted to US dollars based on an exchange rate of 1 USD = 4.42 MYR (the average during the study period).

Data from both eyes of each subject, across all follow-up visits, were included in the analysis. Statistical analyses were performed using the SPSS software (version 22.0; IBM Corp., Armonk, NY, USA). Descriptive statistics were calculated for baseline variables, including UADVA, corneal topography parameters, pupil size, and treatment-zone size. The Shapiro-Wilk test, skewness, and coefficient of variation used to assess the normality of data distribution of continuous variables. For

normally distributed, repeated-measures data, a repeated-measures analysis of variance (RM-ANOVA) was conducted to assess changes over time. When the assumption of sphericity was violated, Greenhouse–Geisser corrections were applied. Post hoc pairwise comparisons were adjusted using the Bonferroni correction. For data that were non-normally distributed, the non-parametric Friedman test was used. A P -value < 0.05 was considered statistically significant

RESULTS

In this retrospective study, we reviewed the clinical records of 18 individuals who underwent Ortho-K treatment at our institution from October 2015 to June 2024. Three patients were excluded: one owing to incomplete topography data and two because of irregular follow-up that did not meet the study criteria. Thus, 15 patients (30 eyes) were included in the final analysis. For each individual, each eye was treated as a separate data point. The mean (standard deviation [SD]) age of patients at the initial visit was 23.3 (9.1) years. Of the 15 individuals, 26.7% ($n = 4$) were aged < 18 years, 26.7% ($n = 4$) were university students aged 18–24 years, and 46.7% ($n = 7$) were aged > 24 years. Table 1 summarizes the demographic and baseline refractive characteristics of participants.

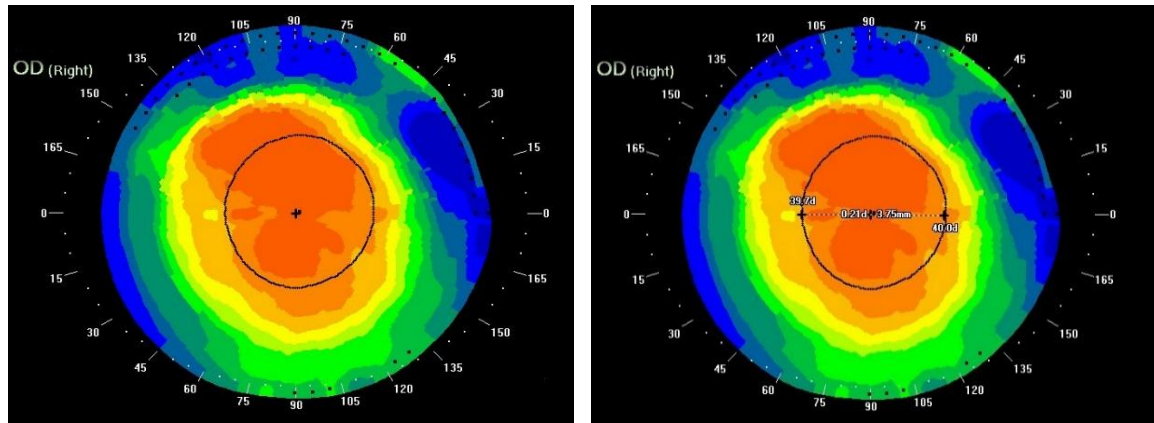


Figure 1. Representative post-orthokeratology (Ortho-K) corneal topography maps of the right eye, acquired using the Tomey TMS-5 Scheimpflug and Topographer device (Tomey Co., Ltd., Nagoya, Japan). The black circle with a central cross indicates the center and boundary of the pupil, with the pupil diameter measured at 3.75 mm in this representative patient. The orange-red central zone reflects the area of corneal flattening induced by the Ortho-K treatment. The dotted line inside the pupil boundary is used by the device to quantify pupil size.

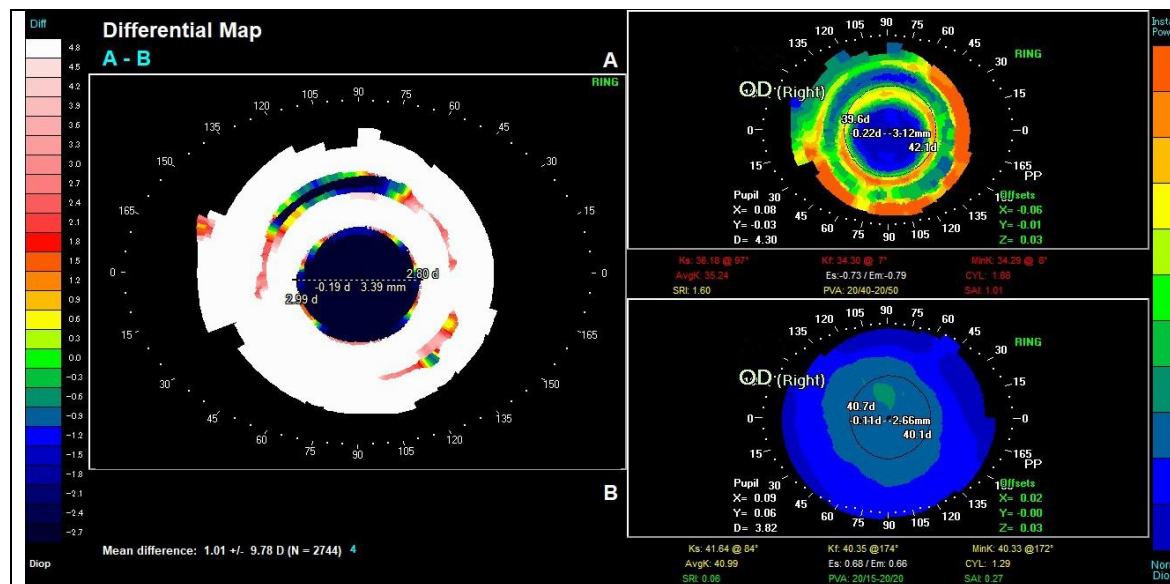


Figure 2. Differential corneal topography maps of the right eye, generated using the Tomey TMS-5 Scheimpflug and Topographer device (Tomey Co., Ltd., Nagoya, Japan). (A–B) Differential map displaying corneal curvature changes induced by orthokeratology (Ortho-K) lens wear. The inner dotted line represents the treatment zone, which measured 3.39 mm in this representative patient. The differential map highlights the magnitude and distribution of curvature change, with red and blue areas corresponding to steepening and flattening, respectively. (A– B) Pre-treatment map (B, bottom right) and post-treatment map (A, top right) used to generate the differential map. The post-treatment map illustrates central corneal flattening and mid-peripheral steepening, which is characteristic of effective Ortho-K treatment.

Table 1. Demographic and baseline refractive characteristics of the study participants

Variable	Values
Age (y), Mean $\pm$ SD (Range)	23.3 $\pm$ 9.1 (9 to 38)
Baseline spherical component of the refraction (D), Mean $\pm$ SD (Range)	- 4.00 $\pm$ 2.09 (- 8.75 to - 0.25)
Baseline cylindrical component of the refraction (DC), Mean $\pm$ SD (Range)	- 0.83 $\pm$ 0.91 (- 4.50 to 0.00)
Baseline spherical equivalent (D), Mean $\pm$ SD (Range)	- 4.43 $\pm$ 2.20 (- 9.38 to - 0.88)

Abbreviations: y, years; SD, standard deviations; D, diopter; DC, diopters cylinder. Note: The spherical equivalent was calculated by adding the spherical component of the refraction to half of the cylindrical component.

Table 2. Measured values of steep and flat keratometry, unaided distance visual acuity, treatment-zone size, pupil size, and corneal eccentricity across follow-up visits in the 30 included eyes

Variable	Mean $\pm$ SD	P-value
Steep keratometry (D)		
Baseline	43.79 $\pm$ 1.87	F(1.79, 51.99) = 34.16, $P < 0.05$
1st F/U	42.85 $\pm$ 1.64	
2nd F/U	42.00 $\pm$ 1.85	
3rd F/U	42.08 $\pm$ 2.17	
Flat keratometry (D)		
Baseline	42.40 $\pm$ 1.61	F(1.76, 51.14) = 28.27, $P < 0.05$
1st F/U	41.35 $\pm$ 1.61	
2nd F/U	40.58 $\pm$ 1.98	
3rd F/U	40.59 $\pm$ 2.31	
UADVA (logMAR)		
Baseline	0.93 $\pm$ 0.36	F(2.33, 67.56) = 34.16, $P < 0.05$
1st F/U	0.41 $\pm$ 0.47	
2nd F/U	0.21 $\pm$ 0.27	
3rd F/U	0.23 $\pm$ 0.24	
Treatment zone (mm)		
1st F/U	2.00 $\pm$ 0.44	F(1.42, 41.23) = 0.242, $P > 0.05$
2nd F/U	2.05 $\pm$ 0.47	
3rd F/U	2.05 $\pm$ 0.47	
Pupil size (mm)		
Baseline	3.74 $\pm$ 0.62	F(2.76, 80.15) = 0.248, $P > 0.05$
1st F/U	3.71 $\pm$ 0.55	
2nd F/U	3.72 $\pm$ 0.61	
3rd F/U	3.81 $\pm$ 0.68	
Eccentricity of the steep meridian		
Baseline	0.48 $\pm$ 0.21	F(2.55, 73.86) = 22.959, $P < 0.05$
1st F/U	0.24 $\pm$ 0.33	
2nd F/U	- 0.02 $\pm$ 0.39	
3rd F/U	- 0.01 $\pm$ 0.40	
Eccentricity of the flat meridian		
Baseline	0.45 $\pm$ 0.25	F(2.39, 69.41) = 34.687, $P < 0.05$
1st F/U	0.10 $\pm$ 0.37	
2nd F/U	- 0.21 $\pm$ 0.37	
3rd F/U	- 0.21 $\pm$ 0.42	

Abbreviations: SD, standard deviation; D, diopters; F/U, follow-up; UADVA, unaided distance visual acuity; logMAR, logarithm of the minimum angle of resolution; mm, millimetres. Note: Patients were required to have attended three key FU appointments: the first visit after the initial overnight lens wear, the second FU (between 1 and 2 weeks), and the third FU (between 1 and 3 months) after fitting; P -values < 0.05 considered statistically significant and are shown in bold; Repeated-measures analysis of variance was used to assess differences in measured parameters across three follow-up visits; The Greenhouse–Geisser correction was applied when the assumption of sphericity was violated; F, F-values are reported with corrected degrees of freedom where applicable; Eccentricity, in corneal topography, eccentricity is a dimensionless parameter that reflects corneal shape, indicating how much the cornea deviates from a perfect sphere. A value of 0 represents a perfectly spherical cornea; positive values indicate a prolate shape (steeper centrally and flatter peripherally, typical of a normal cornea), while negative values, when derived from vector analysis or specific topographic models, may represent an oblate shape (flatter centrally and steeper in the periphery [11, 12], which is often seen after orthokeratology treatment [13]).

Table 3. Pairwise comparisons of steep and flat keratometry, unaided distance visual acuity, and eccentricity of flat and steep meridians across follow-up visits in the 30 included eyes

Variable	Baseline to 1st F/U, MD (95% CI)	Baseline to 2nd F/U, MD (95% CI)	Baseline to 3rd F/U, MD (95% CI)	1st F/U to 2nd F/U, MD (95% CI)	1st F/U to 3rd F/U, MD (95% CI)	2nd F/U to 3rd F/U, MD (95% CI)
Steep keratometry (D)	0.938 (0.45–1.43)	1.790 (1.04–2.54)	1.707 (1.01–2.41)	0.852 (0.32–1.39)	0.769 (0.24–1.30)	0.084 (- 0.23–0.40)
Flat keratometry (D)	1.056 (0.58–1.54)	1.827 (1.09–1.56)	1.819 (0.95–2.69)	0.771 (0.24–1.30)	0.762 (0.04–1.48)	0.009 (- 0.43–0.45)
UDVA (logMAR)	0.518 (0.36–0.68)	0.721 (0.57–0.88)	0.705 (0.56–0.85)	0.203 (0.02–0.39)	0.187 (- 0.01–0.39)	0.015 (- 0.10–0.13)
Eccentricity of the steep meridian	0.239 (0.09–0.39)	0.494 (0.29–0.70)	0.491 (0.29–0.70)	0.255 (0.08–0.43)	0.252 (0.02–0.48)	0.002 (- 0.20–0.20)
Eccentricity of the flat meridian	0.350 (0.13–0.57)	0.661 (0.43–0.89))	0.656 (0.43–0.88)	0.311 (0.10–0.52)	0.306 (0.06–0.55)	0.004 (- 0.13–0.14)

Abbreviations: F/U, follow-up; CI, confidence intervals; D, diopters; UADVA, unaided distance visual acuity; logMAR, logarithm of the minimum angle of resolution. Note: Patients were required to have attended three key follow-up appointments: the first visit after the initial overnight lens wear, the second follow-up (between 1 and 2 weeks), and the third follow-up (between 1 and 3 months) after fitting; Bonferroni-adjusted pairwise comparisons were conducted following repeated-measures analysis of variance to determine the significance of differences in measured parameters across all follow-up visits; Adjusted 95% confidence intervals (CIs) are reported for each comparison; A P -value < 0.05 , after Bonferroni correction, was considered statistically significant. Values outside parentheses represent the Bonferroni-adjusted mean differences (MDs) between time points; values in parentheses indicate the corresponding 95%CI for each pairwise comparison; Eccentricity, in corneal topography, eccentricity is a dimensionless parameter that reflects corneal shape, indicating how much the cornea deviates from a perfect sphere. A value of 0 represents a perfectly spherical cornea; positive values indicate a prolate shape (steeper centrally and flatter peripherally, typical of a normal cornea), while negative values, when derived from vector analysis or specific topographic models, may represent an oblate shape (flatter centrally and steeper in the periphery [11, 12], which is often seen after orthokeratology treatment [13]).

Table 4. Measured components of refraction across follow-up visits in the 30 included eyes

Variable	Median (Range)	P -value
Spherical component of the refraction (D)		$\chi^2(2) = 72.86, P < 0.001$
Baseline	- 3.38 (- 8.75 to - 0.25)	
1st F/U	- 1.00 (- 6.00 to 0.50)	
2nd F/U	- 0.38 (- 4.50 to 0.75)	
3rd F/U	- 0.25 (- 2.75 to 0.50)	
Cylindrical component of the refraction (DC)		$\chi^2(2) = 10.13, P = 0.018$
Baseline	- 0.63 (- 4.50 to 0.00)	
1st F/U	- 0.25 (- 2.75 to 0.00)	
2nd F/U	- 0.13 (- 3.00 to 0.00)	
3rd F/U	- 0.25 (- 3.50 to 0.00)	
Spherical equivalent (D)		$\chi^2(2) = 73.53, P < 0.001$
Baseline	- 3.57 (- 9.38 to - 0.88)	
1st F/U	- 1.25 (- 6.13 to 0.50)	
2nd F/U	- 0.57 (- 4.50 to 0.75)	
3rd F/U	- 0.57 (- 3.38 to 0.50)	

Abbreviations: F/U, follow-up; D, diopter; DC, diopters cylinder. Note: Patients were required to have attended three key follow-up appointments: the first visit after the initial overnight lens wear, the second follow-up (between 1 and 2 weeks), and the third follow-up (between 1 and 3 months) after fitting; P -values are based on the Friedman test, a non-parametric alternative to repeated-measures analysis of variance, which is suitable for analyzing changes in ordinal or non-normally distributed continuous data across multiple related samples. The test statistic is reported as $\chi^2(df)$, where df indicates degrees of freedom; Spherical equivalent, the spherical equivalent was calculated by adding the spherical component of the refraction to half of the cylindrical component.

Data for all parameters, except for spherical power, cylindrical power, and spherical equivalent refraction, were normally distributed. An RM-ANOVA with Greenhouse–Geisser correction found no statistically significant differences in mean pupil size or treatment-zone diameter across time points (both $P > 0.05$). In contrast, significant differences were observed over time in the mean steep keratometry, flat keratometry, UADVA, eccentricity of the steep meridian, and eccentricity of the flat meridian (all $P < 0.05$; Table 2).

Post hoc analyses with Bonferroni adjustment (Table 3) revealed that steep keratometry and the eccentricity of the flat meridian differed significantly between all paired time points (all $P < 0.05$), except between the second and third follow-ups

($P > 0.05$). Flat keratometry, UADVA, and the eccentricity of the steep meridian showed statistically significant differences from the baseline to the first, second, and third follow-ups, as well as from the first to the second follow-up (all $P < 0.05$), but not between the first and third or the second and third follow-ups (all $P > 0.05$).

Friedman tests revealed significant differences in spherical power, cylindrical power, and spherical equivalent refraction across follow-up visits (all $P < 0.05$; Table 4). These results highlighted the efficacy of Ortho-K in reshaping the cornea and improving visual function in a clinical setting in Malaysia.

The mean (SD) cost for Ortho-K lenses per patient was RM 3736.67 (514.25) (RM 3736.67 = USD 846.20), with a range from RM 2000 (USD 452.89) to RM 4200 (USD 951.10).

Patients were fitted with Ortho-K lenses of one of three designs. Twenty eyes (66.7%) were fitted with the Fargo Ortho-K Lens (Paragon Vision Sciences, Inc., Gilbert, AZ, USA), seven (23.3%) with the OCUVIQ® Ortho-K Overnight Lens (Oculus Pte. Ltd., Singapore), and three (10.0%) with the OCUVIQ dK-4 Toric Ortho-K Overnight Lens (Oculus Pte. Ltd.).

DISCUSSION

In this study, we comprehensively evaluated Ortho-K outcomes in a real-world clinical setting in Malaysia. We demonstrated significant improvements in UADVA, corneal curvature, and corneal eccentricity in the Ortho-K-treated eyes over time. While the pupil size and treatment-zone diameter remained stable, meaningful refractive changes were observed across follow-up visits. Our inclusion of diverse lens designs and cost data in our analyses offers valuable insight into the clinical and economic dimensions of Ortho-K practice. Our findings support the effectiveness of Ortho-K in managing myopia across a broad age range and a wide refractive spectrum, highlighting its relevance to personalized care in routine optometric settings.

The average age of our participants was 23 years. This age is typical of Malaysian university students; whose ages usually range from 18 to 24 years [14]. In this study, 26.7% ($n = 4$) of the participants were university students aged between 18 and 24 years, while 46.7% ($n = 7$) were aged >24 years. This finding was consistent with Ezinne et al.'s study [15], who reported that the majority of contact lens wearers were aged 18–30 years, with only a small number aged over 40 years. This trend may be attributed to the greater awareness within this younger age group of the optical, occupational, and cosmetic advantages of contact lenses as compared to spectacles [16].

In the present study, both the steep and flat keratometry values reduced statistically significantly across follow-up visits, with most changes stabilizing within the first 2 months of Ortho-K lens wear. These findings were in agreement with those of Chen et al. [17], who observed a similar trend of corneal flattening in both meridians among 24 myopic children, aged 7–14 years, who were fitted with Euclid VST lenses over a 37-month period. In Chen et al.'s study [17], the flat keratometry decreased significantly within the first month and remained relatively stable thereafter, showing a cumulative reduction of 2.30 D by 36 months and 0.56 D by 37 months. The steep K values followed a comparable trend [17]. Despite a 1-month discontinuation of lens wear at the end of the study, neither keratometry-reading showed full regression to baseline, suggesting some degree of corneal structural adaptation [17]. Our study, which was conducted over a shorter time frame and involved a broader age range and multiple lens brands, also confirmed the occurrence of early keratometric flattening, but did not assess long-term retention of changes or post-discontinuation effects. These differences highlight how lens design, patient demographics, and study duration may influence the magnitude and persistence of corneal reshaping outcomes in Ortho-K treatment.

Previous research by Singh et al. [18] documented an average corneal flattening of 1.2 D within a period of 4 months, with the most significant change occurring after the first night of lens wear [18]. Consistent with these reports, our results demonstrated corneal flattening by approximately 1 D by 30–90 days of treatment, as compared to baseline. Our findings of significant reductions in both steep and flat keratometry values within the initial month after Ortho-K lens fitting are consistent with those reported by Lu et al. [19], who observed similar corneal flattening in a cohort of children with myopia, aged 8–12 years, who were fitted with Dreamlite lenses (CooperVision, Ramon, CA, USA). In their study, steep K values decreased significantly after 1 and 3 months of wear, with no significant difference between the 1- and 3-month marks, indicating early corneal reshaping and stabilization [19]. A parallel trend was observed for flat keratometry [19]. Our study mirrored this temporal pattern of early keratometric changes, even though our cohort included a broader age range and multiple lens designs than did earlier studies, highlighting that early corneal flattening appears to be a generalizable response across Ortho-K modalities and the treated population. Both studies [19] suggested that the first month of Ortho-K treatment is a critical period that requires careful monitoring, particularly regarding factors influencing discomfort linked to the decline in vision quality. In the present study, readings of steep and flat keratometry values stabilized as early as 7 days into Ortho-K treatment.

In the present study, pupil size did not change statistically or clinically significantly across the three follow-up visits, indicating relative stability during the early adaptation phase of Ortho-K treatment. This was in contrast to the findings of Zhu et al. [20], who reported a significant reduction in the photopic pupil diameter (PPD) within the first month of Ortho-K wear in children with myopia, with the effect persisting up to 3 months [20]. Their study suggested that this pupil constriction may be linked to slower axial elongation, particularly in those with baseline PPD ≤ 4.81 mm. Zhu et al. [20] proposed that changes in pupil size may reflect ocular adaptation to improved accommodative function and altered visual quality, which is influenced by factors such as retinal blur, illumination, and improved accommodation function [20]. The discrepancy

between the findings of the two studies may be attributed to differences in age groups, measurement conditions, and sample size [20]. Our older and more diverse population may have demonstrated less dynamic pupil responses. Although our data did not support significant pupillary changes, these observations highlight the need for future studies with longer follow-up durations and more sensitive measurement protocols to clarify the role of subtle pupillary dynamics in Ortho-K-mediated myopia control.

During the follow-up period, the UADVA gradually improved, which corresponded with the reduced refractive error that was observed during Ortho-K treatment. Our results also showed that the mean spherical power and spherical equivalent refraction demonstrated a statistically significant difference across follow-up visits. The use of Ortho-K lenses significantly reduced refractive error and caused flattening of the corneal curvature, leading to improved visual acuity. This improvement in vision is directly related to the corneal shape changes that are induced by the treatment, as the flattening of the cornea reduces its refractive power, thereby enhancing UADVA [10, 21]. A study conducted by Zhang et al. [22] examined the improvements in visual acuity at 30, 90, and 180 days after initiating Ortho-K lens wear. Their findings indicated that children of varying ages at Ortho-K initiation and refractive conditions can achieve a stable enhancement in visual acuity by using suitable Ortho-K lenses, ultimately reaching a consistent level of unaided daytime visual acuity [22]. In the present study, UADVA began to stabilize as early as 7 days after starting Ortho-K treatment.

In the present study, we found that the eccentricity values of both the steep and flat meridians changed significantly across visits. A steeper cornea from the center to the periphery before starting the Ortho-K treatment corresponded to a smaller treatment-zone diameter by 1 month after lens wear [23]. This relationship is linked to the steeper peripheral cornea exhibiting less eccentricity at the flattest meridian. Wang et al. [24] have suggested that slightly decentered Ortho-K lenses may be more effective in slowing myopia progression than are well-centered lenses, provided that uncorrected visual acuity remains acceptable and no significant corneal complications, glare, or ghosting are present [24].

The findings of the present study differ from those of previous studies in that the mean treatment-zone size remained relatively stable across visits, although a minimal, non-significant increase in mean treatment-zone size was noted between the first and second follow-ups. This contrasted with Guo et al. [25], who reported that the most significant changes in treatment-zone diameter occurred within the first 6 months of Ortho-K lens wear [25]. The discrepancy likely stems from the difference in the design of the lenses used. The university optometry clinic involved in the present study employed three different lens designs: 27 were spherical lenses and 3 were toric lenses, but a stable treatment-zone size was observed. Cylindrical power changed to a lesser extent by follow-up visits. Previous research has linked higher initial astigmatism with increased progression of refractive error over time, particularly in terms of myopic power [26].

The total costs of Ortho-K lenses were calculated in this study, based on the price per pair for each participant. This approach was used by Agyekum et al. [27], who conducted a cost-effectiveness analysis of myopia-control strategies in children from a societal perspective. That study found that Ortho-K was the most expensive intervention, with a total cost of 20 474 Hong Kong dollars (US \$15 347) over a 5-year period [27]. In the present study, the mean cost per patient to purchase Ortho-K was 3736.67 RM (USD 846.20).

A study by Holmes et al. [28], conducted in a university optometry clinic, highlighted concerns about the generalizability of retrospective study findings, as the university optometry clinic setting may not directly reflect primary care environments [28]. Their results encouraged the use of Ortho-K in general practice, particularly because their study population likely included those with myopic eyes who showed significant axial elongation by the 1-year follow-up, which is inversely correlated with age [28]. The present study, in which the mean participant age was around 23 years, is more applicable to adults seeking refractive error correction. Similarly, Skidmore et al. [29] evaluated the efficacy of two different types of lenses in a university optometry clinic setting, where different student clinicians performed measurements in patients at each visit, leading to inconsistencies in data collection [29]; this paralleled the data acquisition by student clinicians in the present study. As noted in a systematic review with a meta-analysis on Ortho-K-related studies conducted by Wang et al. [30], the retrospective nature of these studies may have introduced selection bias, while the unpredictable occurrence of lens decentration hampers double or triple blinding in a retrospective study, complicating the feasibility of conducting randomized controlled trials [30]. The present study aimed to investigate clinical parameters and visual outcomes of Ortho-K lens wearers in a university optometry clinic setting, where conducting randomized controlled trials with potential double blinding is feasible. Such a setting offers an opportunity to generate more rigorous evidence of the efficacy and safety of Ortho-K. Such clinical trials should be considered when planning future studies.

This study had several strengths, including its real-world clinical setting, inclusion of multiple lens designs, and comprehensive evaluation of visual, topographic, and economic outcomes across a diverse patient cohort. Its longitudinal design with multiple follow-up points enhanced the reliability of the observed treatment effects. However, it also had some limitations. The retrospective nature and relatively small sample size limit generalizability of the results. Additionally, axial length measurements, which is a key parameter in myopia control, were not included. Future research should incorporate larger, prospectively collected data from cohorts with axial length monitoring and quality-of-life measures to assess long-term efficacy and patient satisfaction better. Comparative studies between different Ortho-K lens designs and treatment protocols may also inform more personalized, cost-effective care strategies for myopia management in diverse populations.

CONCLUSIONS

Ortho-K treatment delivered in a university-based optometry clinic in Malaysia resulted in significant corneal flattening and improvements in UADVA, with most clinical parameters stabilizing within the first 30 days of starting lens wear. These results were obtained with varied lens designs and over a broad age range of individuals, which highlights the adaptability of Ortho-K across diverse patient profiles. While pupil size and treatment-zone dimensions remained stable, meaningful changes were observed in keratometry and corneal eccentricity, supporting the optical and biomechanical effects of Ortho-K in refractive correction. Treatment costs varied according to lens design, but remained within a comparable range. These findings reinforce the clinical utility of Ortho-K in myopia management and emphasize the need for personalized fitting strategies that are guided by both optical outcomes and patient-specific factors.

ETHICAL DECLARATIONS

Ethical approval: The study adhered to the tenets of the Declaration of Helsinki. Informed consent was obtained from all individuals prior to Ortho-K lens fitting. Ethics committee approval was obtained for the study.

Conflict of interests: None.

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REFERENCES

1. Bullimore MA, Johnson LA. Overnight orthokeratology. *Cont Lens Anterior Eye*. 2020 Aug;43(4):322-332. doi: [10.1016/j.clae.2020.03.018](https://doi.org/10.1016/j.clae.2020.03.018). Epub 2020 Apr 22. PMID: [32331970](https://pubmed.ncbi.nlm.nih.gov/32331970/).
2. Liu YM, Xie P. The Safety of Orthokeratology--A Systematic Review. *Eye Contact Lens*. 2016 Jan;42(1):35-42. doi: [10.1097/ICL.0000000000000219](https://doi.org/10.1097/ICL.0000000000000219). PMID: [26704136](https://pubmed.ncbi.nlm.nih.gov/26704136/); PMCID: [PMC4697954](https://pubmed.ncbi.nlm.nih.gov/PMC4697954/).
3. Chan B, Cho P, Mountford J. Relationship between corneal topographical changes and subjective myopic reduction in overnight orthokeratology: a retrospective study. *Clin Exp Optom*. 2010 Jul;93(4):237-42. doi: [10.1111/j.1444-0938.2010.00489.x](https://doi.org/10.1111/j.1444-0938.2010.00489.x). Epub 2010 Jun 23. PMID: [20579079](https://pubmed.ncbi.nlm.nih.gov/20579079/).
4. Nordin BA. Slowing Myopia Progression in Adolescents Using Orthokeratology: A Retrospective Chart Review. *Cureus*. 2025 Jun 30;17(6):e87073. doi: [10.7759/cureus.87073](https://doi.org/10.7759/cureus.87073). PMID: [40600105](https://pubmed.ncbi.nlm.nih.gov/40600105/); PMCID: [PMC12208949](https://pubmed.ncbi.nlm.nih.gov/PMC12208949/).
5. Lv H, Liu Z, Li J, Wang Y, Tseng Y, Li X. Long-Term Efficacy of Orthokeratology to Control Myopia Progression. *Eye Contact Lens*. 2023 Sep 1;49(9):399-403. doi: [10.1097/ICL.0000000000001017](https://doi.org/10.1097/ICL.0000000000001017). Epub 2023 Jul 20. PMID: [37471255](https://pubmed.ncbi.nlm.nih.gov/37471255/); PMCID: [PMC10442101](https://pubmed.ncbi.nlm.nih.gov/PMC10442101/).
6. Ouzzani M, Mekki MB, Chiali S, Kail F, Chahed L. Practice of orthokeratology in Algeria: a retrospective study. *J Optom*. 2021 Apr-Jun;14(2):176-182. doi: [10.1016/j.optom.2020.05.003](https://doi.org/10.1016/j.optom.2020.05.003). Epub 2020 Sep 26. PMID: [32988782](https://pubmed.ncbi.nlm.nih.gov/32988782/); PMCID: [PMC8093529](https://pubmed.ncbi.nlm.nih.gov/PMC8093529/).
7. Mohidin N, Mat Yacob A, Norazman FN. Corneal thickness and morphology after orthokeratology of six-month lens wear among young Malay adults. *Med J Malaysia*. 2020 Sep;75(5):538-542. PMID: [32918423](https://pubmed.ncbi.nlm.nih.gov/32918423/).
8. Mohd-Ali B, Low YC, Mohamad Shahimin M, Arif N, Abdul-Hamid H, Wan Abdul-Halim WH, Mohidin N. Comparison of vision-related quality of life between wearing Orthokeratology lenses and spectacles in myopic children living in Kuala Lumpur. *Cont Lens Anterior Eye*. 2023 Feb;46(1):101774. doi: [10.1016/j.clae.2022.101774](https://doi.org/10.1016/j.clae.2022.101774). Epub 2022 Oct 29. PMID: [36319519](https://pubmed.ncbi.nlm.nih.gov/36319519/).
9. Low YC, Mohd-Ali B, Shahimin MM, Mohidin N, Abdul-Hamid H, Mokri SS. Peripheral Eye Length Evaluation in Myopic Children Undergoing Orthokeratology Treatment for 12 Months Using MRI. *Clin Optom (Auckl)*. 2024 Feb 9;16:35-44. doi: [10.2147/OPTO.S448815](https://doi.org/10.2147/OPTO.S448815). PMID: [38351972](https://pubmed.ncbi.nlm.nih.gov/38351972/); PMCID: [PMC10863466](https://pubmed.ncbi.nlm.nih.gov/PMC10863466/).
10. Liong SL, Mohidin N, Tan BW, Ali BM. Refractive error, visual acuity, and corneal-curvature changes in high and low myopes with orthokeratology treatment: A Malaysian study. *Taiwan J Ophthalmol*. 2015 Oct-Dec;5(4):164-168. doi: [10.1016/j.tjo.2015.07.006](https://doi.org/10.1016/j.tjo.2015.07.006). Epub 2015 Sep 12. PMID: [29018692](https://pubmed.ncbi.nlm.nih.gov/29018692/); PMCID: [PMC5602134](https://pubmed.ncbi.nlm.nih.gov/PMC5602134/).
11. Heydarian S, Hashemi H, Shokrollahzadeh F, Yekta AA, Ostadimoghaddam H, Derakhshan A, Khabazkhoob M. The normal distribution of corneal eccentricity and its determinants in two rural areas of north and south of Iran. *J Curr Ophthalmol*. 2017 Dec 6;30(2):147-151. doi: [10.1016/j.joco.2017.11.006](https://doi.org/10.1016/j.joco.2017.11.006). PMID: [29988918](https://pubmed.ncbi.nlm.nih.gov/29988918/); PMCID: [PMC6033779](https://pubmed.ncbi.nlm.nih.gov/PMC6033779/).
12. Benes P, Synek S, Petrová S. Comparison of keratometric values and corneal eccentricity. *Coll Antropol*. 2013 Apr;37 Suppl 1:31-6. PMID: [23837219](https://pubmed.ncbi.nlm.nih.gov/23837219/).
13. Liu T, Ma W, Wang J, Yang B, Dong G, Chen C, Wang X, Liu L. The effects of base curve aspheric orthokeratology lenses on corneal topography and peripheral refraction: A randomized prospective trial. *Cont Lens Anterior Eye*. 2023 Jun;46(3):101814. doi: [10.1016/j.clae.2023.101814](https://doi.org/10.1016/j.clae.2023.101814). Epub 2023 Jan 20. PMID: [36681621](https://pubmed.ncbi.nlm.nih.gov/36681621/).

14. Mohd Azlan S, Mohamad F, Dahlan R, Ismail IZ, Kadir Shahar H, Kamaruddin KN, Shibraumalisi NA, Syed Mohamad SN, Shamsuddin NH. Self-system and mental health status among Malaysian youth attending higher educational institutions: A nationwide cross-sectional study. *Malays Fam Physician*. 2024 Feb 7;19:12. doi: 10.51866/oa.341. PMID: 38496770; PMCID: PMC10944643.
15. Ezinne NE, Bhattarai D, Ekemiri KK, Harbajan GN, Crooks AC, Mashige KP, Ilechie AA, Ziered FM, Osuagwu UL. Demographic profiles of contact lens wearers and their association with lens wear characteristics in Trinidad and Tobago: A retrospective study. *PLoS One*. 2022 Jul 22;17(7):e0264659. doi: 10.1371/journal.pone.0264659. PMID: 35867670; PMCID: PMC9307171.
16. Abokyi S, Manuh G, Otchere H, Ilechie A. Knowledge, usage and barriers associated with contact lens wear in Ghana. *Cont Lens Anterior Eye*. 2017 Oct;40(5):329-334. doi: 10.1016/j.clae.2017.05.006. Epub 2017 May 19. PMID: 28533022.
17. Chen X, Yang B, Wang X, Ma W, Liu L. The alterations in ocular biometric parameters following short-term discontinuation of long-term orthokeratology and prior to subsequent lens fitting: a preliminary study. *Ann Med*. 2023;55(2):2282745. doi: 10.1080/07853890.2023.2282745. Epub 2023 Nov 21. PMID: 37988719; PMCID: PMC10836244.
18. Singh K, Bhattacharyya M, Goel A, Arora R, Gotmare N, Aggarwal H. Orthokeratology in Moderate Myopia: A Study of Predictability and Safety. *J Ophthalmic Vis Res*. 2020 Apr 6;15(2):210-217. doi: 10.18502/jovr.v15i2.6739. PMID: 32308956; PMCID: PMC7151515.
19. Lu W, Song G, Zhang Y, Lian Y, Ma K, Lu Q, Jin Y, Zhao Y, Zhang S, Lv F, Jin W. The effect of orthokeratology lenses on optical quality and visual function in children. *Front Neurosci*. 2023 Apr 14;17:1142524. doi: 10.3389/fnins.2023.1142524. PMID: 37123367; PMCID: PMC10140410.
20. Zhu MJ, Ding L, Du LL, Chen J, He XG, Li SS, Zou HD. Photopic pupil size change in myopic orthokeratology and its influence on axial length elongation. *Int J Ophthalmol*. 2022 Aug 18;15(8):1322-1330. doi: 10.18240/ijo.2022.08.15. PMID: 36017053; PMCID: PMC9358181.
21. Kang SY, Kim BK, Byun YJ. Sustainability of orthokeratology as demonstrated by corneal topography. *Korean J Ophthalmol*. 2007 Jun;21(2):74-8. doi: 10.3341/kjo.2007.21.2.74. PMID: 17592236; PMCID: PMC2629700.
22. Zhang S, Zhu H, Zhang L, Gao M, Liu C, Zhao Q. Effects of orthokeratology on corneal reshaping and the delaying of axial eye growth in children. *Heliyon*. 2024 Jun 20;10(12):e33341. doi: 10.1016/j.heliyon.2024.e33341. PMID: 39022009; PMCID: PMC11253518.
23. Kou S, Ren Y, Zhuang X, Chen Y, Zhang X. Study on Related Factors of the Treatment Zone After Wearing Paragon CRT and Euclid Orthokeratology Lenses. *Eye Contact Lens*. 2023 Dec 1;49(12):521-527. doi: 10.1097/ICL.0000000000001035. Epub 2023 Sep 14. PMID: 37707469; PMCID: PMC10659246.
24. Wang A, Yang C. Influence of Overnight Orthokeratology Lens Treatment Zone Decentration on Myopia Progression. *J Ophthalmol*. 2019 Nov 15;2019:2596953. doi: 10.1155/2019/2596953. PMID: 31827908; PMCID: PMC6881772.
25. Guo B, Cheung SW, Kojima R, Cho P. Variation of Orthokeratology Lens Treatment Zone (VOLTZ) Study: A 2-year randomised clinical trial. *Ophthalmic Physiol Opt*. 2023 Nov;43(6):1449-1461. doi: 10.1111/opo.13208. Epub 2023 Aug 6. PMID: 37545099.
26. Lee YC, Wang JH, Chiu CJ. Effect of Orthokeratology on myopia progression: twelve-year results of a retrospective cohort study. *BMC Ophthalmol*. 2017 Dec 8;17(1):243. doi: 10.1186/s12886-017-0639-4. PMID: 29216865; PMCID: PMC5721542.
27. Agyekum S, Chan PP, Adjei PE, Zhang Y, Huo Z, Yip BHK, Ip P, Wong ICK, Zhang W, Tham CC, Chen LJ, Zhang XJ, Pang CP, Yam JC. Cost-Effectiveness Analysis of Myopia Progression Interventions in Children. *JAMA Netw Open*. 2023 Nov 1;6(11):e2340986. doi: 10.1001/jamanetworkopen.2023.40986. Erratum in: *JAMA Netw Open*. 2025 May 1;8(5):e2518553. doi: 10.1001/jamanetworkopen.2025.18553. PMID: 37917061; PMCID: PMC10623196.
28. Holmes M, Liu M, Singh S. Retrospective Analysis of Axial Length Changes in Overnight Orthokeratology in an Academic Myopia Control Clinic. *Optom Vis Sci*. 2023 Sep 1;100(9):597-605. doi: 10.1097/OPX.0000000000002060. Epub 2023 Aug 29. PMID: 37639686; PMCID: PMC10637306.
29. Skidmore KV, Tomiyama ES, Rickert ME, Richdale K, Kollbaum P. Retrospective review of the effectiveness of orthokeratology versus soft peripheral defocus contact lenses for myopia management in an academic setting. *Ophthalmic Physiol Opt*. 2023 May;43(3):534-543. doi: 10.1111/opo.13121. Epub 2023 Mar 15. PMID: 36919952.
30. Wang A, Shen L, Yang C. Influence of orthokeratology lens treatment zone decentration on myopia progression: a systematic review with meta-analysis. *Pediatric Medicine*. 2023 Aug 30;6:1-10. doi: 10.21037/pm-23-20.