

ORTHOKERATOLOGY and VISION THERAPY to MANAGE ACCOMMODATIVE ESOTROPIA A Case Study

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Abstract

This case describes a six-year-old girl with a comitant, constant, alternating, accommodative esotropia with hyperopia. The esotropia was intermittent and evident since infancy and became increasingly constant with age. Management of accommodative esotropia involves the application of plus to reduce accommodative effort. While other options had been tried or considered, I used orthokeratology to correct the hyperopia and vision therapy to manage the binocular function and sensory anomalies associated with the esotropia.

Key Words

accommodative esotropia, contact lenses, orthokeratology, hyperopia, vision therapy, AC/A ratio, spectacle plus lenses

INTRODUCTION

Esotropia (ET) is the most common type of strabismus, occurring in approximately 1-2% of the population. It can be further divided into various groups, e.g., infantile, refractive, and accommodative, requiring different prognoses and approaches to treatment. One of these groups, accommodative ET, develops between the ages of six months and seven years, most often in two- to three-year-olds, and is related to an abnormal accommodation-convergence relationship.¹

Accommodative ET occurring in young children is an excellent illustration of abnormal binocular visual function caused by an uncorrected or undercorrected refractive condition. While accommodative ET is usually associated with moderate hyperopia, it also may occur in lower amounts of hyperopia, emmetropia or even myopia due to unusually high AC/A ratios.^{2,3}

Accommodative ET arises because of an abnormal relationship between accommodation and convergence. Normally there is a linear relationship between the two, but in accommodative ET this relationship is higher than normal, resulting in an over convergence response to accommodation.³

The primary treatment for accommodative ET typically involves full-time wearing of ophthalmic lenses or contact lenses to correct the refractive condition, which is most usually hyperopia. The lenses reduce the accommodative effort

thereby decreasing the associated convergence and the eyes tend to straighten so that less esophoria or esotropia results.⁴⁻⁷

The effect of correcting the hyperopia and the binocular imbalance may have further benefits to the child. There is evidence that there is relationship between hyperopia and reading.^{8,9} These findings also suggest a relationship between hyperopia and reading-disabled students.¹⁰⁻¹⁵

TREATMENTS

Spectacle Correction

The conventional approach to management of accommodative ET is to provide the patient with single vision plus (convex) lenses and/or bifocal spectacles.^{3,4} However, compliance with wearing the spectacle lenses, often in a bifocal or progressive lens design, can lead to non-compliance with children for reasons that include: appearance (cosmesis), social and peer pressure effects, and simply not understanding the need to wear the lenses.

Contact Lenses

These devices have the property of reducing prismatic effect during near work, and they do not produce spectacle magnification. Further there is no cosmesis component as with spectacles. In this regard they can provide a viable option to treat accommodative ET. However, in young children, insertion, removal, and daily care can be a significant obstacle to compliance.

Refractive Surgery

Another option for treatment of accommodative ET is hyperopic laser in situ keratomileusis (LASIK). Several studies have shown the efficacy of this procedure in adults.¹⁶⁻¹⁸ Though there was some success in adults, there is still no evidence of the use of LASIK in children for hyperopia and esotropia.

Orthokeratology

I propose that a fourth option is the use of orthokeratology (Ortho-K) to correct the hyperopia. Just as providing an appropriate lens correction, Ortho-K may be effective in managing horizontal vergence problems e.g., accommodative esophoria or ET. Ortho-K is a clinical contact lens technique that can be defined as the “reduction, modification, or elimination of refractive error by the application of contact lenses.”¹⁹ It had lost favor in the late 1970’s and early 1980’s, due to the unpredictability reported in several controlled studies.^{20,21} However, the use of Ortho-K for myopia and astigmatism reduction has more recently been shown to be effective.²²⁻²⁵ In view of the high incidence of myopia in Chinese children, overnight Ortho-K has become a popular treatment for myopia control in Hong Kong.^{26,27}

LENS DESIGN FOR HYPEROPIC ORTHO-K

The use of Ortho-K for hyperopia reduction has not been generally investigated clinically or, if so, it is only on a minimal and subjective basis. Contact lens designs for the correction of hyperopia through Ortho-K are being developed in Australia and in the USA. In principle, these lenses aim to gently steepen the cornea, increase corneal optical power, and thus correct the hyperopia.

The traditional method of managing hyperopia by Ortho-K is to apply a series of progressively steeper GP (oxygen permeable) contact lenses in order to move the corneal tissue toward its central portion.²⁸⁻³⁰ However, anecdotal reports have found that often the tissue piles up at the mid-peripheral portion instead of at the central portion of the cornea; this can flatten the central cornea curvature and increase the hyperopia.

To address this, I designed the dual geometric lens,³¹ intended for the reduction of hyperopia by Ortho-K. It is a re-

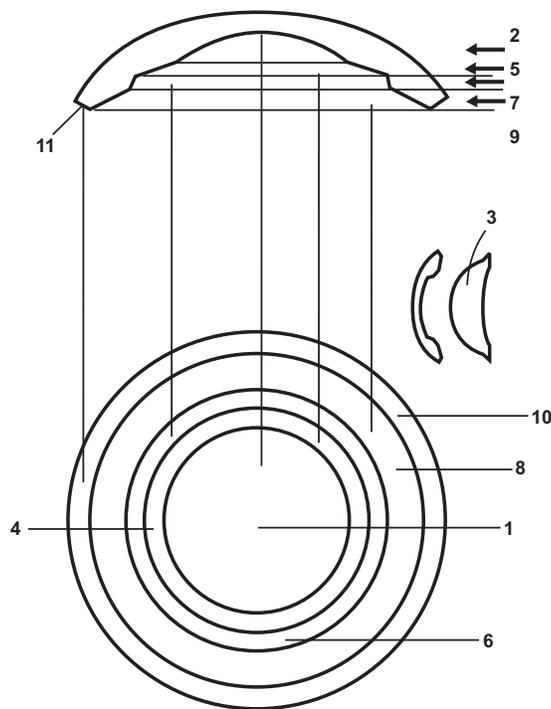


Figure 1. Dual geometric lens for hyperopic presbyopia or multi-focal ortho-K. There are one or more optical zones used to redistribute corneal tissue to cause the cornea to have a steepened central portion surrounded by a flat mid-peripheral ring.³¹

verse design to the traditional Ortho-K lens for myopia. (Figure1)

The contact lens has a plurality of zones that includes one or two optical zones, a plateau zone, a fitting zone, an alignment zone and a peripheral zone. The one or more optical zones are utilized to redistribute corneal tissue to cause the cornea to have a steepened central portion surrounded by a flat mid-peripheral ring. The plateau zone helps steepen the central cornea in two ways: a positive molding effect of pushing the cornea tissue inward to pile up, and a negative molding effect to enhance flattening of the mid-peripheral cornea.

The optical zone of the lens is designed steeper than the measured curvature of a central portion of the cornea. This is intended to provide a steep central space for cornea tissue to pile up during vision correction. This is accomplished by using the mean keratometry measurements in diopters and the spherical equivalent of the refractive condition to determine the Base Curve or Back Optic Zone Radius (BOZR). The BOZR targets the total correction plus an additional +0.75 diopters to ensure a full reduction. In concert with

An ortho-K contact lens comprising:

A. An optical zone (1) having a curvature defined by a base curve (2), the base curve being steeper than a measured curvature (3) of a central portion of said cornea;

B. A plateau zone (4) coupled to the optical zone and extending radially there from the plateau zone having a curvature defined by a plateau curve (5), the plateau curve being flatter than the base curve (2).

C. A fitting zone (6) coupled to the plateau zone and extending radially there from, the fitting zone having a curvature defined by a fitting curve (7), the fitting curve being steeper than the plateau curve.

D. An alignment zone (8) coupled to the fitting zone and extending radially there from the alignment zone having a curvature defined by an alignment curve (9), the alignment curve being flatter than the fitting curve.

E. A peripheral zone (10) coupled to the alignment zone and extending radially there from the peripheral zone having a curvature defined by a peripheral curve (11), the peripheral zone forming an edge lift to act as tear reservoir.

the BOZR is the plateau zone which is approximately 5 to 20 diopters flatter than the central BOZR and blends into the fitting zone. The fitting zone is 10 to 30 diopters steeper than the plateau zone and brings the lens back into alignment with the peripheral cornea. The balance of the lens is the alignment curve, which is aspheric and provides centration and approximately 100µ of edge lift to facilitate tear circulation and prevent lens binding. The anterior surface of the lens consists of a central power curve to correct the distance vision. Generally speaking, the lens has a central optical zone steeper than the central cornea. This is followed by a flat plateau zone to prevent tissue pile up at the mid peripheral area when trying to push the tissue all the way into the central portion of the cornea.

The dual geometric designs may also be used for correcting hyperopic presbyopia (HP lens). This lens provides a steep central button for reading and a sloping pericentral zone for correcting hyperopia. The BOZR of a HP lens is determined in a similar way to target hyperopia plus the add required for correction. This multi-focal ortho-K design can also be

used to eliminate or to relieve the excessive convergence, triggered by near-work accommodation in cases with high AC/A ratios.

The dual geometric lens is matched to the individual cornea by the same principle of sagittal depth calculation in myopia Ortho-K correction.³²

CASE REPORT

This case report describes the use of a unique contact lens design that provides Ortho-K treatment of hyperopia and vision therapy (VT) for a six-year old female patient with accommodative ET.

History

A colleague referred a six-year-old girl (MB) to me requesting an evaluation of an ET. She appeared shy but cooperative. The ET was apparently evident even with her spectacles. Her parents reported they noted MB to have intermittent ET, more in her left eye during infancy. The intermittent ET became constant gradually with age. After visiting a pediatric ophthalmologist, she was confirmed to have moderate hyperopia and accommodative ET at about two years of age. Plus lens and partial time right eye occlusion were initiated as treatment. She was willing to wear the glasses only for close work because of the heaviness and unpleasant appearance of her glasses.

There was no reported family history of strabismus. The birth history was also uneventful and normal. There was no reported febrile events, trauma or acquired head injury during her infancy. She was in good health and was not taking any medications.

Diagnostic Data

Her entering prescription was: OD: +1.75 DS, OS: +2.00 DS. Her corrected visual acuities were: OD: 20/25 and OS: 20/25. Without correction the ET was comitant, and cover testing revealed 35 prism diopters of constant alternating ET.

With correction, the strabismic angle decreased to approximately 8-10 prism diopters of constant alternating ET at far and near. Dry and wet (2% cyclopentolate and 1% tropicamide) retinoscopies and subjective refractions indicated: OD: +2.75 DS, OS: +3.00 DS. The best correctable visual acuity was 20/20 in each eye.

Pupillary responses were present with no afferent defect. External and internal ocular examinations were unremarkable

for all eye structures including: cornea, crystalline lens and retina.

Initial Diagnosis and Management

The diagnosis was comitant, constant, alternating basic accommodative ET with a preference for the right eye for fixation, without amblyopia. A new prescription of OD: +2.75, OS: +3.00 was issued with instructions for constant wear.

Follow Up Visit

We scheduled another visit to evaluate her binocular vision status one month later. MB's mother reported poor compliance with the spectacle wearing instructions. The Keystone Vision Tester^a and Random Dot Stereogram in the Vision Therapy Assessment (VTA)^b were used. With the new prescription MB demonstrated only simultaneous perception, and the binocular alignment test indicated eso posture (uncrossed diplopia). The useable vision, Random Dot Stereogram and Worth 4-Dot Tests established that there was a constant suppression of the left eye. Based on her history and early onset of the ET, the lack of stereopsis and suppression in the left eye may be associated with a monofixational esophoria-tropia.^{33,34}

Considering her age, personality, and poor compliance with the lenses as well as good vision with each eye, I considered alternative treatments. Contact lenses were a possibility, but I decided to offer my new hyperopic Ortho-K protocol. My goals were to reduce the hyperopia and consequently reduce the esotropia with the possibility of enhancing her overall binocular status. The girl and her mother were pleased to have an alternative to the glasses.

Treatment Rationale

Step 1: Fitting TRIAL hyperopia Ortho-K contact lenses

I fit all Ortho-K patients, including those with myopia, with my standardized trial fitting system.^c The system utilizes subjective spherical equivalent and mean corneal curvature measurements for lens selection, which then are verified by fluorescein stain before ordering lenses from specific contact lens laboratories in the United States. In this case I ordered from E & E Optics.^d The original corneal curvatures were: 44.50/44.75 @90 with a mean K of 44.62 D, in each eye. The manifest refraction, as aforementioned, was, OD: +2.75D and OS: +3.00D. My initial

fitting rationale was to overcorrect the manifest hyperopia by +0.75D; consequently, I used the base curve of 6.94mm radius for the OD, 6.87 mm for the OS. I instructed the patient's mother in lens insertion and removal and that the devices were to be worn overnight. I further instructed that the spectacle lenses were to be worn during all other hours until MB experienced blurred vision with them; at this time, the glasses should not be worn.

My examination on the first morning showed a mild cornea superficial punctate keratitis (SPK) at the nasal lower portion of the left eye. This did not occur on subsequent nights and the initial SPK was likely due to her mother not being adept with the insertion and removal of the lenses. The central portion of the cornea gradually steepened following two weeks of night wear and her manifest refraction became OD: plano and OS: +0.50

After two weeks on this protocol, her eyes appeared better aligned, but MB was still intermittently esotropic at near. Binocular sensory testing still showed uncrossed diplopia without stereopsis. An addition of +2.00 D. OU changed the residual ET at 40cm to slight esophoria. We continued to monitor her refractive status and binocular status. After approximately four weeks of wearing these lenses, I instituted a program of vision VT. The immediate goal was to eliminate the residual ET. See the discussion of VT below.

Step 2: Multifocal Ortho-K Contact Lenses

I now proceeded to the next step of multifocal molding. I designed these lenses so that the base curves were much steeper than the central portion of the cornea and overcorrected her hyperopia by 2.00 diopters. The base curves of the contact lenses now became OD: 6.67 mm and OS: 6.60 mm. The aspheric base curves were carefully calculated to ensure shaping a new corneal curvature that provided good far visual acuity, while relieving the near stress of accommodation after molding.

The Ortho-K lenses were manufactured using Boston® XO lens material (Bausch and Lomb, Rochester, New York). This is a tough, stable, high Dk material that can be made into a wide variety of special designs for special visual requirements. This material has an ISO/Fatt Dk of 100 with an established record as a

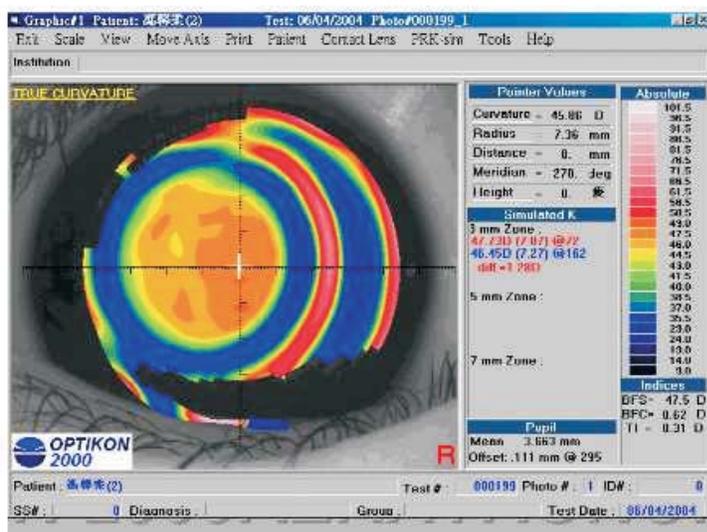


Figure 2. Corneal Topography illustrates the central corneal steepening



Figure 3. This illustrates the fluorescent stain pattern with central pooling and Bull's eye pattern.

premium extra oxygen exceptional stability GP material for overnight wear. In this case, I recommended a wearing schedule of 8-10 hours per night for the initial period of several days until the cornea demonstrated a steepened central button. This then could be reduced to a maintenance wear of 6-8 hours per night. The pair of multifocal Ortho-K lenses effectively straightened her eyes to ortho at near and far without glasses. The corneal topography showed much steeper central buttons as evidence of the additional plus lens effect for relieving her accommodation and excessive convergence during near-work. (Figures 2 and 3)

The second pair of lenses were dispensed five weeks after the initiation of VT. The distance refractive status became slightly myopic (-0.50 D OU) without much interference to her daily life. Her visual acuity remained stable (20/20 in each

eye) as before at distance and near. Her eyes appeared aligned and were cosmetically straighter at both far and near though there were variable and small amounts of an eso deviation at distance. She developed a mild post-fitting problem, not due to the molding or lens, but rather to an allergic reaction. The ocular condition returned to normal after replacing the soaking solution. I propose that the residual soaking solution may have affected the eyes more during overnight wear. Her hyperopia reduced to nearly plano within two weeks. With Ortho-K, there is a potential for residual glare or similar disturbances. In her case, there were no such complaints of glare for several possible reasons. First, she was virtually never subjected to bright night lights. Further, a hyperopia molding is prolate in shape, i.e., watermelon shaped (central steepest and flattens to the periphery) creating poten-

tially less spherical aberration. At this writing, MB has worn the second pair, nearly everyday, for 18 months. There have been no corneal problems, her hyperopia has been fully corrected and there is no evidence of strabismus or significant phoria at distance and near.

Step 3: Vision Therapy

My overall strategy was to reduce the ET primarily with application of plus lens power through Ortho-K and VT, and then to continue VT to ameliorate any residual binocular vision dysfunctions. Even though there was orthophoria after the final Ortho-K treatment and MB now attained second degree fusion, she still could not appreciate clinical stereopsis. I considered this absence was possibly related to the early onset of her ET that resulted in a microesotropia with monofixation. If the eyes are straightened before or shortly after the esodeviation becomes constant, then there is a much better chance of bifixation and binocularity.³⁴

VT for esophoria/ET is thought more difficult than that of exotropia/exophoria especially if no fusion or stereopsis is detectable.²⁵⁻²⁹ Although we were unsuccessful in obtaining third degree fusion and stereopsis after corneal molding, she did show flat fusion. We scheduled her for oculomotor, anti-suppression, and vergence therapy. Techniques such as a swinging ball and computerized saccadic, pursuit, anti suppression, and vergence training were applied. In addition, we utilized the Red-Green anaglyphic fusion targets^d and the computerized HTS program.^b Office based VT was conducted twice a week with home therapy at least three times per week.

At the cessation of 20 VT office sessions, MB was still orthophoric at distance and near, and demonstrated stable second degree fusion. This is consistent with other reports in the literature that a good number of the patients with accommodative ET developed good fusion but poor stereopsis at the end of treatment.³⁵ The last evaluation indicated that MB's ocular health status was unremarkable, notably that there were no corneal problems. The Ortho-K findings and the patient's binocular status were now stable for about 15 months. As she grows older and matures, continual monitoring of the binocular status will be maintained as well as consider-

ation of incorporating contact lenses and spectacle lenses as an alternative treatment.

DISCUSSION

Modern Ortho-K has been shown to be an effective procedure for the reduction of certain myopias and astigmatism.³⁶⁻³⁸ Because of reports of corneal infections with the overnight component of Ortho-K, the safety of the procedure is under active investigation. It is clear that minimal clinical standards must be promulgated internationally to ensure a future for this approach to refractive correction.³⁹⁻⁴⁰ The use of an overnight lens-wearing protocol provides an alternative to refractive surgery for many patients. My experience is that the onset of the refractive effect is relatively quick, with observable changes within days, and the procedure appears to be fully reversible on cessation of lens wear.

CONCLUSION

This case of a six-year old girl with accommodative ET is an example of the benefit and potential use of applying this innovative method of multifocal Ortho-K to young children. Since there was poor compliance with the traditional method of spectacles, this alternative method was applied. She was shy and self demeaned with the heavy glasses and the clearly visible ET. She rejected the spectacles and wore them only occasionally for reading. She was unhappy and unwilling to face people and the camera. When I asked her mother for previous pictures as demonstration, only a few were available.

The use of Ortho-K is not new; however, it has been mainly used in the treatment of myopia in the adult population. In this case, I employed similar methods of tissue molding, but applied different lens designs of dual geometry for hyperopia molding. This new and unique application of Ortho-K and the use of VT to enhance binocular functioning resulted in several behavioral changes in this hyperopic six-year old. Her mother reports she is more at ease and confident in school. She faces the camera naturally and smilingly with her cosmetically straightened eyes. In spite of an inability to attain stereopsis, her level of binocularity has been significantly enhanced.

Current clinical evidence strongly suggests that myopic Ortho-K is revers-

ible and that reversibility has been demonstrated after short to medium term lens-wearing periods,⁴¹ although no data are currently available with regard to hyperopic Ortho-K.

Dr. Tung holds the US patents for, and is the owner of the System and Method for Orthokeratology and the Dual Geometric Contact Lenses for Hyperopia and Presbyopia Orthokeratology. He has no financial interest in the other products discussed in the article.

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