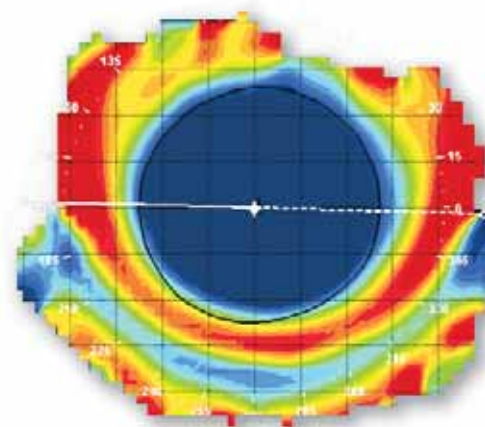


A Guide to Overnight  
**ORTHOKERATOLOGY**



Polymer Technology,  
a Bausch & Lomb company  
International English Edition, 2004  
Not for distribution in U.S.A.

A Guide to Overnight  
**ORTHOKERATOLOGY**

---

All rights reserved. No part of this book may be reproduced or transmitted in any form by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without express written permission from Polymer Technology, a Bausch & Lomb company, except for the inclusion of brief quotations in a review.

Copyright © 2002, 2004 by Polymer Technology, a Bausch & Lomb company

## TABLE OF CONTENTS

|   |           |
|---|-----------|
| Foreword .....  | 5         |
| <b>I. Background .....</b>  | <b>5</b>  |
| • About Myopia .....  | 5         |
| • History .....   | 6         |
| • Ortho-k Designs, Then .....                                       | 8         |
| <b>II. Modern Orthokeratology .....</b>                             | <b>12</b> |
| • Theory/Mechanisms .....   | 12        |
| • Ortho-k Designs, Now .....  | 15        |
| • Daily Wear Orthokeratology Versus Overnight Orthokeratology ..... | 16        |
| • Is Ortho-k Myopia Control? .....                                  | 18        |
| <b>III. The Modern Ortho-k Fitting Process .....</b>                | <b>19</b> |
| • Alternate Ways to Correct Nearsightedness .....                   | 22        |
| • Patient Interview and Selection .....                             | 22        |
| • Pre-Fitting Examination .....                                     | 23        |
| • Instruments Required/Suggested .....                              | 24        |
| • The General Fitting Process .....                                 | 25        |
| • Shaping Lens Adaptation and Follow-Up .....                       | 25        |
| • The Importance of Using High Dk Materials .....                   | 28        |
| • Treatment Considerations .....                                    | 29        |
| • Importance and Use of Topography .....                            | 31        |
| <b>IV. Practice Management .....</b>                                | <b>34</b> |
| • Fees and Costs .....  | 34        |
| • How to Incorporate Ortho-k into the Practice .....                | 36        |
| • Ortho-k Lens Care and Handling .....                              | 36        |
| • Sample Fitting and Care Agreement .....                           | 40        |
| <b>V. Glossary .....</b>  | <b>42</b> |
| <b>VI. Frequently Asked Questions (FAQs) .....</b>                  | <b>49</b> |
| <b>VII. Suggested Reading .....</b>                                 | <b>54</b> |
| <b>VIII. Useful Ortho-k Web sites .....</b>                         | <b>55</b> |
| <b>IX. Bibliography .....</b>                                       | <b>56</b> |

## FOREWORD

This publication is an educational tool intended to provide an overview for the use of specialized contact lenses for overnight orthokeratology (corneal reshaping) treatment for the temporary reduction of myopia.

Presented is a general foundation behind the history and principles of the orthokeratology process. Training for fitting specific ortho-k designs can be obtained from individual ortho-k lens designers and/or manufacturing laboratories.

## I. BACKGROUND

### IN THIS CHAPTER...

- This section discusses the worldwide incidence of myopia and its potential impact on ocular health and vision.
- A brief history of orthokeratology is presented as it began in the 1960s right up to the present-day evolution.
- Early ortho-k lens designs are reviewed with regard to their advantages over the earlier systems and their shortcomings.

### About Myopia

Myopia (nearsightedness) has been labeled as one of the most common ocular disorders affecting human beings—and is increasing worldwide. The increased incidence is occurring worldwide as countries industrialize and education levels rise. The percentage varies from country to country from as little as 25% in the United States to as much as 90% in some parts of China<sup>(16)</sup> (*Figure 1*). This has caused concern among some governments and their health agencies with regard to the ability of citizens to function in times of emergency and natural disasters.

|   |               |     |
|---|---------------|-----|
|  | United States | 25% |
|  | China         | 55% |
|  | Japan         | 40% |
|  | Singapore     | 70% |

**Figure 1. Epidemiology of myopia in some countries**

This concern has sparked an interest in a variety of methods to attempt to control or reduce myopia including:

1. Contact lens fitting methods (orthokeratology) to temporarily reduce myopic correction requirements
2. Surgical techniques (RK, PRK, LASIK, etc.) to permanently alter the corneal shape, reducing myopic correction requirements

## History

Orthokeratology is the temporary reduction of myopia achieved by the programmed application of contact lenses to reshape the cornea.

Modern orthokeratology achieves this using specially designed reverse geometry gas permeable (GP) ortho-k shaping lenses worn during sleep. This overnight wearing process provides a faster, more predictable result than early ortho-k attempts as practiced in the 1960s using conventional, rigid contact lenses fitted incrementally flatter. Modern 4-, 5-, and 6-zone designs speed corneal reshaping and the myopic reduction process while the wearer sleeps. Using this technique, properly selected patients can go through the day wearing no correction and usually enjoy excellent visual acuity.

Orthokeratology, or ortho-k fitting, has been employed since the early 1960s in one form or another in the United States. George Jessen first attempted to deliberately change refractive myopic error using rigid contact lenses using a technique he named “Orthofocus.”<sup>(13)</sup> Ziff, May, Grant, Fontana, Tabb, Carter, and Kerns are names that figure prominently among the early researchers and proponents of ortho-k fitting.

Much of this early work in orthokeratology arose from myopia control studies such as those performed by Robert Morrison in 1956. His study showed that 1,000 teenagers wearing PMMA rigid lenses fitted 1.50 to 2.50D flatter than the flattest corneal curvature<sup>(20)</sup> (*Figures 3 and 4*) had no myopic progression over a two-year period. In similar circumstances, practitioners found that corneal curvatures had changed, refractive errors had decreased, and unaided visual acuities had improved in these myopic patients wearing rigid contact lenses.

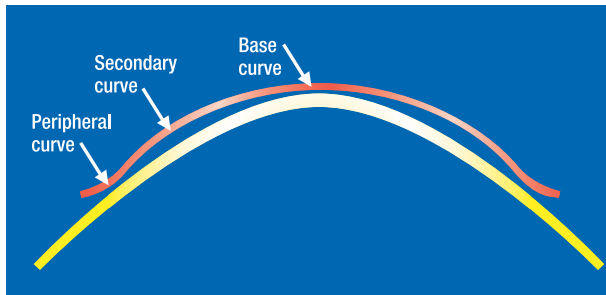


Figure 3

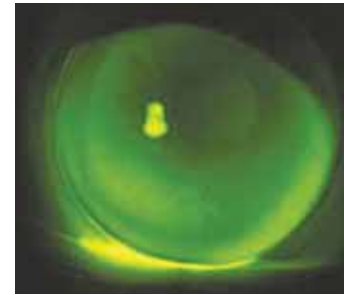


Figure 4

For more than two decades, orthokeratology did not gain widespread acceptance, partly due to resistance from the scientific community who maintained that altering the central cornea would not be safe. Optometry and ophthalmology did not accept the procedure as being sound in the absence of clinical evidence that this procedure would not interfere with the structure and function of the cornea. The fact that only keratometry was available to evaluate, demonstrate, and monitor corneal topographical changes limited its use to a body of fitters who had ample anecdotal evidence, yet little scientific data. For this reason, orthokeratology was classified as a “fringe” science at best. The introduction of corneal mapping instruments allowed a more scientific approach to employing this procedure. Studies were carried out using standard PMMA lens designs to test the theory.<sup>[2, 3, 4, 14, 15]</sup> These studies showed a certain reduction in myopia during treatment before a “plateau effect” limited further myopic reduction. These reductions in myopia varied from 0.30 to 1.52D in subjects with 2.50 to 4.00D of myopia.

The time it took to achieve these changes ranged anywhere from three to ten months, with varied myopia reduction rates reported among individual patients during the treatment time. On average, most myopia reduction occurred during the first six months. The early methods of fitting progressively flatter lenses also led to an increase in “with-the-rule” corneal astigmatism of as much as 0.80D.

This was most likely caused by lenses fitted with very flat base curves that centered very high, causing pressure on the superior cornea and remolding it to be steeper inferiorly (*Figure 5*). This phenomenon gives credence to a later theory that “corneal power can neither be destroyed or created, it is simply redistributed.” The problems with

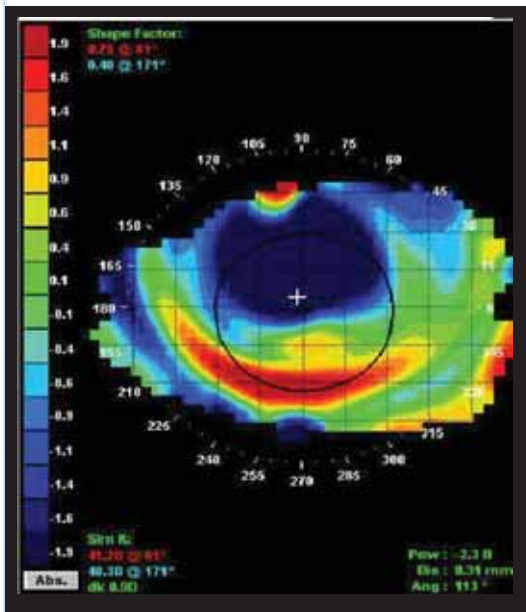


Figure 5

these early methods were that the amount of myopia reduction was difficult to predict and visual acuity often fluctuated greatly during the course of the treatment.

Predicting ortho-k success using the early fitting methods was dependent on the initial shape of the cornea even though the method of determining this was based on an inherently inaccurate corneal measurement system (keratometry). The theory at this time was that the more spherical

the cornea and the lower the eccentricity, the smaller the ortho-k effect. As a result, corneas that had steeper corneal curves and higher eccentricities were believed to have a better chance of experiencing reduced myopia. During this process, the cornea became more spherical (“sphericalization”) as the difference between the flatter and steeper corneal meridians became more similar and the eccentricity became lower.

Early corneal measurements were taken as they still are today, using the keratometer. Later studies<sup>(3)</sup> claimed that if the temporal horizontal meridian of the cornea is flatter than the central horizontal curvature, the chance for myopia reduction would be excellent.

### Ortho-k Designs, Then

The reasons for early failures and a general lack of acceptance of orthokeratology among the ophthalmic community are now more obvious. The fitting philosophies of altering the cornea as little as possible with contact lenses prevailed. The early ortho-k lenses were still conventionally designed with peripheries flatter than the central base curves. They were simply conventional rigid contact lenses fit as flat as possible, while still maintaining acceptable lens position on the cornea.

These designs were flat-fitting, commonly de-centering up or down. This resulted in corneal distortion and problems such as increased



astigmatism. Another factor in early failures was due to the use of PMMA lenses. They caused corneal edema, thereby exacerbating corneal distortion. However, despite the acknowledged physiological disadvantages of PMMA contact lenses, no other significant lasting effects were noted as a result of ortho-k lens wear.

The procedure involved making very small incremental lens design changes. The process was very slow, costly, and tedious for fitter and patient alike.

Myopia reduction did not last very long when lenses were worn occasionally on a daily wear basis. The lack of high-permeability GP materials did not allow for safe overnight wear of a retainer lens to maintain corneal shape.

The second generation of ortho-k lenses addressed the problem of controlling and increasing the amount of myopic reduction that could be achieved. Pioneers like Nick Stoyan, who patented designs using reverse curve configurations (base curve flatter than the central cornea with a secondary curve of steeper radius) specifically for orthokeratology (*Figure 6*); Dr. Sami El Hage (who was the first to use topography to fit ortho-k lenses);<sup>[7]</sup> and Dr. El Hage and Dr. Tom Reim (who independently and separately developed different aspheric and spherical 4-zone ortho-k design prototypes), and others such as Al Blackburn, ushered in this next orthokeratology era.

The Contex OK<sup>®</sup>-3 lens utilized three distinct zones (*Figure 7*) to effect a more controlled and profound flattening of the central cornea. Use of this design also shortened the time in which myopia reduction could be achieved versus fitting conventional rigid lenses incrementally flatter.

#### Ortho-k Design, Then:

1. It took a long time to achieve only a short-term reduction of myopia.
2. The amount of myopia reduction was limited to 1.00 or 2.00 diopters.
3. The number of trial lenses needed to fit ortho-k were many, making the process time consuming and expensive.
4. It was difficult to predict a result because the lens fit was unstable over the course of the treatment.

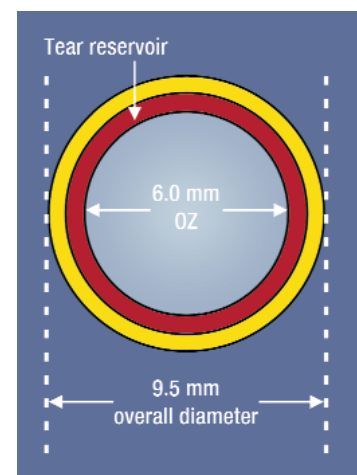


Figure 6. Contex OK-3 Lens

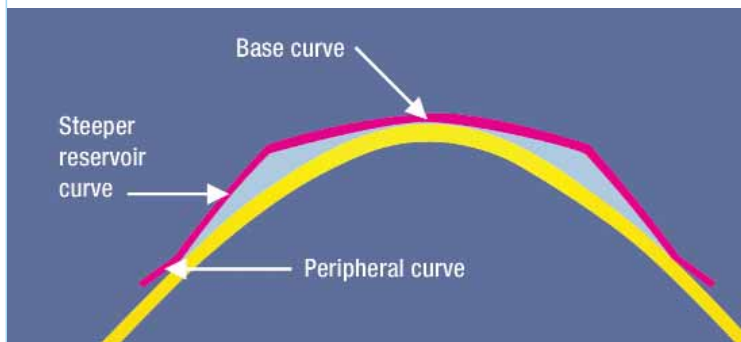


Figure 7

This new design offered a vast improvement over the older system of simply fitting conventional rigid lenses as flat as possible. Research has revealed that

corneas with prolate shapes (steep in the center and flat in the periphery) and moderate curvature (46.00 to 49.00 diopters) seem to respond best to orthokeratology. Corneas with flatter curves (36.00 to 39.00 diopters) are thought to be more resistant to change,<sup>(9)</sup> although this is an area that has recently come under debate.

The 3-curve reverse geometry design was fitted 1.50 to 4.00 diopters flatter than the flattest corneal curvature (flatter than “K”). Lenses would exhibit 1.00 to 2.00 mm of movement with a blink. Centration is critical to success, as the earlier lenses failed because they centered high and induced “with-the-rule” astigmatism, as would these designs if fitted improperly. Wearers would also complain of double vision and reflections (flare) when pupils became larger, as happened when driving at night.

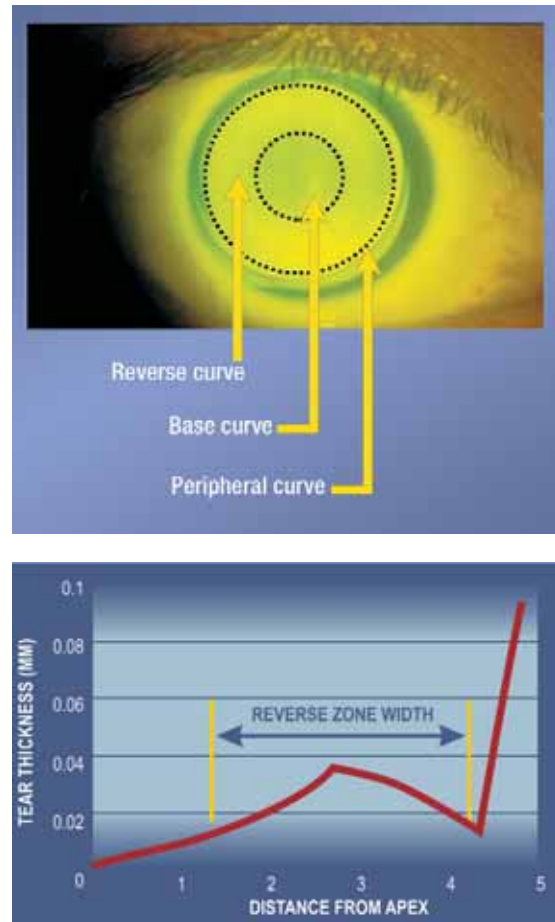
Although designs like these were an improvement over the previous methods, they still had some significant shortcomings. Controlling centration was still difficult with these designs. The reverse curve (steeper zone) was very wide (*Figures 8 and 9*), with a high degree of edge lift that caused lens movement to be erratic, making an ideal lens position more difficult to achieve.

Patients were typically checked after four hours of lens wear to check for lens tightening and/or adhesion. If this was the case, the tight-fitting or adhered lenses had to be discontinued until lenses having flatter base curves were ordered. It was not unusual to order two pairs of lenses for each patient from the beginning of the fit. One pair would have base curves 0.10 mm flatter than the initial dispensed lens.

Once the lens had tightened due to corneal reshaping, the flatter lenses were dispensed to the wearer for wear of 1 to 3 weeks more.

A third pair of lenses would then be ordered in preparation for the next lens change. It was essential that each flatter lens also have the appropriate power compensation to assure optimum vision during daily lens wear.

The method of making four to five small incremental (flatter) base curve changes allowed better control of lens centration. Initial reduction in myopia after approximately two to seven days would be approximately 1.00 diopter, with additional myopic reduction occurring over the remainder of the three- to six-month treatment period, reaching a maximum of 2.00 to 3.00 diopters myopic reduction.<sup>[8]</sup>



Figures 8 & 9.  
Steep-wide reverse curve on 3-zone designs

### KEY POINT SUMMARY...

- Myopia is one of the most common ocular disorders affecting humans.
- Orthokeratology has been used in some form since the 1960s in the USA.
- Early ortho-k fitting was time consuming and expensive, with unpredictable results.
- Early reverse geometry ortho-k shaping lens designs made myopic reduction more predictable and achievable.

## II. MODERN ORTHOKERATOLOGY

### IN THIS CHAPTER...

- Modern ortho-k designs are discussed and compared to their predecessors.
- Theories for how ortho-k treatment effects myopic reduction are presented.
- This chapter discusses the advantages of overnight (accelerated) orthokeratology versus previous methods.

### Theory/Mechanisms

The new orthokeratology designs have allowed the reshaping process to take place rather quickly. This accelerated form of ortho-k (also known as AOK) offers some immediate change after one-night wear of the shaping lens, with the remainder usually occurring over a treatment period of about 10–30 days.

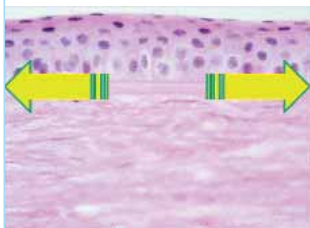


Figure 10. Example, before ortho-k treatment

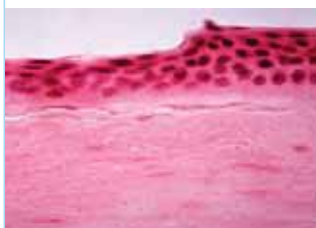


Figure 11. Example, after ortho-k treatment

There is debate regarding the actual mechanism by which orthokeratology works. Some believe that the rigid shaping lenses actually bend the cornea to reshape it and thereby reduce myopia.<sup>[23]</sup>

Other studies seem to indicate that the corneal shape changes in orthokeratology are temporary, demonstrating that the cornea is elastic and has a “memory” (the cornea will resume its pre-ortho-k shape, once lens wear has been discontinued). This is contrasted to a “plastic” change (one where the cornea is permanently molded into a different shape by wear of a rigid lens). Polse’s result in this study showed that whatever the mechanism,

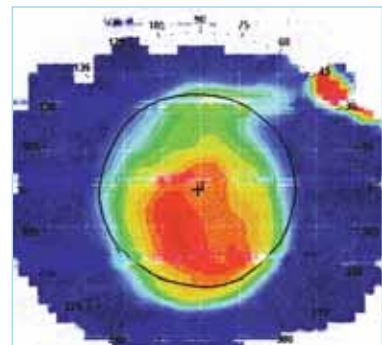
the changes to the shape of the cornea and resultant myopic reduction were temporary and reversed themselves once rigid contact lens wear was discontinued. The question remained whether this was due to a bending of the corneal surface or by another mechanism.

Newer studies suggest that ortho-k shaping lens fitting using reverse geometry GP designs may compress corneal tissue (in some fashion) rather than changing refractive error by bending the cornea, at least after initial adaptation. The hypothesis is that a thin layer of tear film exists between the back of the ortho-k shaping lens and the central cornea. These tear film “shear” forces act hydraulically to force a compression and possibly subsequent redistribution of very anterior epithelial cells under the shaper from the center toward the periphery<sup>[29]</sup> (Figures 10 & 11). This seems to refute the old theory that ortho-k lens wear changes myopic correction by permanently bending the cornea. It also may explain why these patients can wear shaping lenses whose base curves are flatter than “K” and still experience no central corneal staining or irritation with well-fitted ortho-k shaping lenses.

A study conducted by Helen Swarbrick et al., of The University of New South Wales, Sydney, Australia in 1998<sup>[32]</sup> evaluated topography and pachometry changes in accelerated ortho-k lens wearers over a 30-day period. Their study concluded that:

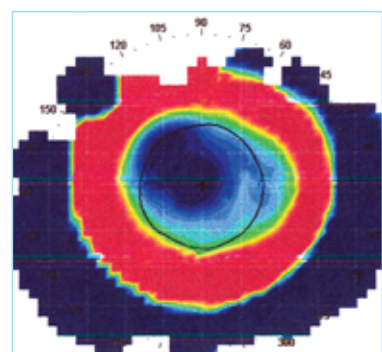
1. The corneal epithelial cell layer was redistributed in some manner, leading to a thinning of the central cornea to significant levels across the corneal surface.
2. There was concurrent thickening of the mid-peripheral cornea, particularly in the stromal layer.

These changes occurred with no apparent change to the posterior cornea curvature. It was the corneal epithelial cells that were affected in some manner by the fluid pressure effect of the aforementioned tear film “forces.”



**Figure 12. Pre- and post-ortho-k lens wear topography.**

**Pre-treatment cornea with steep center and gradually flattening periphery.**



**Post-treatment cornea with flat center and steeper mid-periphery.**

In theory, these tear film forces cause a compression that results in a redistribution of the epithelial cells (and possibly some stromal) toward the corneal periphery.<sup>(1, 32)</sup> This process of compression and redistribution is thought to produce a reduction in corneal sagittal

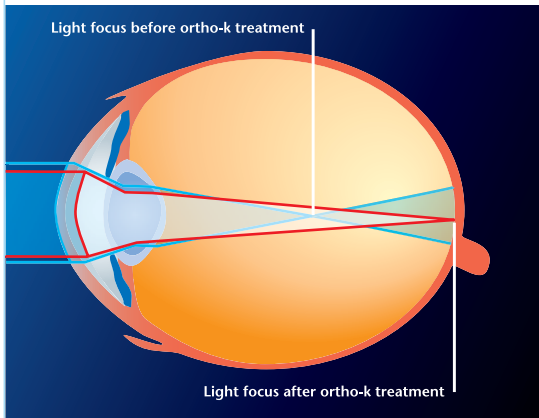


Figure 13. Corneal flattening resulting in correct focus of light rays on the retina

height, which results in a change (flattening) in corneal curvature of the eye (Figures 12 and 13). This corneal shape change results in the refocusing of the light rays on the retina (macula) of the eye, reducing or eliminating the need for myopic correction.

It must be remembered that the reduction of myopia, whether done permanently by means of removing tissue by use of a laser (LASIK and

PRK) or by changing corneal shape by use of ortho-k shaping lenses, is measured in microns or thousandths of a millimeter. For example, the cornea is estimated to be approximately 540 microns in thickness or about 0.54 millimeter (Figure 14).

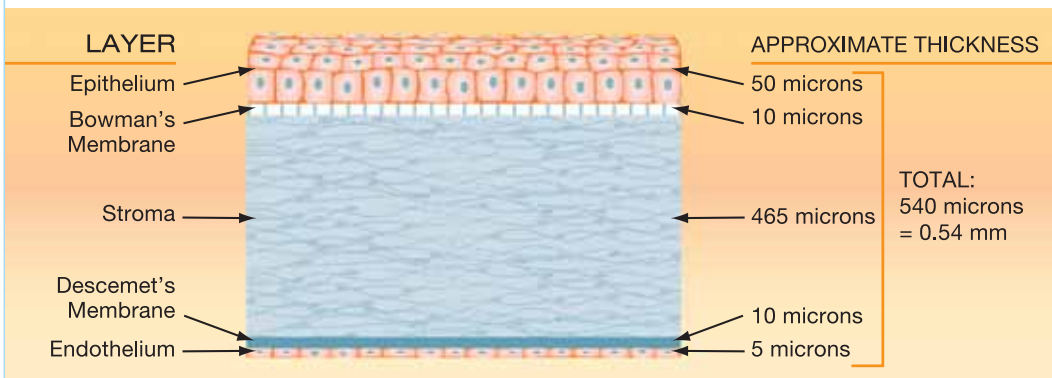


Figure 14. Corneal thickness by layer

Comparatively, a human hair is approximately 50 microns in thickness, the same thickness as the human corneal epithelium. So, the gradual redistribution of corneal mass in orthokeratology that takes place under the shaping lens is what accounts for the reduction in the sagittal depth and thickness of the cornea, and the resultant reduction in myopia.

### Ortho-k Designs, Now

Depending on the fitting philosophy of the design being used, an initial base curve is chosen that is 0.30 mm to 1.40 mm flatter than the flattest corneal curvature (flat “K”). This optical zone width may vary from 6.0 mm to 8.0 mm. Commonly a posterior optical zone diameter of 6.0 to 6.5 mm is most often used.

The secondary (reverse) lens curve of the shaping lens is chosen steeper than the base curve radius. This “reservoir” zone is commonly 3.00 to 5.00 diopters steeper than the base curve radius, but may also be 9.00 D or more steeper than the base curve in some designs. The width of the reverse curve ranges from 0.6 mm to 1.0 mm (Figures 15 and 16). All these parameters can be manipulated individually to reach an optimal shaping lens fit and myopic reduction effect. In most cases, making a change in one parameter will also require making a compensatory change in one or more other parameters. In some fitting systems, the actual shaper parameter combinations are proprietary and protected, leaving the fitter to relate poor fitting characteristics to the lens manufacturer who then provides another lens with the parameters necessary to improve the fit.

Peripheral curve radius is slightly steeper than what is used for conventional GP lens fits, producing an edge (edge lift) clearance of 60 to 70 microns (0.06 mm to 0.07 mm). Edge clearance on conventional GP lenses is typically 80 to 120 microns (0.08 mm to 0.12 mm).

Modern four-zone ortho-k shaping lenses typically consist of:

- base curve
- reverse (steeper) curve
- fitting (alignment) curve
- peripheral curve

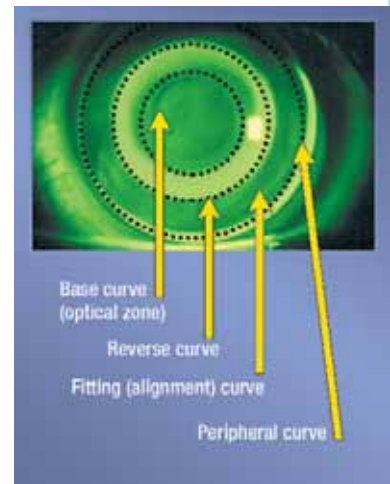


Figure 15

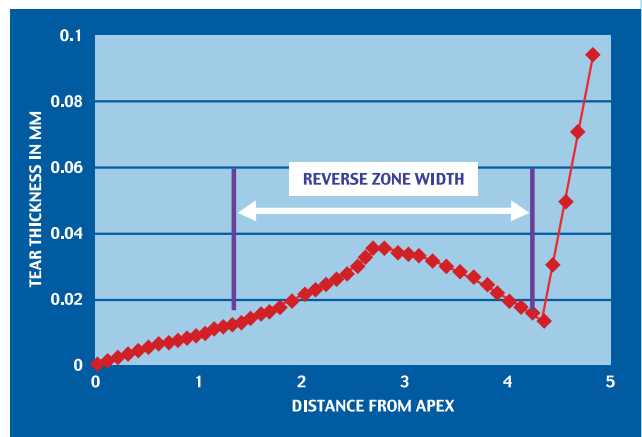


Figure 16. Reverse curve tear film profile

Modern three-zone ortho-k shaping lens designs were made available by Roger Tabb, Jim Day (Fargo™), Donald Harris, and Nick Stoyan (Contex OK®). Modern four-zone designs were introduced by Sami El Hage (CKR), Tom Reim (Dreimlens®/DreamLens™), Euclid (Emerald™), Don Noack and John Mountford (BE Retainer™), Rinehart-Reeves, Paragon CRT®, and others.

### Daily Wear Orthokeratology Versus Overnight Orthokeratology

The limitations imposed by the poor physiologic effects of PMMA lens wear dictated that early ortho-k lens wear be limited to daily lens wear. The same is true today of ortho-k shaping lenses that are made of gas permeable plastics of medium and low permeabilities. Like PMMA, these materials are not optimal for safe overnight ortho-k wear, since the new generation of ortho-k lens designs are typically larger and thicker than conventional gas permeable lenses.

Being limited to daily wear made the early ortho-k process more difficult for the patient to endure in terms of comfort and consistent vision as compared to wearing conventional rigid lenses for vision correction alone. Added to this was the cost of this procedure in terms of the number of lenses required (eight pairs or more) and the treatment period (nine to twelve months), with no way to accurately predict the visual result.

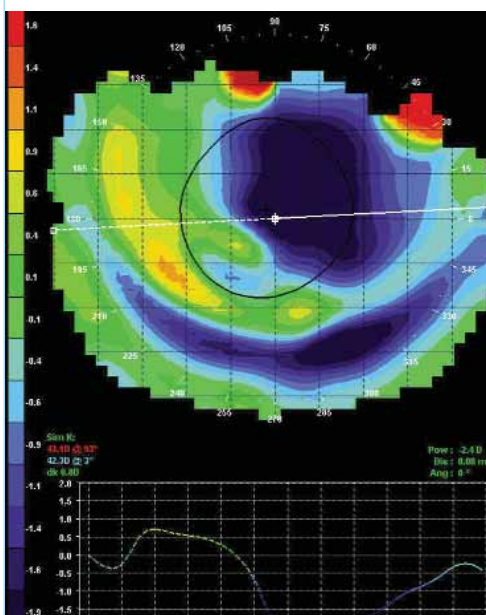


Figure 17

Ortho-k of decades past simply employed conventional rigid contact lens designs, progressively fit as flat as possible to reduce the height of the central cornea, thereby reducing myopia. During the treatment, vision at times became worse due to poor lens positioning (high-riding lenses) that caused an increase in “with-the-rule” astigmatism or worse, corneal distortion (Figure 17).



Comparing the ortho-k methods of the '60s with the designs and techniques of today is like comparing a 1930 Model A Ford to the latest model Mercedes Benz. This brings up the issue of what to call this modality. In its beginnings in the 1960s, George Jessen called it "Orthofocus." It soon came to be known simply as "orthokeratology." Looking at the PDR Medical Dictionary definition, orthokeratology is defined as: "A method of molding the cornea with contact lenses to improve unaided vision." And in fact, that's exactly what it is. The process involves the programmed application of a contact "shaping" lens for the purpose of systematically and predictably reshaping the corneal surface to temporarily reduce the need for myopic correction.

Today, other names have been coined for the more modern process utilizing four and five zone reverse geometry designs, such as "accelerated orthokeratology" (AOK), "Ortho-K," "Advanced Orthokeratology," Corneal Refractive Therapy (CRT®), etc.

The advent of new high-permeability GP materials (ISO/Fatt Dk of 85 or more) has allowed overnight wear of these ortho-k shaping lenses instead of during the day.\* This provides easy and fast lens adaptation for the patient.

New innovative four, five, and six curve reverse geometry designs in large diameters have not only allowed for better control of position of the shaping lens, but have also provided ortho-k fitters with a scientific and more accurate means to control and predict myopic reduction. These modern ortho-k shaping lenses allow for rapid myopia reduction as well. What took nine to twelve months to achieve in the '60s now will occur usually within 30 days.

Approximately 70 to 80% of the patients treated with modern ortho-k shaping lenses achieve their desired myopia reduction with only one pair of shapers, as compared to the old process that often took eight or more pairs of conventional rigid contact lenses to achieve myopia reduction. The first approvals for overnight orthokeratology in the U.S. were obtained by Paragon Vision Sciences (CRT®) and Euclid Systems Inc. (Emerald Lens).

*\* Overnight orthokeratology should only be performed using GP lens materials and designs approved for overnight use.*

### Is Ortho-k Myopia Control?

Orthokeratology treatment effects a rapid reduction in myopia. This reduction is temporary in nature and is maintained by regular nightly wear of the shaping lens as prescribed.

Since orthokeratology treatment results in this myopic reduction, it is logical that questions have arisen regarding the effect this process might have on myopic progression. Among these question are:

- Would the systematic reshaping of the cornea to reduce myopia also slow its progression?
- If ortho-k treatment is discontinued, what (if any) is the effect on myopic progression? Will there be a “rebound” effect that results in an increased amount and rate of progression of myopia or will it slow?

There are no definitive answers or scientific evidence to address these questions at this point. The role that orthokeratology may play in affecting myopic progression is currently under investigation.

#### KEY POINT SUMMARY...

- Overnight (accelerated) orthokeratology allows for treatment results within approximately 30 days.
- Reverse geometry designs utilize tear film forces to effect corneal shape changes.
- Modern four and five zone designs allow better control of treatment process.
- Patients easily accept overnight ortho-k because adaptation is rapid with minimal awareness of the shaping lens.
- The role that orthokeratology may play in myopia control is currently under investigation.

## III. THE MODERN ORTHO-K FITTING PROCESS

### IN THIS CHAPTER...

- Modern orthokeratology involves the combination of reverse geometry designs, high permeability GP materials, and corneal topography to understand the relationship of the shaping lenses to the cornea.
- This chapter provides guidance to practitioners to help select and interview potential ortho-k wearers.
- The pre-fitting screening examination is outlined with tips on how to evaluate patients as good candidates.
- A list of essential equipment to fit, evaluate, and manage ortho-k patients in the practice is provided.
- An overview of the general fitting process is provided.
- Emphasized is the importance of using high Dk GP materials for overnight lens wear of orthokeratology shaping lenses.
- Possible complications are presented with a discussion on how to use corneal topography to assess fit, follow progress, and avoid unfavorable results.

For the purpose of explaining the ortho-k fitting process and the progress of myopic reduction, we will speak in general terms regarding the use of four-zone ortho-k shaping lenses (*Figure 18*).

The base curve of the shaping lens (which is

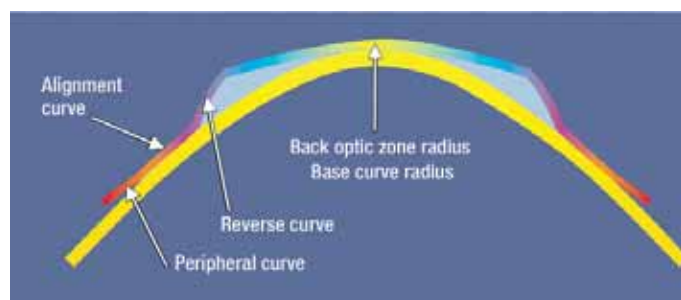
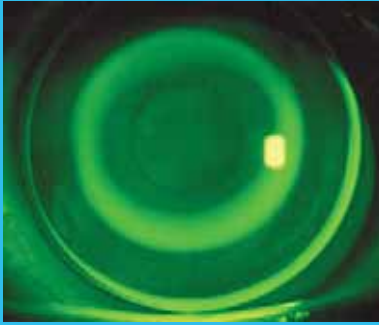


Figure 18



Three major developments changed not only the process by which ortho-k shaping lenses were fit, but also how they are perceived. These are:

1. reverse geometry designs
2. the availability of high Dk GP lens materials
3. a better understanding of the relationship of these shaping lenses to the cornea through the use of corneal topography.

purposely chosen to be flatter than the flattest central apical radius) applies pressure on the thin layer of tear film that lies between the back of the ortho-k shaper and the corneal surface. Even though the use of fluorescein to observe the lens fit gives the appearance of apical touch, a tear film layer of less than 10 microns exists.

Theoretically, these “tear film forces” cause the apical epithelial cells to compress and possibly “migrate” toward the periphery. This corneal reshaping process creates a decrease in corneal sagittal height and causes the cornea to become more spherical and flatter, thereby reducing or eliminating the need for myopic correction.

As epithelial mass is shifted toward the periphery, the steeper secondary curve (reverse curve) forms a tear reservoir where excess tear and the displaced corneal cells may form.

The mid-peripheral or fitting curve (also known as alignment curve) is actually the curve that allows the shaping lens to center and position properly on the eye. This curve is calculated to be in alignment (parallel) with the mid-periphery of the cornea.

The purpose of the peripheral curve on an ortho-k shaping lens is the same as on any GP lens, to allow for tear circulation under the shaper, allow for its easy removal, and provide a means to remove debris from under the shaper.

Generally, an ortho-k fitter will calculate the parameters of the trial shaping lens with a design-specific nomogram or computer program. In some cases, “K”s and refraction are given to the laboratory to calculate the shaping lens parameters. The trial shaping lens or the shaper to be dispensed is then placed on the patient’s eye and allowed to settle before it is evaluated to ensure that it does not tighten

excessively. There have been cases of “corneal responders” who will display corneal shape and refractive changes anywhere from 10 to 30 minutes.<sup>[14, 33]</sup> This allows the fitter to decide whether the patient will respond successfully to the treatment.

Once it is decided to allow the patient to wear the ortho-k shaping lenses overnight, the patient is instructed to return to the office as early as possible (within a few hours of awakening) in the morning. Prior to wearing the shaping lenses overnight, the patient must be instructed how to insert, remove, and care for the shapers. Under no circumstances should patients be allowed to leave the office and wear the shaping lenses overnight if they cannot confidently remove them. Patients should be instructed in shaper removal using the eyelids (blink/scissor method). At the practitioner’s discretion, the patient may also be supplied with and instructed in the use of the silicone rubber (DMV) lens remover.

Probably the most critical step in the fitting process is to examine the patient early the first morning after the first night of ortho-k shaping lens wear. It is important for the fitter to assess position of the shaping lenses and the location of the flattened zone on the cornea for centration. This is accomplished by observing the shapers on the eyes and evaluating corneal topography after removal of the shaping lenses. Unaided visual acuity is also checked at this time. De-centered shaping lenses will not produce the desired myopia reduction and may even cause corneal distortion. Shapers must also be checked for adherence and corneal integrity must be determined.

A significant degree of myopic reduction (1.00 to 2.00 diopters) often occurs after the first night of ortho-k shaper lens wear. If the initial shaper appears to have tightened, a shaping lens with a lower sagittal height should be fitted.

A significant degree of myopic reduction (as much as 2.00 diopters) often occurs after the first night of lens wear.

The patient should not be allowed to wear a tight-fitting shaper in order to avoid metabolic and corneal distortion problems. Some fitters order a second shaper that has a lower sagittal height at the same time that the initial shaper is ordered to facilitate this change easily.

As mentioned, a large part of the ortho-k effect occurs in the first seven days of shaping lens wear, with maximum results usually achieved in one month.<sup>(19, 22, 30)</sup> In some cases, myopia reduction may take up to three months.

The initial goal in ortho-k shaping lens fitting is to achieve the desired amount of myopia reduction. Having reached that point, the fitter's goal is then to try to reduce overnight shaper wear to a frequency that will still maintain the patient's cornea in the desired shape and visual acuity level.

One benefit to the ortho-k treatment is that the process is reversible. Studies have shown that regression will usually occur in a period of approximately 30–90 days,<sup>(12, 25, 26)</sup> with most wearers showing complete reversal in less time. While this factor represents an advantage over surgical refractive correction, it is a disadvantage at the same time. For most, nightly wear of the shaping lens will be required to maintain myopic reduction. For others, lens wear may be required only every second or third night. The last shaping lens worn that produced the optimum corneal shape change is typically used for nightly wear to maintain reduction.

### Alternative Ways to Correct Nearsightedness

Myopia (nearsightedness) can be corrected by any method that reduces the focusing power of the eye. The most common methods of correction utilize eyeglasses or regular standard daily, extended, or continuous wear contact lenses. These represent a means of correcting myopia only during the time that the eyeglasses or regular contact lenses are worn, with no lasting effect on the myopia. Other methods of correcting myopia involve various surgical procedures such as LASIK.

### Patient Interview and Selection

Patient selection criteria will depend on the approach and philosophy of the fitter. Patient selection criteria are presented here using a "broad-range" approach.

### Orthokeratology Candidate Profile

- Age: juvenile to adult myopes
- Spherical refractive error:
  - 1.00 D to -5.00 D spherical power correction
- Cylindrical refractive error:
  - 1.50 D or less “with-the-rule” corneal astigmatism
  - 0.75 D or less “against-the-rule” astigmatism
- Recreational and sports activities where periods without wearing visual correction are beneficial
- Those whose vocation requires unaided visual acuity for certain periods, such as police, firemen, military, or occupations where refractive surgery may be a cause for exclusion (deep-sea divers, high altitude pilots, etc.)
- Free of corneal dystrophies (e.g. keratoconus), ocular diseases, or any condition that may preclude the patient from wearing any type of GP lens
- Motivated to undergo full or partial myopia reduction and willing to return to the office for two to three months of active treatment and every six months for passive treatment
- Committed to the initial and ongoing cost of ortho-k treatment (See section on fees and costs)
- Practitioners should consult fitting information provided by specific design/fitting systems.

### Pre-Fitting Examination

#### This should include:

- Refraction (with dilation)
- Baseline topography  
(keratometry optional, but topography is a must)
- Tear film analysis
  - a. Schirmer test (quantitative)
  - b. Tear Break-Up Time or TBUT (qualitative)
- Biomicroscopy

Several fitting systems advocate the use of corneal shape factors or eccentricity comparison of central corneal curvature to temporal curvature to predict which wearers might have good myopic reduction potential. Other studies have not been able to verify this procedure as being indicative of myopic reduction.<sup>(12)</sup> However, these studies did find that there was a correlation between the amount of refractive error and the amount of myopia reduction that was achieved.

These were categorized by Carkeet, Mountford, and Carney<sup>(4)</sup> as:

|                      |   |
|----------------------|---|
| Good responders:     | Decrease of > 1.50 diopters myopia (spherical equivalent)       |
| Moderate responders: | Decrease of 0.75 to 1.50 diopters myopia (spherical equivalent) |
| Poor responders:     | Decrease of < 0.75 diopter myopia (spherical equivalent)        |

Horner and Bryant<sup>(12)</sup> categorized the results of their retrospective study as:

|  |                                  |
|--|----------------------------------|
| Very low (< 2.00 D):<br>(spherical equivalent)     | Decrease of 1.12 diopters myopia |
| Low (2.00 to 3.00 D):<br>(spherical equivalent)    | Decrease of 1.86 diopters myopia |
| Middle (3.00 to 5.00 D):<br>(spherical equivalent) | Decrease of 2.15 diopters myopia |
| High (> 5.00 D):<br>(spherical equivalent)         | Decrease of 2.48 diopters myopia |

### Instruments Required/Suggested

The instruments required for ortho-k shaping lens fitting are the same that are required for fitting conventional contact lenses.

- Topographer (preferred) or keratometer (minimal)\*
- Slit lamp (biomicroscope)
- Autorefractor, phoropter, or universal trial frame
- Visual acuity charts
- Contrast sensitivity charts (may be helpful to quantify visual acuity)

\* Certain shaping lens designs (DreamLens and Contex) utilize either corneal topography or keratometry information to determine the initial diagnostic shaping lens.



## The General Fitting Process

### Initial Fitting:

Some ortho-k fitting systems advocate use of diagnostic trial shaping lenses for initial parameter selection. Diagnostic fitting not only yields valuable clinical information, but also provides important information on patient response and potential for successful ortho-k shaping lens adaptation. However, equally successful ortho-k fitting systems require that the initial shaper be ordered from keratometry readings and refraction. In either case, baseline topography, evaluation of response to wear of the shaping lens, and post-wear topography will serve as valuable information that will be used to guide the course of treatment.

**Step 1:** An initial shaping lens is chosen by use of a nomogram or computer design software. As a rule the initial shaping lens chosen should not be fit flat enough to cause seal-off in the intermediate zone. The shaper should move approximately 1 mm with blinking.

**Step 2:** The initial shaping lens should be evaluated 10 to 30 minutes after insertion so that reflex tearing may subside. This also allows the fitter to determine if the patient has a rapid flattening effect. This event will be followed by tightening of the shaping lens on the eye, in the manner that might be expected after about one week of shaping lens wear.

**Step 3:** If the initial fit of the shaping lens is acceptable (*Figure 19*), the patient may be allowed to wear it overnight and be evaluated the following morning. Studies are suggesting that short term, in-office wear of the diagnostic shaping lens (30 to 60 minutes) may be an indication of how much corneal change may take place.

In any case, a tight-fitting lens (*Figure 20*) should be replaced with a lens of lower sagittal height.

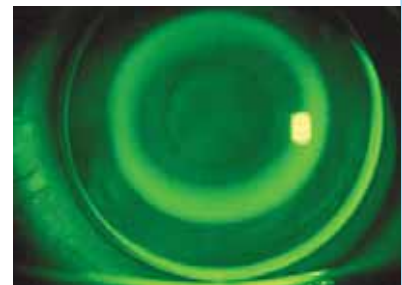


Figure 19. Ideal fit

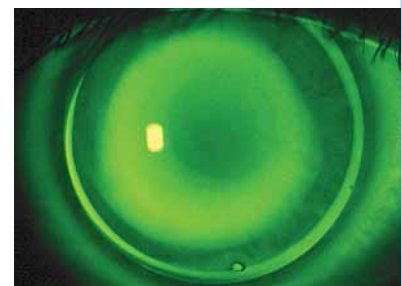


Figure 20. Tight fit

## Shaping Lens Adaptation and Follow-up

**Step 4:** Once the optimal initial shaping lens is chosen, the patient is instructed on insertion, removal, and care. Accelerated ortho-k treatment allows patients to wear their shaping lenses overnight immediately. For this reason, these patients should be seen in the office (wearing their shapers) the morning after the first night of wear. Shaping lenses are checked for:

- **Centration:** Centration of the shaping lens is critical to the ortho-k effect. De-centered shapers do not produce the desired myopia reduction. The result will not only be poor visual acuity, but may also cause localized corneal distortion.
- **Movement:** Shaping lenses should move approximately 1 mm with blinking. Shapers that are adhered during wear should be replaced with shaping lenses of lower sagittal height.

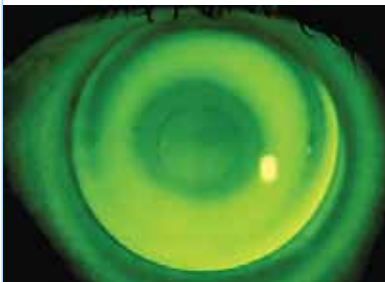


Figure 21. Flat fit

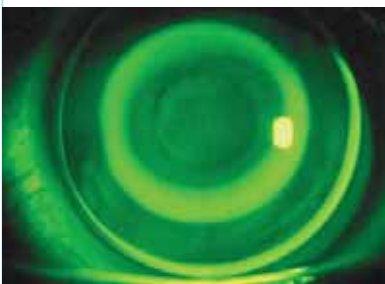


Figure 22. Ideal fit

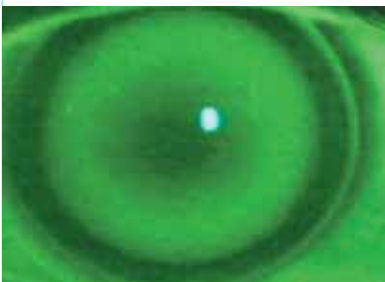


Figure 23. Steep fit

- **Fluorescein pattern:** Note tear reservoir size and shape, shaper lens movement; look for signs of adherence, air bubbles in the reverse curve (reservoir) zone (*Figures 21 through 23*), change in central bearing (steeper appearance), staining (well-fitted shaping lenses should not cause staining). There should be no evidence of debris trapped behind the shaping lens.

Fluorescein pattern evaluation in ortho-k fitting has limited value. Since tear film thicknesses under these lenses vary by only microns, it is almost impossible to differentiate between acceptable and unacceptable fits using fluorescein. Therefore, the value of fluorescein evaluation is limited to observing the position of the shaping lens on the open eye, detecting adherence of the shaping lens, evaluating corneal integrity, and assessing reverse zone width and depth (*Figures 21, 22, 23*).



**Figure 24.**  
Boston® Wratten Yellow Slit Lamp Filter



**Figure 25.**  
Filter in front of slit lamp objective

Since the fluorescein pattern in ortho-k shaping lens fitting is unusual and has many subtle nuances, use of a yellow Wratten filter is recommended to accurately evaluate the fine detail of these fits (Figures 24 and 25).

### Step 5:

- **Remove shaping lenses:** to check unaided vision. Perform a slit lamp examination of the cornea.
- **Perform refraction:** (or perform refractometry)
- **Perform topography:** to determine and record corneal shape changes.

**Characteristics of acceptable and unacceptable fitting of the ortho-k shaping lens are as follows:**

|                                      | Insufficient Sagittal Height            | Ideal Sagittal Height                        | Excessive Sagittal Height       |
|--------------------------------------|---|--|---------------------------------|
| Centration:                          | Usually superior (may also be inferior) | Well-centered vertically and horizontally    | Well-centered or inferior       |
| Central alignment zone:              | > 3 mm                                  | 3–5 mm                                       | < 3–5 mm                        |
| Reverse curve zone: (Tear reservoir) | Wide                                    | Wide, but tapered approximately 50 µm deep   | Deep bubbles in reverse zone    |
| Mid-peripheral curve:                | Reduced or absent                       | Alignment (uniform) fluorescein pattern 360° | Wide zone of heavy bearing 360° |
| Periphery:                           | > 0.70 µm axial edge lift               | axial edge lift approx. 0.70 µm              | < 0.70 µm axial edge lift       |
| Movement:                            | > 2.0 mm                                | 0.5–1.0 mm                                   | < 0.5 mm                        |

## The Importance of Using High Dk Materials

Questions have arisen regarding the safety of fitting rigid lenses for the purpose of intentionally changing the shape (flattening) of the cornea. However, studies over time indicate that ortho-k shaping lens wear appears to be safe, with no permanent adverse visual and corneal physiological effects.<sup>[8, 23, 27, 32]</sup> Even early studies using PMMA lenses reported no significant adverse effects that could be attributed to the disruption of the integrity and/or function of the corneal epithelium or any other ocular adverse effects.<sup>[27]</sup>

More conservative fitters may think orthokeratology opposes the principle of conventional rigid lens fitting—that contact lenses should not alter the corneal surface when fitted “properly.” Yet, it is interesting to note that properly fitted reverse geometry shaping lens designs exhibit only 0.5 mm to 1.0 mm movement, similar to a soft lens, while still employing the “tear pump” mechanism for debris removal.

Most of the studies published to date agree that the myopic reduction resulting from wear of ortho-k shaping lenses is temporary.<sup>[3, 9, 12, 14, 25, 26]</sup> That is, the myopic reduction effect lasts only as long as the patient wears the shaping lenses. Therefore, it has a “built-in” safeguard: if adverse reactions are noted, wear of the shaping lenses is discontinued and the cornea begins to revert back to its baseline shape. This process may take from 20 hours to 95 days.<sup>[12, 25, 26]</sup> Studies indicate that recovery time for the cornea is based upon the individual shape of each cornea, as well as the amount of time ortho-k shaping lenses are worn (months, years, etc). It appears that the longer these shapers are worn, the longer the recovery time required.<sup>[12, 25]</sup>

The advent of today’s techniques of accelerated orthokeratology requires that strict attention be paid to the GP lens material used to make these specialized shaping lenses. Use of high permeability materials such as Boston<sup>®</sup> XO or Boston<sup>®</sup> Equalens<sup>®</sup> II can reduce hypoxic stress levels during overnight wear of these shapers.

Holden and Mertz found that limiting corneal edema levels to 4% or less during sleep requires a lens capable of 87 Dk/t using conventional soft contact lenses.<sup>[11]</sup> This conclusion was based on using the transmissibility formula  $\times 10^{-9}(\text{cm}^2/\text{sec})(\text{mlO}_2/\text{ml} \times \text{mmHg})$ . It should also be taken into consideration that GPs cover a smaller area of the

cornea and the Dk ratings are generally higher than with conventional soft contact lenses.

There is another reason why use of high Dk materials is critical. Ortho-k shaping lenses generally have center thicknesses which are greater than conventional GP lenses,<sup>(19)</sup> to avoid flexure and produce the desired, controlled corneal flattening.

### Ortho-k Treatment Considerations

One of the most critical fitting criteria is centration of the ortho-k shaping lens (See “The Importance and Use of Topography”). Without good centration (both vertical and lateral), visual acuity will not be optimal and may be unacceptable to the wearer because the “treatment” zone will not be centered over the pupil and optical axis of the eye. This is why observation of the fit of the shaping lens, movement, visual acuity, and corneal topography are so important and why the fitter must see the patient within several hours of awakening in the morning after the first night of overnight wear of the shaping lens. Patients must not be allowed to continue to wear shapers that are misfit in any way.

Modern orthokeratology studies have shown that the complication rate associated with this modality is within the confines of acceptable clinical sequelae as seen in fitting conventional GP lenses.<sup>[23, 32]</sup> Adaptation may even be easier and faster since the lenses are of large diameter and worn only at night during sleep, so issues of lid sensation are minimized.

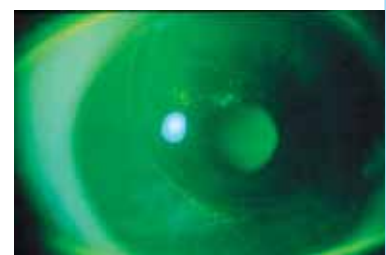
Adherence (binding) of the shaping lenses is always a possibility when a large diameter shaping lens is worn overnight (*Figures 26 through 28*). Fitters often advise wearers to instill several drops of the recommended wetting/rewetting solution in each eye just before going to sleep. Upon awakening, several more drops should be instilled in each eye.



**Figure 26. Slit lamp white light view of adhered lens**



**Figure 27. Adhered lens viewed with fluorescein**



**Figure 28. Epithelial indentation (fluorescein staining) following lens removal**

Another option is not to remove the shaping lenses immediately upon arising. Oftentimes an adhered lens will begin to move spontaneously after instillation of drops and a few minutes of blinking. Patients can also be taught how to observe binding of a shaping lens with a flashlight and how to loosen a bound shaper manually, prior to removal (*See page 38*). Patients should contact their eye care practitioner for instructions if a bound lens does not move freely after 30 minutes.

Corneal staining levels are equivalent to those that are clinically acceptable for wear of conventional rigid lenses. Patients with insufficient tear quantity and/or quality are not good candidates for ortho-k treatment, since the amount of corneal staining may rise to unacceptable levels in these patients.<sup>(17)</sup> It is also important to distinguish true corneal epithelial staining from that of mucus binding to the corneal surface.

Corneal epithelial fluorescein staining may be noted centrally as the result of either mechanical irritation (e.g. deposits on posterior side of lens) or corneal physiology (high oxygen demand cornea). Central corneal apical staining should not be present with a properly designed and fit ortho-k shaping lens. This underscores the need to use a Dk material that offers reliable stability of the ortho-k shaper.

Dimple veiling (fluorescein staining of indentations in the epithelium due to air bubbles between the shaping lens and the cornea) occurs if the base curve, or depth of the reverse or reservoir curve is too steep.

Other complications such as irritation or infection may be associated with a lack of patient education and/or compliance with wearing and care instructions (*See page 36*).

The two most common side effects that occur in any rigid contact lens wearer are corneal edema and corneal staining. It is anticipated that the same side effects may also occur in some wearers of orthokeratology shaping lenses to some degree. Other side effects that sometimes occur in all rigid contact lens wearers are extreme discomfort, redness, tearing, irritation, discharge, corneal abrasion or distortion of vision. These are usually temporary conditions if the shaping lenses are removed promptly and professional care is obtained. The wearer should be advised to remove the shaping lenses

and not to re-insert them if any of these symptoms are present and to contact the eye care practitioner immediately.

In rare instances, there may occur permanent corneal scarring, decreased vision, and infections of the eye, corneal ulcer, iritis, or neovascularization. The occurrence of these side effects should be minimized or completely eliminated if a proper schedule of shaping lens care and professional follow-up is exercised.

### Importance and Use of Topography

The appearance of the cornea changes over time from the start of the treatment (*Figure 29*) until the desired result is attained. These changes may occur rapidly at first (*Figure 30*), then slow as the cornea adjusts to its new shape and reaches the point where the desired effect is achieved (*See Figures 31 and 32*).

Topography is important to ensure that the treatment is being applied to the center of the cornea. Ortho-k shaping lenses that position too high can cause a flattening of the superior cornea and may actually induce localized corneal distortion. These can be recognized by the typical “Smiley Face” inferior corneal steepening pattern (*Figure 33*) or “Frowny Face” superior corneal steepening (*Figure 35*). Shaping lenses that are fitted too steeply can cause certain areas of the central cornea to protrude forming small islands which will negatively impact visual acuity (*Figure 34*).

Shaping lenses that position too low will present a “Frowny Face” pattern indicating superior corneal steepening caused by pressure from the shaper on the lower cornea (*Figure 35*). The “Bull’s Eye” pattern indicates that the shaping lens is centering acceptably both vertically and horizontally (*Figure 36*). Lateral decentration is usually resolved by increasing the overall diameter of the ortho-k shaping lens.

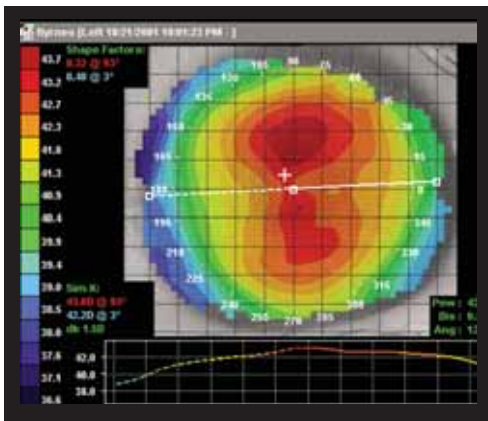


Figure 29. Before OK treatment

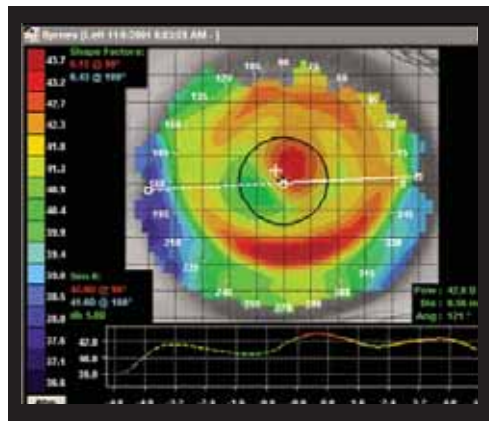


Figure 30. One day

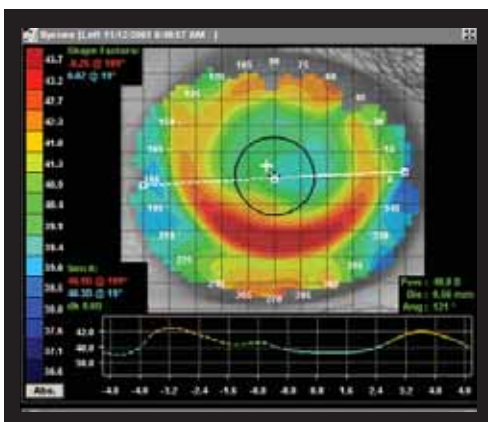


Figure 31. One week

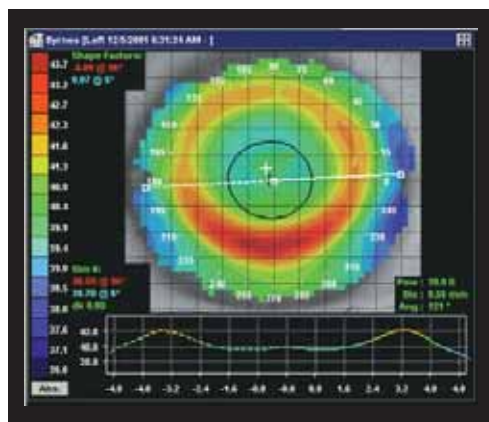


Figure 32. Two weeks

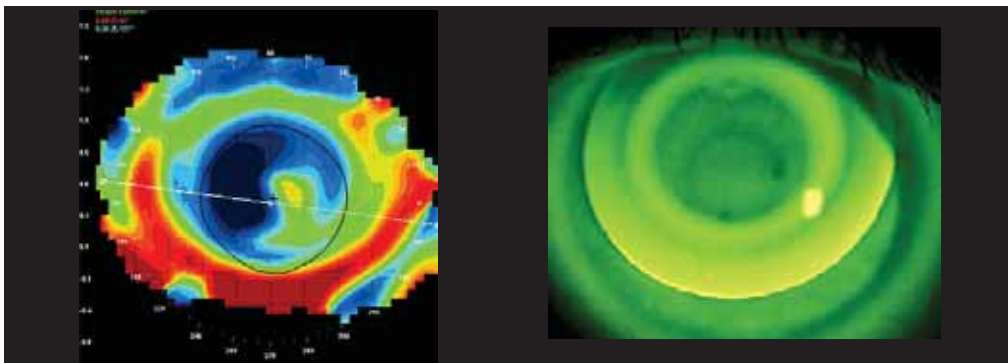


Figure 33. "Smiley Face" pattern (left) caused by shaping lens positioned high (right)

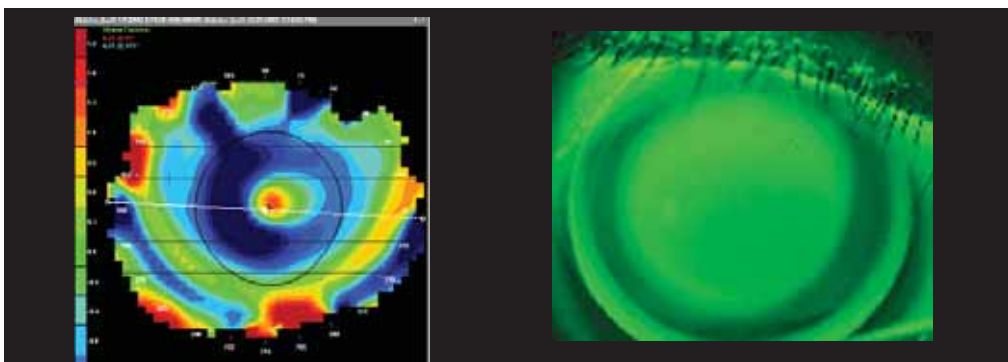


Figure 34. Central Island (left) caused by steep-fitting shaping lens (right)



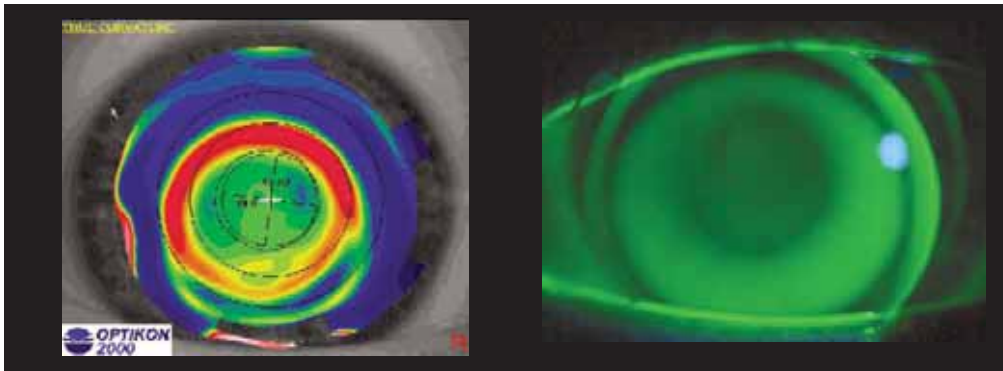


Figure 35. "Frowny Face" pattern (left) caused by shaping lens that is positioning low (right)

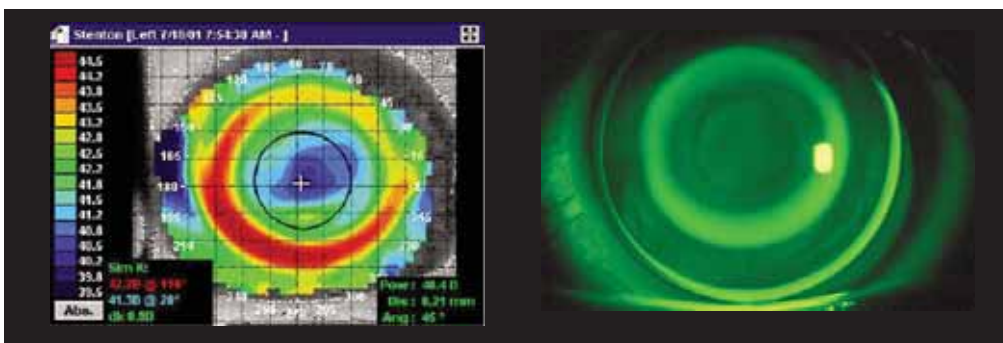


Figure 36. Bull's Eye pattern indicating perfect centration of the shaping lens

### KEY POINT SUMMARY...

- The combination of modern reverse geometry designs, high Dk GP materials, and corneal topographers make orthokeratology fitting fast, safe, and more predictable.
- One of the most critical visits for both the patient and the practitioner is the first morning after the shaping lenses are worn at night.
- An advantage of orthokeratology is that it is reversible.
- Both objective and subjective patient information must be considered when presenting options and evaluating a potential wearer for ortho-k shaping lenses.
- Pre-fitting examination does not vary much from those routine exams done in the office.
- It has been suggested that patients who may expect the best chance for success with ortho-k treatment are those candidates who have steep corneas with high eccentricity, although this is not always the case.

## IV. PRACTICE MANAGEMENT

### IN THIS CHAPTER...

- This section offers examples of fee structures for ortho-k shaping lenses and services.
- Follow-up programs are discussed for continued wear of ortho-k shaping lenses.
- Care and handling of these special designs is reviewed.
- Important points on incorporating orthokeratology into the practice are presented.
- Examples of pre-treatment permission forms are presented.
- Helping the patient to decide if ortho-k treatment is the right vision correction modality.

### Fees and Costs

Fitting of ortho-k shaping lenses involves higher costs for the fitter, both in terms of materials (shaping lenses) and increased time for fitting and follow-up. Therefore, fees for ortho-k treatment are significantly higher than for conventional GP lens fitting. That said, ortho-k fitting competes to some extent with refractive surgery and other vision correction modalities, such as conventional contact lenses and eyeglasses. As the number of laser surgical centers and LASIK procedures increases, so does the competition for the same adult myopic patients. Fees for ortho-k fitting vary from place to place and may be comprehensive (all-inclusive) or based on the duration of the treatment. Generally, all-inclusive fees are between \$750 and \$2,500, depending on the length of treatment required and the number of

shaping lenses needed. However, the average fees range from \$1100.00 to \$1400.00 (US) for ortho-k shaping lenses and three months of visits.

| <b>Sample Fitting Fee Structure</b>              |                   |               |                 |
|--|-------------------|---------------|-----------------|
|  | Practitioner Cost | Patient Fees  | Practice Income |
| Initial ocular exam/<br>consultation             | ---               | \$175         | \$175           |
| Diagnostic fitting/<br>dispensing shaping lenses | ---               | \$200         | \$200           |
| Shaping lenses (4@\$70/lens)                     | \$280             | \$350         | \$70            |
| 8 visits (@\$75/visit)                           | ---               | \$600         | \$600           |
| <b>TOTALS</b>                                    | <b>\$280</b>      | <b>\$1325</b> | <b>\$1045</b>   |

Some fitters may also offer “Shaping Lens Service” Programs to provide a yearly package for patient exams and shaping lens maintenance.

| <b>Sample Shaping Lens Retainer Program Fees</b>              |                    |              |                 |
|---|--------------------|--------------|-----------------|
|   | Practitioner Costs | Patient Fees | Practice Income |
| Annual fee (1 yr/2 yrs)<br>Includes 2 visits per year         | ---                | \$200/300    | \$200/300       |
| Shaping lens replacement<br>(lost, broken, parameter changes) | \$70/lens          | \$100/lens   | \$30/lens       |

All ortho-k lens patients should be encouraged to have a spare pair of shaping lenses in case they should break or lose one. Failure to wear ortho-k shaping lenses regularly will lead to a regression of treatment that will result in a return to pre-treatment myopic state. Replacement of shaping lenses may be an additional cost to the wearer or may be included in the Shaping Lens Service Program fee. Since maintenance of corneal shape is dependent on the ortho-k shaping lens remaining constant in micron accuracy, it is strongly recommended that ortho-k shapers be replaced on a yearly basis.

## How to Incorporate Ortho-k into the Practice

The introduction and incorporation of orthokeratology to the practice requires a change in mindset for not only the practitioner, but also for the office staff. The following steps are recommended prior to beginning to offer orthokeratology:

1. Fitter research into the various ortho-k shaping lens design options.
2. Upgrade or refresh GP fitting skills as needed.
3. Education and training for the fitter in using the design chosen by attending courses, seminars and home study.
4. Training for the office staff on discussing the ortho-k option with patients, handling patient questions, and instructing ortho-k wearers on lens care, insertion, removal, etc. of the ortho-k shaping lenses.
5. Establishing office fees and policies for ortho-k treatment. This should include development of ortho-k information sheets (FAQs), ortho-k shaping lens wear and care instructions, and Patient Fitting and Care Agreements for patients or parents of minors to read and sign (*See pages 40 and 41*).

## Ortho-k Shaping Lens Care and Handling

In order to minimize the potential for wearing complications such as eye irritations or serious infections, patients must be thoroughly trained in the proper way to wear and care for their ortho-k shaping lenses, and using good hygienic methods whenever they handle their ortho-k shapers.

### Preparing the Lens for Wearing

Cleanliness is a very important aspect of proper care of the shaping lenses. Hands should be clean and free of any foreign substances whenever the shaping lenses are handled.

- Always wash, rinse, and dry hands thoroughly before handling the shaping lenses.

- Avoid soaps containing cold cream, lotions, or oily cosmetics prior to handling shapers. These substances can adhere to the surface of the shaping lens and be difficult to remove.
- Handle shaping lenses with the fingertips, avoiding use of fingernails that can scratch or chip them.
- Always start with the same shaping lens first to avoid mix-ups.
- Remove the shaping lens from its storage case and examine it. Be sure it is clean, moist, and free of any nicks or cracks.

### Placing the Lens on the Eye

After thoroughly washing and rinsing hands, follow these steps to insert the shaping lens on the eye:

- Remove shaping lens from case.
- Rinse shaping lens with fresh conditioning solution.
- Inspect shaping lens for cleanliness, uniform wetness, and unwanted debris.
- Rub several drops of fresh conditioning solution over the surface of the shaping lens.
- Place shaper on the top of index finger of dominant hand.
- Hold down lower lid and lift upper lid up with other hand (*Figure 37*).
- Gently place shaping lens on the center of the eye. It is not necessary to press the shaper on the eye.
- Gently release lids and blink. The shaping lens should center automatically.
- Use the same technique to insert the other lens.
- The wearer should be instructed to place two or three drops of the recommended rewetting solution in each eye prior to wear.



Figure 37

### Removing the Shaping Lenses

Before attempting to remove a shaping lens, it is very important that the wearer verify that it is moving. If the shaping lens is not moving, instill 5 drops of the recommended rewetting solution. Oftentimes an adhered lens will begin to move spontaneously after instillation of drops and a few minutes of blinking. Wait until the shaper begins to move freely with the blink before attempting to remove it.

From the office, the practitioner should instruct the patient as follows: While looking upwards, a finger is placed at the lower eyelid margin at the edge of the shaper to gently but firmly apply pressure. Looking downward, the process is repeated using the fingertip placed on the upper eyelid at the shaper edge. The patient should then look straight ahead and blink several times.



Figure 38

Once the shaping lens begins to move, it can be removed using one of the following methods: The shaping lens may be removed manually by using the “blink” or “scissor” method customary with standard GP lenses. Removing large diameter ortho-k shaping lenses may require use of a soft silicone rubber removal device (*Figure 38*).

### Cleaning and Storing the Shaping Lenses

The shaping lenses should be rubbed gently for 20 seconds on each side with the recommended cleaner, followed by a thorough rinse in the recommended solution. Care must be taken not to press or squeeze the shapers excessively during handling. Ortho-k shaping lenses are susceptible to distortion and breakage.

The cleaned shaping lenses should be placed in the proper well of the case and covered completely with the storage (conditioning) solution. Maintaining the proper orthokeratology effect depends on the patient wearing the prescribed shaping lens on the correct eye. Laboratories manufacturing ortho-k lenses produce them in different colors between right and left to help the patient avoid a mixup.

Typically, the **R**ight lens is made in g**R**een, and the **L**eft lens is made in b**L**ue (*Figure 39*). In the United States, all Boston® material used for orthokeratology shaping lenses will have two unique, distinctive tints,

red and yellow, for the same purposes. The red and yellow tints are available exclusively in the U.S.

The ortho-k shaping lenses should be allowed to soak for a minimum of four hours or as recommended on solution label. If a multi purpose solution (such as Boston® Simplus™ or Boston® Simplicity™) is used, all steps (including protein removal) are performed with the one solution only. If a two-bottle care system is used, a weekly enzymatic cleaner (such as the Boston® One Step Liquid Enzyme Cleaner) may be recommended for weekly use to ensure that stubborn deposits are removed. In all cases, the wearer should be instructed to follow the directions for use on each solution package.



Figure 39

#### The major benefits of orthokeratology are:

1. It is a non-surgical alternative for myopia management.
2. Orthokeratology appears to be safe with few, if any, complications.
3. It is reversible with corneal shape returning to baseline within about 90 days after discontinuing shaping lens wear.
4. Both juveniles and adults can benefit from the visual freedom that ortho-k offers.
5. Very easy adaptation with large diameter ortho-k shaping lenses and overnight wear.
6. Limited or no daytime wear of correction lenses needed once treatment correction is achieved.

#### KEY POINT SUMMARY...

- A complete ortho-k program that includes developing fee structures, refund policies, and staff training is essential for success of the modality.
- “Preparing the office” for orthokeratology includes thorough training of the office staff.
- Thorough education of the ortho-k lens wearer on lens care and handling of shaping lenses is essential for a successful outcome.
- A thorough discussion of the benefits that orthokeratology offers will help the patient to make an intelligent decision about vision correction modalities.

Below is an example of an agreement form that also contains treatment fee information:

**Hartsdale Vision Health Center**  
**1355 West Main Street · Anywhere, USA 12345**  
**(555) 123-4567**  
**ORTHOKERATOLOGY FITTING AND CARE AGREEMENT**

This document is supplemented by an ortho-k pre-treatment evaluation, about orthokeratology and care of ortho-k shaping lenses, which I have read and understood. All questions that I had were answered by Dr. (*Name*). This program involves me wearing specially designed gas-permeable shaping lenses overnight (while sleeping) that reshape my corneas in order to provide acceptable unaided distance vision during my waking hours. I understand that the ortho-k effect is temporary and reversible and that it may be necessary to wear my shaping lenses longer to maintain satisfactory distance vision, especially if I failed to wear these shaping lenses as advised. I also understand that the quality of my unaided vision is dependent on wearing these shaping lenses as prescribed by my doctor and on how much internal astigmatism is present in my eyes, which is not always predictable. If I do not find the results acceptable, the process will be reversed by my wearing rigid gas permeable or soft contact lenses for about one to three weeks.

**BENEFITS:** These orthokeratology shaping lenses have been designed to provide excellent visual acuity and oxygen transmission to the eye. The design of the shaping lens is believed to provide a reduction in the refractive error of a treated eye with a resultant improvement in the unaided distance visual acuity. This change is believed to be completely reversible and temporary in nature.

**RISKS:** While no harmful health risks to your eyes are anticipated from using the ortho-k shaping lenses, as with any contact lens there are potential risks of irritation to the eye, infections, or corneal ulcers. Transient distorted vision that is not corrected with spectacle lenses may occur after removal of the lenses. No harmful effects are expected from any of the examination procedures used in the fitting process. If you develop any unusual symptoms or prolonged discomfort, removing the shaping lens should, in most cases, provide immediate relief. In addition, you should contact your eye care practitioner immediately.

In the event it is determined that use of shaping these lenses presents new risks or the possibility of undesirable side effects, you will be advised of this information so that you may determine whether or not you wish to continue ortho-k treatment.

**ALTERNATIVES:** Currently available alternatives to ortho-k shaping lenses are spectacles or other types of soft, conventional hard or gas permeable contact lenses or surgical vision correction. Dr. (*Name*) or his/her staff can discuss these alternatives with you.



**FEE SCHEDULE**

|                                       |   |
|---------------------------------------|---|
| <b>Initial consultation:</b>          | Includes comprehensive evaluation of refractive status, corneal topography, and determination of diagnostic ortho-k shaping lens parameters. \$175.00 (payable at time of examination).   |
| <b>Diagnostic shaping lens trial:</b> | Includes evaluating the refractive changes over a period of three to five hours resulting from the wearing of diagnostic ortho-k shaping lenses<br>\$200 (payable at time of examination) |
| <b>Treatment Program:</b>             | \$625 (Includes all visits for three months)  |
| <b>Retainer lenses:</b>               | \$300<br>\$925 (\$300 payable in advance and \$625 payable by fourth week scheduled visit.)   |
| <b>Refund policy:</b>                 | If you should wish to discontinue the treatment on or before the fourth week's scheduled visit, the balance of \$625 will be credited or, if paid by cash or check, refunded.             |

I have read all of the above information regarding ortho-k shaping lenses. I understand what I have read and the circumstances have been explained to me. Although it is impossible for my eye care practitioner to inform me of every possible complication, he/she has answered all my questions to my satisfaction and has assured me that he will advise me of new risks if they develop and will answer any further inquiries I may have about this treatment or wearing this type of lens. Should any complications occur, I agree to contact Dr. (Name) immediately at: (555) 123-2020 daytime or (555) 123-4321 after hours.

**(please print)**

Name: \_\_\_\_\_

Practitioner: \_\_\_\_\_

Address: \_\_\_\_\_

Date: \_\_\_\_\_ Phone: \_\_\_\_\_

Signature: \_\_\_\_\_

If patient is under 18 years old, parent or guardian signature required.

Signature, Parent/Guardian: \_\_\_\_\_

Relationship to minor: \_\_\_\_\_

Signature, Witness: \_\_\_\_\_

## V. GLOSSARY

|                                       |  |
|---------------------------------------|--|
| <i>Ablate/Ablation</i>                | The process of using a laser light to vaporize corneal epithelial cells in a specific area (treatment zone) during a LASIK or PRK refractive surgical treatment.   |
| <i>Accelerated orthokeratology</i>    | The use of specially designed 4, 5, and 6 zone lens designs that employ base curves calculated to be flatter than the flat corneal curvature, reverse zones of steeper radii, and alignment zones that provide improved lens positioning and the positive-negative pressures between lens and cornea necessary to effect desired myopic reduction quickly and systematically, while worn during sleep. |
| <i>“Against-the-rule” astigmatism</i> | The flattest (longest) radius of corneal curvature lies vertically at 90° and the steepest (shortest) curve of the cornea is horizontal at 180°.   |
| <i>Alignment Curve (AC)</i>           | Based on specific design, this curve may also be called Anchor Curve, Landing Zone, or Fitting Curve. Area of posterior lens surface that aligns lens with mid-periphery of cornea to control lens position and centration during lens wear.   |
| <i>Anterior optical zone (AOZ)</i>    | Front, central lens curve that (combined with the base curve and refractive index) determines lens power.  |
| <i>Apical/Apex</i>                    | The extreme top or tip of a curve (e.g. corneal apex: tip of the cornea).  |
| <i>Apical bearing</i>                 | Posterior lens curvature lightly touches the corneal apex.   |
| <i>Apical touch</i>                   | Posterior lens curvature rests on corneal apex.  |
| <i>Aspheric</i>                       | Not spherical. A posterior or anterior lens surface design which progressively flattens at a given rate (eccentricity) as the curve progresses toward the periphery.   |
| <i>Astigmatism</i>                    | Refractive defect where the refractive components of the eye have differing powers in different meridians. The result is that light rays will focus at more than one point inside the eye.   |
| <i>Axial edge lift</i>                | Vertical distance from the lens edge to an extension of the base curve of a lens.  |

|   |   |
|---|---|
| <i>Back Optic Zone diameter (BOZD)/Optic Zone diameter (OZD)</i>                  | Chord length measurement across back optic zone. In ortho-k, determines size of central corneal treatment area.   |
| <i>Back Optic Zone radius (BOZR)/Base curve (BC)/Posterior optical zone (POZ)</i> | The major central posterior curve of the lens that fits over the apex of the cornea.  |
| <i>Biomicroscopy/slit lamp exam</i>   | Use of high power microscope and light source to examine the anterior segments of the eye using various amounts of magnification.   |
| <i>Bowman's Membrane</i>  | Second layer of the cornea located between the epithelium and the stroma, approximately 10 microns in thickness.  |
| <i>"Bull's Eye" topography</i>  | Corneal topography map that shows acceptable centration and central corneal flattening with an ortho-k shaping lens fit.  |
| <i>"Central Island" topography</i>  | Topography maps that show areas of steepness in the central cornea caused by an ortho-k shaping lens that is fitted too steeply, causing a squeezing of the cornea and central steepening.  |
| <i>Contrast sensitivity test</i>  | Contrast sensitivity tests plot the lowest contrast level at which a person can detect an object of a given size to detect variations in the quality of the image on the retina.  |
| <i>Cornea</i>   | Transparent, small dome-shaped anterior portion of the eye through which light rays pass into the eye.  |
| <i>Corneal astigmatism</i>  | Condition where the toroidal (oval) shape of the cornea is the reason that light rays are caused to focus at various points within the eye.   |
| <i>Corneal staining</i>   | Healthy corneal epithelial cells normally will not take up fluorescein dye. Damaged or dead cells will allow fluorescein dye to enter. The extent and location of this staining is an indication of corneal irritation (mechanical or chemical) and/or insufficient oxygen (hypoxia). |
| <i>Cylindrical refractive error/power</i>   | Requiring a lens whose correcting power is located in one specific meridian.  |
| <i>Descemet's Membrane</i>  | Thin elastic fourth layer of the cornea that adds to the flexibility of the cornea, approximately 10 microns in thickness.  |
| <i>Dk</i>   | Refers to the inherent permeability of a lens material to allow the passage of gases through it. D = diffusion coefficient, k = degree of material solubility.  |
| <i>Dk/L or Dk/t</i>   | Refers to the amount of oxygen (gases) that pass through a lens material of a specified thickness ("D" and "k" references are same as above. "L" or "t" refers to specific lens average thickness).   |

|   |   |
|---|---|
| <i>Dimple veiling</i>                   | Fluorescein staining of indentations made in the corneal epithelium by trapped air bubbles under the lens.  |
| <i>Diopter</i>                          | Unit of measurement of light ray convergence or divergence equal to the reciprocal focal length of a lens in meters (e.g. a 2.00 diopter lens brings light rays into convergence at 0.5 meter).   |
| <i>Eccentricity</i>                     | The rate of flattening of an aspheric curve measured as an "e" value.   |
| <i>Edema (corneal)</i>                  | Condition where the corneal water content increases causing a loss of clarity.  |
| <i>Edge lift (clearance)</i>            | Distance between lens edge and the corneal surface. Created by the width and radii of the peripheral curves. Allows for tear circulation under the lens and aids in lens removal.   |
| <i>Endothelium</i>                      | Fifth (innermost) layer of the cornea, responsible for corneal metabolism and maintaining the water content of the cornea. Approximately 5 microns in thickness.  |
| <i>Epithelial flap</i>                  | Use of a microkeratome instrument to incise and lift an epithelial layer of the central cornea prior to applying laser ablation.  |
| <i>Epithelium</i>                       | The outermost layer of the cornea comprised of approximately five layers of cells that is approximately 50 microns in thickness.  |
| <i>Fitting curve (FC)</i>               | Depending on specific ortho-k design, this may also be called Alignment curve or Reverse curve.   |
| <i>Flat meridian/Flat "K"</i>           | Meridian of the cornea having the longer radius of curvature.   |
| <i>Fluorescein pattern</i>              | The appearance of the tear film distribution and thickness between the posterior of a rigid lens and the anterior corneal curvature, as viewed with fluorescent dye that stains the tear film.  |
| <i>Fluoro-silicone acrylate (F-S/A)</i> | An oxygen permeable rigid contact lens material developed in the 1980s that combines fluorine for lens stability, wettability, and added oxygen transmission; with silicone for oxygen permeability; and methyl methacrylate for stability, machinability, durability, and optical quality. |
| <i>"Frowny Face" topography</i>         | Topography map that shows a steepened area of the superior cornea caused by an ortho-k lens that centers too low on the cornea causing inferior flattening.   |
| <i>GP/RGP</i>                           | Gas permeable (rigid) contact lens.   |
| <i>High Dk</i>                          | Having permeability ratings 31 to 60 (ISO/Fatt).  |
| <i>Hyper Dk</i>                         | Having permeability ratings greater than 100 (ISO/Fatt).  |

|                                 |   |
|---------------------------------|---|
| <i>Hyperopia</i>                | Farsightedness; condition where the eye is underpowered causing light rays to focus at a point behind the retina. Correction is supplied using “plus” or “positive” powered optical lenses.   |
| <i>Hypoxic stress</i>           | Refers to corneal oxygen uptake rates on a given eye with a lens of a given permeability or the lack thereof.   |
| <i>ISO/Fatt</i>                 | International Standard Organization (ISO) method for measuring and stating oxygen permeability and other values for all contact lens materials.   |
| <i>Keratoconus</i>              | Degenerative corneal disease characterized by thinning and cone-shaped protrusion of the central cornea.  |
| <i>Keratometry (K-readings)</i> | Use of a keratometer to measure central apical cornea curvature zone of 3 to 4 millimeters in diameter.   |
| <i>LASEK</i>                    | Laser Assisted Subepithelial Keratectomy is a refractive surgery procedure where a thin flap of epithelium only is created using an alcohol solution to soften the epithelium and a thin surgical blade to lift it. This process is said to be beneficial for corneas too thin to have LASIK or PRK. The underlying cornea is then treated with a laser to reshape the central cornea. The flap is then replaced to heal. |
| <i>LASIK</i>                    | Laser Assisted In-Situ Keratomileusis; same as LASEK except a thicker hinged flap consisting of the epithelium and some stroma is created using a microkeratome instrument. The central cornea is then treated by laser as in LASEK and PRK and the flap replaced to heal.  |
| <i>Low permeability</i>         | GP materials having Dk ratings of less than 15 (ISO/Fatt).  |
| <i>Macular degeneration</i>     | Degeneration of the macular portion of the retina which leads to permanent loss of central vision.  |
| <i>Medium Dk</i>                | Having Dk ratings between 15 and 30 (ISO/Fatt).   |
| <i>Micron</i>                   | One-thousandth of a millimeter. One average human cell is 10 microns in height. One human hair is approximately 50 microns thick.   |
| <i>Myopia (nearsightedness)</i> | Nearsightedness; condition where the eye is over powered causing light rays to focus at a point in front of the retina. Correction is supplied using “minus” or “negative” powered optical lenses.  |
| <i>Myopic progression</i>       | Process by which myopia in an individual gradually increases over a period of time, requiring the need for increased myopic prescription changes.   |
| <i>Nomogram</i>                 | Calculation system (charts, tables, computer programs) used to calculate appropriate diagnostic or final lens design.   |

|  |  |
|--|--|
| <i>Oblate shape</i>  | A curve whose central curve is nearly flat (similar to the long curvature of an egg).  |
| <i>Ophthalmoscopy</i>  | Direct or indirect examination of the internal structures of the eye, especially the optic nerve, macula, and retina.  |
| <i>Optical zone (POZ)/Back Optical Zone radius (BOZR)/ Base curve (BC)</i> | Central portion of the posterior lens, not including the peripheral curves, that the wearer sees through.  |
| <i>Orthokeratology, ortho-k</i>  | Use of gas permeable (rigid) contact lenses to gradually and systematically alter the shape of the cornea to cause a temporary and reversible reduction in myopia.   |
| <i>Ortho-k shaping lens, lens shaper, ortho-k shaper, retainer, etc.</i>   | A specially designed gas permeable (rigid) contact lens used in ortho-k treatment to change the shape of the cornea to reduce sagittal height, refocus light rays onto the retina, and temporarily reduce the myopic requirement of the eye. |
| <i>Overall diameter (OAD) or Total Lens Diameter</i>                       | Chord length of a lens across the widest point of lens.  |
| <i>Over-refraction</i>   | Refraction performed over an existing correction (contact lens or ortho-k treatment) to gauge extent of under- or over-correction.   |
| <i>Pachometry</i>  | Measurement of corneal thickness.  |
| <i>Peripheral curve(s) (PC)</i>  | Curve(s) of flatter radius added to the posterior surface of the rigid lens edge to approximate the flattening of the peripheral cornea. Essential for lens comfort, tear circulation, debris removal, and to facilitate lens removal.       |
| <i>Permeability</i>  | See "Dk."  |
| <i>Phoropter</i>   | Refraction device containing a large variety of spherical plus and minus powered lenses, cylinder powers, prisms, etc. used to determine the eye's best optical correction.  |
| <i>Photorefractive keratectomy (PRK)</i>                                   | Use of eximer laser light to "sculpt" a prescribed area of the central cornea, creating a flatter zone and reducing myopia.  |
| <i>Polymethylmethacrylate (PMMA)</i>                                       | Plastic very similar to Plexiglas™ used in contact lens manufacture from the 1930s as the original contact lens material. Totally impermeable to gases.  |
| <i>Prolate shape</i>   | A curve having a steeper (higher) center than its periphery (similar to the curve at the tip of an egg).   |
| <i>Punctate staining</i>   | Appearance of the cornea when stained with fluorescein dye where scattered to diffuse areas of "pinpoint" staining occur. This usually indicates corneal epithelial cell damage or destruction.  |

|   |  |
|---|--|
| <i>Radial Keratotomy (RK)</i>               | Radial incision made in the periphery of the cornea that causes central corneal flattening with resultant reduction in myopia.   |
| <i>Refraction</i>                           | Subjective test used to determine the refractive error of the eye in order to prescribe the best correcting lens powers.   |
| <i>Refractive error</i>                     | Internal optical defect where light rays are not focused on the retina of the eye causing blurred vision.  |
| <i>Refractive surgery</i>                   | Use of incisions, implants, or laser light to alter the shape of the corneal surface to affect vision.   |
| <i>Retainer lens<br/>(See shaping lens)</i> | Ortho-k shaping lens worn nightly as prescribed to maintain the shape of the cornea and myopic reduction. Similar to a retainer worn for teeth.  |
| <i>Reverse Curve</i>                        | Also known as Reservoir Curve, Fitting Curve, depending on specific ortho-k design. Secondary curve with steeper radius of curvature than preceding (Back Optic Zone Radius/BOZR) curve. Area of shaping lens where corneal mass will accumulate during ortho-k treatment. |
| <i>Reverse geometry design</i>              | Designs that use secondary curves that are steeper than the preceding curve.   |
| <i>Sagittal depth</i>                       | The distance between the crest of an arc and a straight baseline. Area under the arc of a curve depends on the steepness or flatness of the curve radius.  |
| <i>Schirmer tear test</i>                   | Screening test that uses sterile filter paper strips to determine tear production volume for a given time period.  |
| <i>Seal-off</i>                             | A contact lens whose edges have sealed against the cornea 360° preventing tear exchange and debris removal.  |
| <i>Shaping lens</i>                         | See "Ortho-k shaping lens."  |
| <i>Silicone acrylate (S/A )</i>             | Oxygen permeable plastic developed in the 1970s for contact lenses (GP) that combines silicone for oxygen transmissibility and methacrylate for optical quality, lens machinability, and stability.  |
| <i>"Smiley Face" topography</i>             | Corneal topography map that shows an area of inferior steepening caused by an ortho-k shaping lens that rides too high, causing superior corneal flattening.   |
| <i>Spherical equivalent</i>                 | Average power of a sphero-cylindrical lens equal to the sum of the spherical power plus half of the cylindrical power.   |
| <i>Spherical refractive error/power</i>     | Requiring a lens whose correcting power is equal in all meridians.   |
| <i>Steep meridian/Steep "K"</i>             | Meridian of the cornea having the shorter radius of curvature.   |

|                                    |   |
|------------------------------------|---|
| <i>Stroma</i>                      | Middle (third) layer of the cornea composed of layered collagen fibrils and cells, approximately 460 microns thick. Comprises 90% of corneal thickness.   |
| <i>Super-Dk</i>                    | Having permeability ratings between 61 and 100 (ISO/Fatt).  |
| <i>Tear Breakup Time (TBUT)</i>    | Time interval between a blink and the appearance of a dry spot in the tear film. Indication of the quality of the tear film.  |
| <i>Tear pump mechanism</i>         | Dynamic mechanism created by lens movement with each blink which causes an exchange of tears under the lens to remove de-oxygenated tears and cellular debris.  |
| <i>Topography</i>                  | Corneal modeling instrument that produces color-coded maps of the corneal surface using a variety of views.   |
| <i>Visual acuity</i>               | Measure of the eye's ability to distinguish objects, details, and shape assessed by the smallest identifiable object that can be seen at a specific distance (usually 20 feet for distance and 16 inches for near). |
| <i>"With-the-rule" astigmatism</i> | The flattest (longest) radius of corneal curvature lies horizontally at 180° and the steepest (shortest) curve of the cornea is vertical at 90°.  |
| <i>Wratten (yellow) filter</i>     | A photographic yellow filter of a specific density that allows the visualization of greater detail gradations in the fluorescein stained-tear film.   |



## VI. FREQUENTLY ASKED QUESTIONS (FAQS)

### IN THIS CHAPTER...

- The most often asked questions about orthokeratology by patients to practitioners.
- Questions that are frequently asked about orthokeratology from fitters to the laboratory.

The FAQ (Frequently Asked Questions) section may be applicable to fitter, manufacturer, or consumer, depending on their knowledge of orthokeratology.

### General

**Q:** How do ortho-k lenses work?

**A:** Ortho-k shaping lenses are designed to progressively reshape the central surface of the cornea systematically, similar to the effect of lasers in reversing nearsightedness. However, unlike laser surgery, the effect of ortho-k treatment is temporary and reversible.

**Q:** Is everyone a candidate for ortho-k?

**A:** No! While orthokeratology can help most individuals (including those with certain types and amounts of astigmatism and moderately high myopia) improve their vision, the procedure is often most effective for those prescriptions falling within a specific range. Additional factors may include individual corneal rigidity and shape factors as well as an ability to wear contact lenses. A thorough consultation and examination using advanced computerized diagnostic instrumentation can easily determine if orthokeratology is right for an individual.

**Q:** Who is not a candidate for ortho-k?

**A:** While ortho-k can be performed on practically anyone with healthy eyes who can insert a contact lens and follow lens care directions, it is not recommended for people with prescriptions above 5.00 diopters of myopia or above 1.50 diopters of astigmatism. Also, people with pupils that are larger than normal (> 6 mm in normal light) and those having irregular corneal astigmatism or any corneal disorder such as keratoconus are not candidates.

**Q:** How safe is ortho-k?

**A:** Ortho-k is believed to be safe when appropriately fitted and managed properly. Many people have been able to eliminate their dependence upon their glasses and standard contacts with no adverse effects. Unlike surgical procedures like radial keratotomy (RK), photorefractive keratectomy (PRK), laser assisted in-situ keratomileusis (LASIK), and laser assisted subepithelial keratectomy (LASEK), the corneal tissue is not incised or vaporized by a laser. As with all contact lenses, proper lens care and handling must be performed to maintain eye health. The state-of-the-art, high-permeability GP materials now available provide adequate amounts of oxygen to the tissues of the eye.

**Q:** Is ortho-k permanent?

**A:** After treatment, maximum results are achieved and retainer shaping lenses are worn to stabilize and maintain the new corneal shape. Failure to wear the shaping lens on an ongoing basis will result in a return to the pre-existing prescription. Retainer shaping lenses will likely be prescribed for overnight wear.

**Q:** What are the risks of wearing lenses overnight?

**A:** The complications of wearing contact lenses include corneal ingrowth of vessels, ulcers, and abrasions. The risks associated with wearing contact lenses overnight are higher than wearing contact lenses only while awake. Contact lenses cannot become lost behind the eye (this is anatomically impossible) and it is rare for ortho-k shaping lenses to become decentered from the cornea.

**Q:** How long does it take for the process to stabilize and provide functional vision for the whole day?

**A:** It generally requires four to seven consecutive nights of wearing the shaping lenses to achieve the desired result. It may take somewhat longer for those with higher degrees of nearsightedness.

**Q:** Are ortho-k lenses uncomfortable to wear?

**A:** Overnight wearing of the shaping lenses is surprisingly comfortable. Most patients are unaware of their presence within a very short time after insertion. And because the ortho-k shapers are made in large diameters and worn during sleep, the normal adaptation process is very short.

**Q:** Will I still have to wear glasses or contacts?

**A:** Once the desired myopic reduction is obtained, the final shaping lenses act as retainers to maintain that level. Regular contact lenses are not needed. Glasses may be needed for reading or other part-time use. During the initial treatment period, if unaided vision does not last a full day, the patient will be given soft disposable contact lenses to wear to maintain normal distance vision.

**Q:** Once the treatment phase is completed, how frequently will I need to wear the overnight retainer lenses?

**A:** Most people will need to wear the shaping lenses six to seven consecutive nights in order to enjoy good, unaided vision during the entire day. Patients with lesser degrees of myopia (nearsightedness) may find that wearing them every other night is satisfactory. However, this will be determined on an individual basis by the eye care practitioner.

**Q:** How much myopia can a person realistically expect to be able to reduce using orthokeratology?

**A:** Generally, 5.00 diopters of myopia is the upper limit for myopia reduction. However, work is underway on designs that will hopefully correct higher amounts of myopia. Lower amounts of myopia are easier and faster to reduce.

**Q:** How about ortho-k for astigmatism?

**A:** The amount of astigmatism reduction achievable will depend on the amount and the type. 1.50 diopters of "with-the-rule" corneal astigmatism and 0.75 diopter of "against-the-rule" corneal astigmatism are considered the upper limits for astigmatism reduction. Ortho-k will not have an effect on residual (internal) astigmatism.

**Q:** How long does it take to be able to see well without glasses?

**A:** Rapid visual improvement normally occurs in the first few days. Stabilization then follows over the next few weeks and months. Once the wearer's eyes are stabilized, improved eyesight is maintained by wearing shaping lenses as recommended to maintain vision at the desired level.

**Q:** If the patient decides to return to wearing glasses, can vision be restored to its pre-treatment level?

**A:** The wearer's eyes will return to their pre-treatment nearsightedness after about two weeks. Depending on how long ortho-k lenses have been worn, this process may be as long as 30–90 days. In order to provide good vision during this transitional period, patients are refitted with gas permeable lenses or disposable soft lenses while the corneas recover their pre-treatment shape.

**Q:** If the patient becomes less nearsighted or presbyopic in later years how will that be handled?

**A:** Unlike laser surgery that cannot be reversed, corneas can usually be remodeled to accommodate the change in prescription by changing the design of the maintenance lenses to correct for near vision using a technique called "monovision."

**Q:** How much does ortho-k cost?

**A:** The actual cost will depend on the complexity of the case. Each doctor sets fees accordingly. Fees can range from \$750 to \$2,000 depending on length of treatment and the number of shaping lenses needed. The doctor will be able to provide an estimate for each patient.

#### **For the Fitter/Lab:**

**Q:** What is the current prediction for the number of orthokeratology fits that will be done worldwide?

**A:** The use of orthokeratology will vary from market to market. Current estimates in the US market suggest that there could be as many as 50,000 to 100,000 ortho-k fits annually. Much of this will depend on the acceptance of the professional community, potential candidates, and promotion from GP lens manufacturers and the media.

**Q:** Is it necessary to use topography to fit today's ortho-k lenses or can I use keratometry as I always have to fit GP lenses?

**A:** Use of topography is highly recommended in all phases of the fitting and follow-up. Some fitting systems base initial shaping lens selection on topography data, while others recommend use of manual keratometry. Virtually all ortho-k fitting systems recommend the use of topographical data to establish a baseline reference as part of the fit evaluation, to identify and help solve fitting problems and to monitor the progress of myopic reduction.

**Q:** What are the benefits of using four and five zone designs over the earlier three zone designs?

**A:** These modern four and five zone shaping lens designs use wider alignment (mid-peripheral) zones to achieve easier, more stable lens centration. Corneal shape changes can be made in larger increments; myopia reduction occurs more rapidly, requiring only one pair of shaping lenses in a high percentage of cases. This makes material costs to both fitter and patient lower.

**Q:** If ortho-k shaping lenses need modification or blending, can I do this in my office to save time?

**A:** While in-office lens modification has long been a skill valued by lens fitters, modern ortho-k shaping lens designs are complex and precise. Any hand modification made by the fitter to improve the lens fit will probably be impossible to duplicate if a lens is lost, broken, or requires other parameter changes.

**Q:** How important is dispensing and the next-day visit in evaluating the overnight ortho-k shaping lens fit?

**A:** Each patient will respond differently to orthokeratology treatment. These shaping lenses generally tighten with wear, which may occur in as little as an hour. It is important to evaluate the shaping lens after allowing it to settle-down in the office. Centration is the key to a successful ortho-k treatment; therefore, shaping lenses must be checked early the first morning for centration, binding, and adhesion. Shaping lenses are then removed to evaluate topography and to check unaided visual acuity.

**Q:** If an ortho-k shaping lens is lost, broken, or not able to be worn, how can I provide suitable vision to the patient until the replacement lens arrives?

**A:** Soft disposable lenses can be prescribed until the proper replacement shaping lens is received. If the cornea begins to revert back to higher myopia, stronger disposable lenses can be given. The wearer should be checked once again the day after a new shaping lens is worn overnight.

#### KEY POINT SUMMARY...

- The success of orthokeratology in the practice and in the laboratory is dependent on being able to address and adequately answer any questions that arise before, during, or after orthokeratology treatment.

## VII. SUGGESTED READING

- Orthokeratology Handbook, Winkler\_TD, Kame\_RT, Butterworth Heinemann, January 1995
- Orthokeratology: Principles and Practice, Mountford\_J, Ruston\_D, Dave\_T, Butterworth Heinemann, March 2004, ISBN 0750640073
- Myopia and the Control of Eye Growth: Symposium No. 155, Back\_G, John Wiley & Son, Ltd. February 1991, ISBN 0471926922
- Clinical Management of Myopia, Grosvenor\_TP, Goss\_DA, Hofstetter\_HW, Butterworth Heinemann, October 1998, ISBN 0750670606
- Controlled Kerato-reformation (CKR): An Alternative to Refractive Surgery, El Hage\_S, Practical Optometry, Canadian Edition, December 1999, 10:6

## VIII. USEFUL ORTHO-K WEB SITES

- British Orthokeratology Society  
[www.boks.org.uk](http://www.boks.org.uk)
- All About Vision  
[www.allaboutvision.com](http://www.allaboutvision.com)
- The Ortho-k Network  
[www.ortho-k.net](http://www.ortho-k.net)
- National Eye Research Foundation (NERF)  
[www.nerf.org](http://www.nerf.org)

## IX. BIBLIOGRAPHY

1. Alharbi\_A, Swarbrick\_HA, "The Effects of Overnight Orthokeratology Lens Wear on Corneal Thickness," *Investigative Ophthalmology and Visual Science*, 44:6, June 2003
2. Binder\_P, May\_C, Grant\_S, "An Evaluation of Orthokeratology," *American Journal of Ophthalmology*, 87:729, 1980
3. Brand\_RJ, Polse\_KA, Schwalbe\_JS, "The Berkeley Orthokeratology Study, Part I: General Conduct of the Study," *American Journal of Optometry and Physiological Optics*, 60:175, 1983
4. Carkeet\_NL, Mountford\_JA, Carney\_LG, "Predicting Success with Orthokeratology Lens Wear: A Retrospective Analysis of Ocular Characteristics," *Optometry and Vision Science*, Vol. 72, No. 12, 892-898
5. Coons\_LJ, "Orthokeratology Part II: Evaluating the Tabb Method," *Journal of the American Optometric Association*, 55:409, 1984
6. Dave\_T, Ruston\_D, "Current Trends in Modern Orthokeratology," *Ophthalmic and Physiology Optics*, Vol. 18, No. 2, 1998
7. El Hage\_S, "Photokeratoscopy and Controlled Keratoreformation," paper presented at the International Symposium of Ophthalmological Optics, Tokyo, Japan, May 1978
8. Grant\_SC, "Orthokeratology: A Safe and Effective Treatment for a Disabling Problem," *Survey of Ophthalmology*, Vol. 24, No. 5, March-April 1980, 291-297
9. Harris\_DH, Stoyan\_N, "A New Approach to Orthokeratology," *Contact Lens Spectrum*, April 1992, 37-39
10. Holden\_BA, Mertz\_GW, McNally\_JJ, "Corneal Swelling Response to Contact Lens Worn Under Extended Wear Conditions," *Investigative Ophthalmology and Vision Science*, 1983, 24:218-226
11. Holden\_BA, Mertz\_GW, "Critical Oxygen Levels to Avoid Corneal Edema for Daily and Extended Wear Contact Lenses," *Investigative Ophthalmology and Vision Science*, 1984, 25:1161-1167
12. Horner\_DG, Bryant\_MK, "Take Another Look at Today's Ortho-k," *Review of Optometry*, June 1994
13. Jessen\_G, "Orthofocus Techniques," *Contacto*, 6:200, 1962
14. Kame\_RT, "Flatten the Cornea the Nonsurgical Way," *Review of Optometry*, April 1995
15. Kerns\_R, "Research in Orthokeratology II: Experimental Design Protocol Method," *JAOA*, 47:1275, 1976

16. Lin\_LK, Shih\_YF, Lee\_YC, Hung\_PT, Hou\_PK, "Changes in Ocular Refraction and Its Components Among Medical Students: A 5-Year Longitudinal Study," *Optometry and Vision Science*, 73, 1996, 495-498
17. Lu\_Fan, Jiang\_Jun, Qu\_Jia, Jin\_Wangqing, Mao\_Xinjie, She\_Yi, "Clinical Study of the Orthokeratology for Young Myopic Adolescents," presented at the Myopia 2001 Conference, Boston MA USA, July 2001
18. Lund\_ME, Reim\_TR, Wu\_RLT, "Myopia Progression in Orthokeratology," paper presented at VII International Conference on Myopia, Taipei, Taiwan, 1999
19. Marsden\_HJ, "Common Sense Orthokeratology," *Contact Lens Spectrum*, Oct. 1995, 24-31
20. Morrison\_RJ, "Contact Lenses and the Progression of Myopia," *Optometry Weekly*, 1956, 47, 1487-1488
21. Mountford\_J, "An Analysis of the Changes in Corneal Shape and Refractive Error Induced by Accelerated Orthokeratology," *International Contact Lens Clinics*, 1997, 24: 128-143
22. Mountford\_J, *Orthokeratology in Contact Lenses*, Butterworth-Heinemann, Oxford UK, 1997, 653-692
23. Nichols\_JJ, Marsich\_MM, Nguyen\_M, Barr\_JT, Bullimore\_MA, "Overnight Orthokeratology," *Optometry and Vision Science*, Vol. 77, No. 5, May 2000
24. Perrigin\_J, Perrigin\_D, Quintero\_S, Grosvenor\_T, "Silicone Acrylate Contact Lenses for Myopia Control: Three-Year Results," *Optometry and Vision Science*, 1990, 67:764-769
25. Polse\_KA, Brand\_RJ, Vastine\_DW, Schwalbe\_JS, "Corneal Change Accompanying Orthokeratology: Plastic or Elastic?," *Archives of Ophthalmology*, Vol. 101, 1983
26. Polse\_KA, Brand\_RJ, Schwalbe\_JS, Vastine\_DW, Keener\_RJ, "The Berkeley Orthokeratology Study, Part II: Efficacy and Duration," *American Journal of Optometry and Physiological Optics*, Vol. 60, No. 3, 1983, 187-198
27. Polse\_KA, Brand\_RJ, Keener\_RJ, Schwalbe\_JS, Vastine\_DW, "The Berkeley Orthokeratology Study, Part III: Safety," *American Journal of Optometry and Physiological Optics*, Vol. 60, No. 4, 1983, 321-326
28. Ramkuhar\_S, Swarbrick\_H, "Corneal Response to Short-Term Orthokeratology Lens Wear," *Optometry and Vision Science*, 80:3, March 2003
29. Reim\_TR, "Overflowing With Ortho-k," *Optometric Management*, December 1998, 36-39
30. Schachet\_JL, "Optimal Lens Choices for Orthokeratology," unknown publication
31. Stone\_J, "Possible Influence of Contact Lenses on Myopia," *British Journal of Optometry*, 1976, 31, 89-114
32. Swarbrick\_HA, Wong\_G, O'Leary\_DJ, "Corneal Response to Orthokeratology," *Optometry and Vision Science*, 75:11, November 1998
33. Sridharan\_R, Swarbrick\_H, "Corneal Response to Short-Term Orthokeratology Lens Wear," *Optometry and Vision Science*, 80:3, March 2003, 200-206
34. Owens\_H, Garner\_LF, Craig\_J, Gamble\_G, "Posterior Corneal Changes with Orthokeratology," *Optometry and Vision Science*, 81:6, June 2004, 421-426



Polymer Technology  
100 Research Drive  
Wilmington MA 01887  
[www.polymer.com](http://www.polymer.com)



***Boston***<sup>®</sup>

© 2004 Polymer Technology, a Bausch & Lomb company.  
Boston, Boston XO, Boston Equalens II and Boston Simplus are trademarks of  
Polymer Technology, a Bausch & Lomb company. Other product names/brand names  
are trademarks of their respective owners. RIL0174