

## CASE REPORT

# Asymmetrical Increase in Axial Length in the Two Eyes of a Monocular Orthokeratology Patient

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**ABSTRACT:** To report the myopia progression (change in axial length) of a boy in whom the progression was slower in the eye treated with overnight orthokeratology (ortho-k) than in the fellow eye with no visual correction. An 11-year-old boy was fitted with an ortho-k lens in his left eye in 1999 in a private practice. The refractive errors were OD  $-0.25 - 0.75 \times 168$  and OS  $-2.50 - 0.50 \times 170$  before commencing ortho-k lens wear. He participated in one of our research studies and made yearly visits to our clinic in 2001, 2002, and 2003. Logarithm of the minimum angle of resolution (logMAR) visual acuity, refraction, ocular health, and axial length were assessed at each visit. At the visit in 2003, the unaided visual acuity was OD 0.40 logMAR and OS  $-0.04$  logMAR. Between 2001 and 2003, there was a small increase in axial length in the left eye (0.13 mm) but a significant increase in the axial length (0.34 mm) with a corresponding increase in spherical equivalent refractive error (0.75 D) in the right eye. This case suggests that myopia progression may have been slowed down by ortho-k lens wear in the eye undergoing treatment of a boy undergoing unilateral ortho-k treatment. (*Optom Vis Sci* 2004;81:653-656)

Key Words: orthokeratology, refractive error, myopia control, axial length, unaided visual acuity

Temporary myopia reduction with orthokeratology (ortho-k) did not gain widespread popularity until the past decade. The revived interest in ortho-k was the result of the development of high oxygen-permeable rigid lens materials for overnight wear modality, new and better lens design for faster and more predictable myopia reduction, and sophisticated equipment that allows better and more accurate monitoring of corneal changes. Ortho-k treatment has been shown to be effective and with lower risk of corneal adverse effects (compared with earlier forms of ortho-k) for patients with low to moderate myopia and mild with-the-rule astigmatism.<sup>1-4</sup>

In Hong Kong, the majority of overnight ortho-k patients are school-age children who wear the lenses for myopia control.<sup>5</sup> Prevalence of myopia in the region is high. It increases from 11% at the age of 7 years and 55 to 57% at the age of 12 years to >70% at the age of 17 years.<sup>6,7</sup> It is not surprising that despite the lack of scientific evidence on the efficacy of overnight ortho-k for myopia control, many parents are eager to try this treatment that does not require the children to wear lenses during the daytime and that has a potential to slow the progression of myopia of their children.

The efficacy in myopia control is usually studied by assessing the change in the refractive error and the axial length during a time

period.<sup>8-12</sup> However, because ortho-k temporarily reduces the amount of myopia and the amount of reduction is affected by the lens fitting, the change in the refractive error cannot be used as an indication for assessing myopia progression in eyes undergoing ortho-k.

In this article, we present the changes in the axial length, the unaided visual acuity, and the refractive error during a 2-year period in a boy who had undergone ortho-k treatment in the left eye and had no lens wear in the right eye.

## CASE REPORT

In 2001, a 13-year-old boy was referred by a private practitioner (DF), who is an experienced ortho-k practitioner, to the Optometry Clinic of The Hong Kong Polytechnic University (the PolyU Clinic) to participate in a retrospective study on the effects of ortho-k, for which ethics clearance was obtained from The Hong Kong Polytechnic University. The boy had been receiving ortho-k treatment since 1999, and he was fitted in the left eye only. After our first consultation with the boy in 2001, we invited him to come back in 2002 and 2003 to monitor ocular changes. All three annual visits to the PolyU Clinic were carried out in August while the boy was on summer vacation.

## Ortho-k History As Provided by the Private Practitioner

In 1999, the boy failed his school's vision screening, and his parents brought him to an optical shop for an eye examination. The left eye of the boy was myopic, whereas his right eye was almost emmetropic. A pair of spectacles was prescribed but was seldom worn because the boy did not like wearing spectacles.

Although his mother was an emmetrope and his father was a moderate myope (OD  $-4.00$  D, OS  $-3.50$  D), they were concerned about the significant myopia progression among schoolchildren in Hong Kong. The father heard about ortho-k for myopia control from a colleague whose child was undergoing the treatment in DF's practice. Therefore, they brought the boy to DF for ortho-k. The initial refractive error and the keratometric readings (horizontal/vertical) of the boy were OD  $-0.25 - 0.75 \times 168$  (43.00 D/44.00 D) and OS  $-2.50 - 0.50 \times 170$  (43.50 D/44.00 D).

The external and internal ocular health examinations were unremarkable, and there was no contraindication for overnight ortho-k lens wear. Other alternatives for myopia control were presented to the parents, and overnight ortho-k was chosen because it allowed the boy to be spectacle-free in the daytime. DF suggested fitting the left eye only, and the parents agreed with this suggestion. After trial lens fitting, a WAVE lens (Wave Contact Lens System LLC, Veda Beach, FL) was ordered for the left eye: target reduction,  $-2.50$  D; back vertex power,  $+1.23$  D; base curve,  $8.47$  mm; back optical zone diameter,  $6.0$  mm; fitting curve width,  $0.6$  mm; alignment curve width,  $1.3$  mm; diameter,  $10.6$  mm; and central thickness,  $0.22$  mm.

The boy began ortho-k lens wear in November 1999. He wore the lens 6 nights per week, and the average wearing time was 9 hours per night. His mother cleansed the lens using the Alcon system (Opti-Free Daily Cleaner, Saline, Opti-Soak, and Supra-Cleans Daily Protein Remover; Hong Kong). The manifest refractive error in July 2000 was OD  $-0.25 - 0.75 \times 170$  and OS  $-0.25 - 0.25 \times 180$ .

The lens was replaced in August 2001 with a lens of local lens four zones design (dK4, The Opticraft Ltd, Hong Kong). The same laboratory (Custom-craft Lens Service, Las Vegas, NV) lathed the new and old lenses, and the fitting of the new lens was similar to that of the old lens. The parameters of the new lens are as

follows: target reduction,  $-2.50$  D; back vertex power,  $+0.83$  D; base curve,  $8.39$  mm; back optical zone diameter,  $6.0$  mm; fitting curve width,  $0.6$  mm; alignment curve width,  $1.4$  mm; diameter,  $10.8$  mm; and central thickness,  $0.22$  mm.

## Yearly Examinations at the PolyU Clinic in 2001 to 2003

The boy was examined at the PolyU Clinic annually. He was requested to wear the lens the night before the day of examination and to bring the lens to the clinic on the day of examination. He was examined within 1 to 6 hours after lens removal.

Ocular examination comprised automated keratometry (Canon RK-5, Tokyo, Japan), non-contact tonometry (Nidek NT-2000 NCT, Gamagori, Japan), corneal topography (Medmont E-300, Vermont, Victoria, Australia), slitlamp biomicroscopy, and the measurement of the corneal thickness (Orbscan, Bausch & Lomb, Rochester, NY), in that order. Any abnormality observed with the slitlamp was recorded and graded using the Efron scale.<sup>13</sup> Subjective refraction, after retinoscopy, was performed using trial frame and Snellen chart, with the minimum minus dioptric power giving the best visual acuity as the end point. The unaided and aided logarithm of the minimum angle of resolution (logMAR) visual acuities (Early Treatment Diabetic Retinopathy Study series, Precision Vision) then were assessed. The boy was asked to put on his lens, and over-refraction was performed on the left eye. Ultrasound biometry (SONOMED A-5500, Lake Success, NY) was performed after lens removal and after the instillation of 1 drop of 0.4% benoxinate in each eye. Corneal condition of each eye was re-examined after the ultrasound biometry. The right eye was assessed first and then the left eye. The back vertex power and the back optical zone radius were verified at the end of the examination.

Corneal topography showed well-centered treatment zone at the three visits. No central corneal staining was observed at the three visits. Grade 2 peripheral corneal staining at the inferior cornea was observed in the left eye in 2003. No pigmented arc was observed in the examination in 2001 and 2002, but a faint brownish arc was observed in 2003. The central corneal thickness, keratometry, and apical radius were clinically stable during the monitoring period (Table 1).

**TABLE 1.**

Postorthokeratology keratometric readings, apical radius and central corneal thickness, visual acuity, manifest refractive error, and axial length data obtained at three yearly visits

	Right Eye			Left Eye		
	2001	2002	2003	2001	2002	2003
Flattest keratometric reading (D)	43.00	43.00	43.00	42.00	41.50	41.50
Steepest keratometric reading (D)	43.75	43.75	43.75	43.25	43.00	43.00
Apical radius (D)	43.7	43.4	43.6	41.9	40.9	41.1
Central corneal thickness (mm)	584	574	570	565	573	562
Unaided logMAR visual acuity	0.14	0.30	0.40	-0.08	-0.02	-0.04
Manifest refractive error (D)	$-0.25/-0.50 \times 180$	$-1.00$	$-1.25$	$+0.50/-0.50 \times 190$	$+1.00$	$+0.75$
Axial length (mm)	23.40	23.62	23.74	23.92	24.03	24.05

At all visits, the post-ortho-k unaided logMAR visual acuity in the left eye was better than the unaided logMAR visual acuity in the right eye. The unaided visual acuity in the right eye was progressively reduced at each visit and was accompanied by an increase in the refractive error and the axial length (Table 1). The change in residual refractive error (lens removed) and the axial length of the left eye was clinically insignificant (Table 1). There was little change in the refractive error with the lens *in situ*.

The boy was wearing the dK-4 lens when we first saw him in 2001, and he wore the same lens in 2002 and 2003. He was prescribed a new ortho-k lens in the left eye with the same parameters for routine replacement after his last visit to the PolyU Clinic in 2003.

In 2002, the lens care regimen was changed to CIBA VISION Titmus H<sub>2</sub>O<sub>2</sub> (Hong Kong) and Menicon Progent (Nagoya, Japan) for removing the protein on the lens surface; the latter was regularly performed once every 2 to 3 weeks. In mid-2003, the boy was advised to take responsibility of the lens care procedures; therefore, the boy took over the lens cleaning, and he wore the lens every night.

## DISCUSSION

In this case study, we found that the myopic eye that was undergoing ortho-k treatment showed a slower rate of axial length growth than the contralateral emmetropic eye. The parents, the child, and the practitioner were satisfied with the results. During the 2-year monitoring period at the PolyU Clinic, the increase in axial length was 0.13 mm in the left eye (ortho-k lens wear) and 0.34 mm in the right eye (no lens wear). The increase in myopia expected from the change in axial length was 0.36 D and 0.94 D, respectively.<sup>14</sup> For the ultrasound biometer used, the 95% limits of agreement have been found to be  $-0.29$  to  $0.19$  mm (unpublished data). It is possible that the difference in the axial length measurements of the right eye may be the result of test-retest variability of the instrument; however, considering the findings for both eyes, we do not think it was likely.

Development of the refractive error in the two eyes of infants has been widely studied because anisometropia is associated with amblyopia and strabismus during the critical period of visual development.<sup>15, 16</sup> However, reports of the development of refractive error of the two eyes for children and young adolescents are few.

During a 3-year longitudinal study on the refractive error in 238 children with myopia, aged 9 to 11 years, the difference in the refractive error between the two eyes remained unchanged in 67% of the children, increased ( $>0.25$  D) in 27% of the children, and decreased ( $>0.25$  D) in 6% of the children.<sup>17</sup> In another study, among 83 seven-year-old children who had completed the 5-year study, 2 children were anisometropic ( $>1.00$  D) at the age of 7 and remained anisometropic at the age of 12. For the remaining 81 nonanisometropic children, 90% remained nonanisometropic at the age of 12.<sup>7</sup>

Parssinen commented: "changes in the other direction seem to occur only exceptional."<sup>17</sup> Therefore, in the light of limited available evidence, the change in the refractive error in the two eyes is probably symmetrical in the majority of children, although anisometropia may increase in some cases. We believe that in the cur-

rently reported case, if no effective intervention had been introduced, it is most likely that the change in the refractive error in the two eyes of the boy would be similar. It is less likely that the increase in myopia would be faster in the right eye, leading to a decrease in the amount of anisometropia.

The main limitation of this case was the lack of pretreatment axial length data for either eye. However, by following the case for two consecutive years, monitoring of the effect of ortho-k on myopia progression for this particular subject was performed.

This case report is not an attempt to confirm the efficacy of ortho-k for myopia control but to demonstrate that myopia progression may have been slowed by ortho-k in the eye undergoing the treatment for this particular boy. It is unclear whether ortho-k can slow axial length growth for all the children undergoing the treatment; however, a 2-year longitudinal study on myopia control using ortho-k at The Hong Kong Polytechnic University has been completed, and the result is pending.

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