Cutting Out Surgery for the Management of Refractive Error

Melanie Frogozo, OD, FAAO, FSLS & Brianna Rhue, OD, FAAO, FSLS
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Financial Disclosures

Brianna Rhue

- Co-Founder Dr. Contact Lens
- Co-Founder TechifEYE
- MAB- OSRX Pharmacy
- Principal Investigator- STAAR Study
- Medical Advisory Board- Visus
- Speaker Bureau- Bausch & Lomb Specialty Vision Products
- Speaker Bureau- Coopervision
- PAC- Johnson & Johnson

Melanie Fragozo

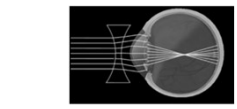
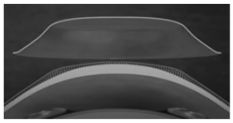
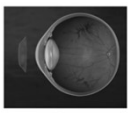
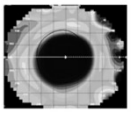
- Euclid
- Coopervision
- ABB Optical Group
- Vyluma
- Boston Sight

All relevant relationships have been mitigated

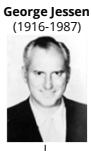
Goals

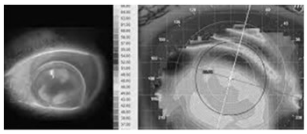
I. History of Orthokeratology
II. Corneal Physiology
III. Corneal Topography
IV. Prescribing Orthokeratology for Myopia Management
V. Setting Expectations
VI. Trouble Shooting
VII. Setting Your Clinic up for success

I. The History of Orthokeratology


History of Orthokeratology





The History of Orthokeratology

- Contact lens wear can produce changes in corneal curvature
- Planned temporary reduction in myopia by the wearing of flat-fitting rigid contact lenses
- early 1960's "orthofocus" technique
  - ISCLS meeting
  - Jessen discussed fitting lenses flatter than K by the amount needed of myopia corrected

ORTHO **KERAT** **OLOGY**
Straight ***Cornea*** ***Knowledge***

A non-surgical, topographical approach to eliminate refractive correction

Advantages Over Surgery

- Reversible
- Costs Less
- Age appropriate treatment for changing eyes
- Quick Results
- Teaches responsibility
- Freedom from day time glasses or contacts

> J Am Optom Assoc. 1976 Aug;47(8):1047-51.

Research in orthokeratology. Part I: Introduction and background

R L Kerns

PMID: 1021577

No abstract available

Similar articles

Research in orthokeratology. Part V: Results and observations--recovery aspects.
Kerns RL.
J Am Optom Assoc. 1977 Mar;48(3):345-59.
PMID: 864189

Research in orthokeratology. Part II: Experimental design, protocol and method.
Kerns RL.
J Am Optom Assoc. 1976 Oct;47(10):1275-85.
PMID: 1022795 No abstract available.

Early Ortho-K

- Used PMMA lenses
- Kerns 1976-1977
  - Compared a group wearing flat-fitting rigid contact lenses during the day to both spectacle wearers and conventional rigid lens wearers Orthok
  - contact lenses were fit 0.25 to 0.50 D flatter than the flattest corneal meridian
  - reduction in myopia (mean change = +0.77 ± 0.91 D) was observed after 300 days of orthokeratology lens wear
  - concluded unpredictable and uncontrollable as changes in refractive error ranged from a 2.62 D decrease to a 1.00 D increase in myopia along with induced astigmatism from lens decentration

Comparative Study > Ophthalmology. 1980 Aug;87(8):729-44.
doi: 10.1016/s0161-6420(80)35171-3.

An evaluation of orthokeratology

P S Binder, C H May, S C Grant

PMID: 7443201 DOI: 10.1016/s0161-6420(80)35171-3

Early Ortho-K

- Binder et al.
  - compared subjects wearing flat-fitting PMMA contact lenses on a daily basis to conventional fitting PMMA lens wearing patients
  - orthok were fit between 0.50 D and 2.75 D flatter than the flattest corneal meridian

lens techniques. The responses to OK are unpredictable and uncontrollable. The quality of uncorrected vision is worse than with contacts or glasses, and the chances of attaining 6/12 (20/40) uncorrected vision are small. Once lenses are removed, the corneal parameters return toward prefit levels

Early Ortho-K

Clinical Trial > Am J Optom Physiol Opt. 1983 Mar;60(3):175-86.
doi: 10.1097/00006324-198303000-00005.

The Berkeley Orthokeratology Study, Part I: General conduct of the study

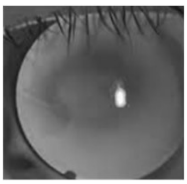
R J Brand, K A Polse, J S Schwalbe

PMID: 6342407 DOI: 10.1097/00006324-198303000-00005

- In the early 1980s, Polse et al. conducted The Berkeley Orthokeratology Study a randomized clinical trial comparing a group wearing flat-fitting contact lenses daily to a control group wearing conventionally fit lenses
  - The mean reduction of myopia in the orthokeratology group was +1.01 ± 0.87 D as compared to +0.54 ± 0.58 D in the control group
  - Polse et al. again regarded these reductions to be variable and unpredictable as indicated by the relatively large standard deviations.

Early ortho-K

- The original flat-fitting approach using conventional rigid contact lenses led to problems with centration of the lens on the cornea and accompanying poor and variable outcomes.



Modern Ortho-K

- No peer-reviewed research for 10 years
- 1990s
  - reverse geometry contact lenses
  - higher oxygen transmissibility
  - corneal topography instruments
- reverse geometry contact lenses
  - Wlodyga and Stoyan
  - base curve radius flatter than the central corneal curvature, and the first peripheral curve steeper than the base curve radius
  - the lens and cornea formed a tear reservoir exhibiting a band of mid-peripheral fluorescein pooling
  - improves the centration and stability of the lens and led to more predictable and consistent reductions in myopia

Modern Ortho-K

- Gas permeable materials
  - Limit corneal edema
  - overnight orthokeratology
  - cornea is reshaped as the patient sleeps
  - without correction through the day
  - reduction is temporary, worn on a nightly basis to continue the effect
- Corneal topographers
  - Due to boom in refractive surgery
  - monitor the change in corneal curvature induced by the lens

Modern Ortho-K

- 1998 Mountford
  - Reverse geometry GP contact lenses overnight
  - predictable and sustained reductions in myopia (pre-treatment mean = −2.19 ± 0.79 D; post-treatment mean = 0.00 ± 0.68 D; mean change = +2.19 ± 0.57 D).
  - follow-up study retention and regression
  - over a period of 8–9 h after contact lens removal
  - Most of the refractive changes occurred within the first month of lens wear.
  - found the amount of regression of the orthokeratology effect to be between 0.50 and 0.75 D during the day
    - greater regression would be expected in higher corrections
    - Modern designs incorporate a compression factor accounts for regression


International Contact Lens Clinic

Retention and regression of orthokeratology with time

Modern Ortho-K

- effective in temporarily reducing myopia, providing good vision for the day in myopes up to −4 D
- Demonstrated partial or complete efficacy in patients with myopia up to −10 D
- The corneal changes occur more rapidly than those noted in earlier studies
  - Reverse geometry lens designs and, possibly, overnight wear of the lenses
  - Most change in visual and refractive outcome occurred first seven nights of contact lens wear and peak around day 30
    - Changes well sustained through an eight-hour day
  - lens wear is discontinued refractive error will regress towards baseline
    - Around half of the myopia reduction will be lost after 24 h and 90 % within 72 h

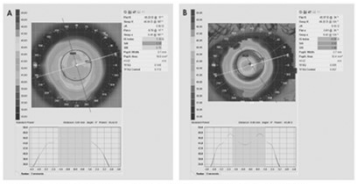


Figure 1. Modern ortho-k lens designs allow for fast and predictable treatment. (A) Topography of a young myopic astigmatic patient before treatment and (B) after 20 minutes of wear.

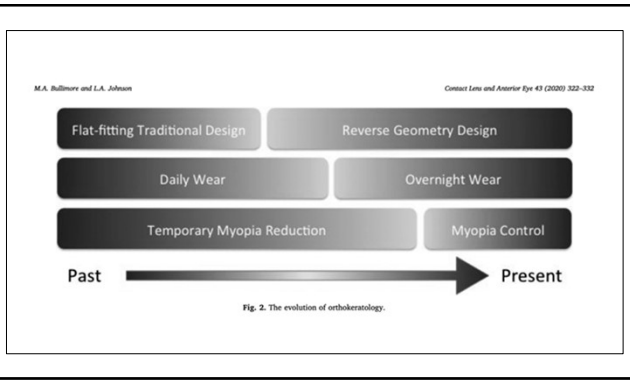
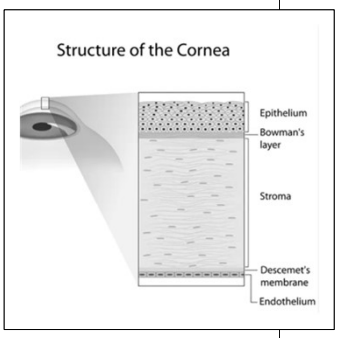


Fig. 2. The evolution of orthokeratology.

II. Corneal Physiology

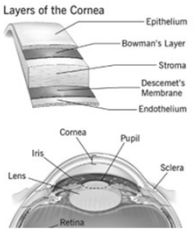
Corneal Anatomy

- Epithelium (50 microns)
  - Tight junctions
  - Rapid Healing
  - In Ortho K central thinning 20 microns, midperipheral thickening
- Bowmen's Membrane (10 microns)
  - Acellular and can scar if irregularly damaged
- Stroma (500 microns)
  - Arrangment of collagen makes transparent
  - Can regenerate but may form scar
  - Possible thickening in midperiphery thickening after long-term ortho K use
- Decrement's Membrane (12 microns)
  - Lattice work for collagen fibers
  - High elasticity with resistance to deform
- Endothelium (5 microns)
  - Single cell layer than decreased number with age
  - Maintains corneal hydration and active transport
  - No or limited regeneration



Corneal Anatomy

- Refractive index = 1.376
- Contributes to 60% refractive power of the eye
- Corneal Parameters
  - Thickness
    - Thicker in periphery
    - Affected by anoxia
    - Greatest corneal swelling after eyes have been closed (sleeping)
      - 3% edema from sleeping without contact lens wear (Harvitt and Bonomo 1999)



Corneal Parameters

Horizontal fissure adult-like at birth, vertical fissure ½ the size of an adult

Most growth in first 2 years

Avg corneal diameter 10mm in newborns, 12 mm in adults

K values avg 47-52D at birth, flatten to 42-44D in adulthood with most changes in first year of life

Corneal Physiology

Innervation and Sensitivity

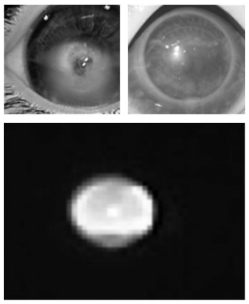
- The ophthalmic division of the 5th cranial nerve enters the middle and anterior stroma in a radial fashion towards the center
- Nerve plexus forms at Bowmans layer
- Corneal sensitivity decreases with lens wear and age

Oxygen Supply

- Different in open and closed eye
- Relative consumption is epithelium:stroma:endothelium 10:1:50 (per unit volume of tissue)
  - Endothelium is active transport
- Minimum amount of oxygen required to anterior cornea to prevent edema is 5-10%
- Overnight sleep with no lenses causes 3% edema
- Severe edema (>30%) will result in corneal rupture and scarring

Corneal Transparency

- Loss of transparency
  - IOP is increased
  - Stromal lattice structure disrupted (Decements)
  - Active corneal pump (deturgescence) disrupted
  - Stromal swelling
- Physical Corneal Barriers
  - Tight junction in epithelium and endothelium are permeable to selected molecules (metabolically important substances)



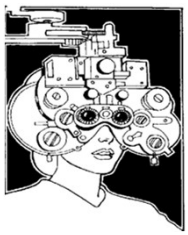
Corneal Transparency

- Active Transport Endothelium Pump
  - Removes water from stroma
  - Oxygen falls below certain level causes reduced function and loss of transparency
  - Glucose from aqueous humor provides pump energy
  - Tears source oxygen and aqueous humor sources metabolites

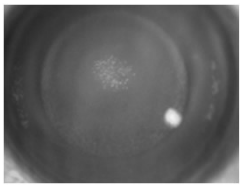
Why does the cornea need O_2?

- **Energy**
  - Cellular division
  - Synthesis of proteins, lipids, etc.
  - Construction and maintenance of junctional attachments
  - Cellular chemical balance (pH and osmotic)
  - Programmed cell maturation
  - Repair

Refractive error (myopic shift)



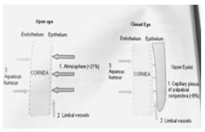
- Edema?
- Poor Corneal molding?



Corneal (Stromal) Swelling

Striae 5%	Folds (8%)	Haze (15%)	Degradation of Vision (20%)
	• Vertical Striae	• Increased vertical striae with posterior folding	• Loss of transparency

Effects of Overnight Contact Lens Wear



1. No blinking
   - No tear exchange for oxygen supply (direct) and removal of debris (indirect)
   - 8% of oxygen comes from capillary plexus of palpebral conjunctiva of upper lid
2. Changes in tears and corneal pH levels
   - Contact lenses reduce carbon dioxide diffusion into environment
   - pH gets more acidic
   - Decreased osmolarity
3. Increase corneal temperature
   - Increase metabolic activity
     - This tightens lens (soft)

Oxygen Supply in Daytime Contact Lens Wear

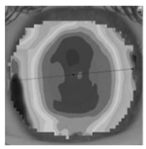
- Oxygen enters cornea by
  - Tear exchange with blink
    - Rigid lenses cause more blinking thus 10-20% more oxygen
  - Diffusion through lens

Lens Material and Dk

- Oxygen supply to the cornea is affected by lens oxygen transmissibility (Dk/t)
  - t = thickness of lens
  - Dk = oxygen permeability of the lens material
- Minimum lens oxygen transmissibility required to avoid edema (Harvitt and Bonomo)
  - Open eye 35 x 10 ^ -9 Fatt units
  - Closed eye 125 x 10 ^ -9 Fatt units

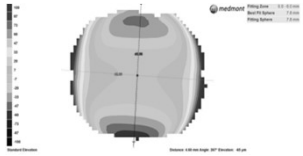
III. Corneal Topography and Contour

Corneal Topography Basics



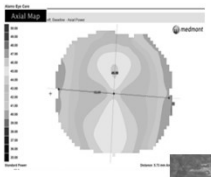
Color Scales

- Curvature Maps
  - Warm (red) → steeper
  - Cool (blue) → flatter
- Elevation Maps
  - Warm (red) → above the reference sphere
  - Cool (blue) → below the reference sphere



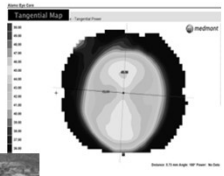
Axial Maps (Sagittal)

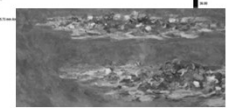
- Describes the surface relative to the optical axis
- General view of the corneal contour
- Highly dependent on patient fixation
- Central information



Tangential Maps (Instantaneous or True Curvature)

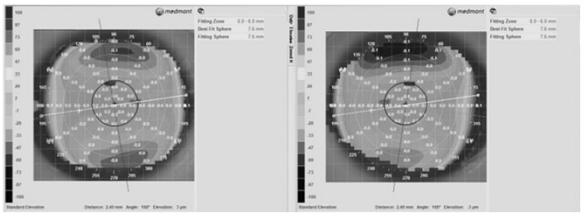
- Describes the corneal surface independent of the optical axis
- Shows small localized changes of the cornea
- Peripheral information





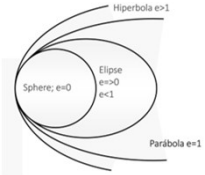
Elevation Maps

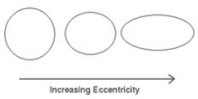
Shows curvature relative to a reference sphere
Useful for advance corneal GP evaluations



Corneal Contour

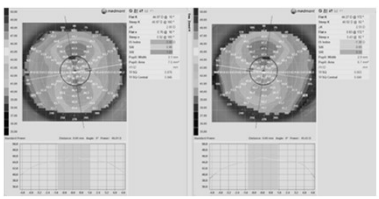
- The human cornea is not spherical or rotationally symmetric
  - Asphere
- Concoid is most common description
  - Bakers equation which describes a conic section
    - y^2 = 2 Ro (x) – p (x^2)
    - Ro is apical radius and p is shape factor





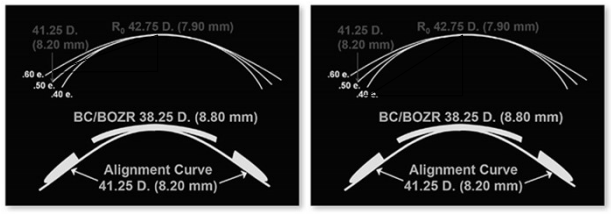
Normal Human Cornea

- Prolate Ellipse
- Eccentricity (e Value)
  - Rate of corneal flattening moving away from corneal apex
  - 0 → sphere
  - Average is 0.5 to 0.6 (Q = -0.4 to -0.2) along horizontal meridian



	Shape factor	*Asphericity*	*Eccentricity*
	p	$Q = p - 1$	$e = \sqrt{(1 - p)}$
Hyperbola	< 0	< -1	> 1
Parabola	0	-1	1
Prolate ellipse	$0 < p < 1$	$-1 < Q < 0$	$0 < e < 1$
Circle	1	0	0
Oblate ellipse	> 1	> 0	(undefined)

Corneal Eccentricity



High e (flatter alignment curve)

Low e (steeper alignment curve)

https://www.clspectrum.com/issues/2017/march-2017/the-anatomy-of-a-modern-orthokeratology-lens

IV. Prescribing Orthokeratology for Myopia Management

Myopia

Definition
- Abnormal process breaks emmetropization

Refractive
- > -0.50 D
- > -6.00 D High Myopia

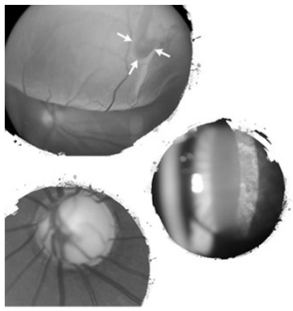
Axial Length Definition
- > 24 mm
- > 26 mm High Myopia

Emmetropization

- Normal emmetropization
  - +2.00 newborns & infants
  - +1.00 ages 2 - 14
    - slow decrease until complete emmetropization
- Axial Length (AL)
  - Normal: 18 mm @ birth
  - Continued growth until age 3
    - 23 mm
    - additional +1 mm until age 13
      - Mean AL in adults in 24mm or less
  - Additional 1 mm contributes 2 to 3 D to myopia
    - Concurrent corneal flattening and lens thinning (loss of power)

The Myopia Epidemic

- Half World Population in 2050
- Myopia diagnosis at increasingly young ages
- Higher rate of progression
  - leading to higher amounts of myopia
  - increased risk of retinal pathology



Slowing the Progression of Myopia

- Orthokeratology
- Soft Bifocal/Dual Focus Contact Lenses
- Myopia Management Spectacles
- Low Dose Atropine

Prevention of Onset

February 14, 2023

Effect of Low-Concentration Atropine Eyedrops vs Placebo on Myopia Incidence in Children

The LAMP2 Randomized Clinical Trial

Key Points

Question Does use of low-concentration atropine eyedrops affect the incidence of myopia in children?

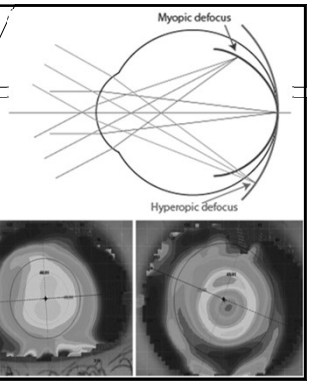
Findings In this randomized clinical trial that included 474 children aged 4 to 9 years without myopia, nightly use of 0.05% atropine, 0.01% atropine, and placebo eyedrops resulted in a 2-year cumulative incidence of myopia of 28.4%, 45.9%, and 53.0%, respectively. The difference between 0.05% atropine and placebo was statistically significant.

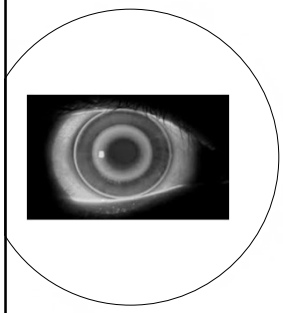
Meaning Although 0.05% atropine eyedrops resulted in a significantly lower incidence of myopia at 2 years compared with placebo, further research is needed to replicate the findings and to understand whether this represents a delay or prevention of myopia.

- Low Concentration Atropine
- Outdoor Time
  - Association with lower likelihood of myopic refractive error
  - Reduces the onset of myopia, but does not reduce progression (Wu et al., 2013)

Orthokeratology (OK)

- Corneal GP molds cornea to correct central refractive error while leaving peripheral myopic blur
- Myopic blur acts as a putative cue to slow the progression of myopia (Kakita et al, 2011; Smith et al., 1994, 2013)
  - Center Distance MF Soft Lenses



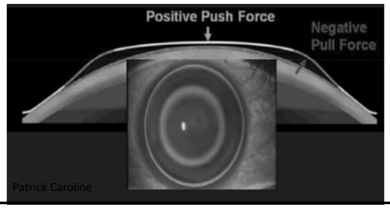


Orthokeratology (OK)

- Axial elongation was ~0.36 mm in OK group as compared to ~0.63 mm in SV spectacle group (Cho and Cheung, 2012)
- High myopes (>-5.00D) corrected with OK and spectacle OR grew ~0.19mm as compared to ~0.50mm in SV spectacle wearing group (Chen, Cheung, and Cho, 2013)
- OK slows growth of the eye by 45%

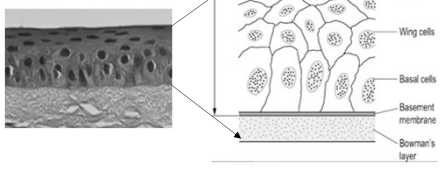
How does Orthokeratology Work?

- The unequal profile of the tears create a positive (push force) in the center of the cornea and the negative(pull force) in the midperiphery.

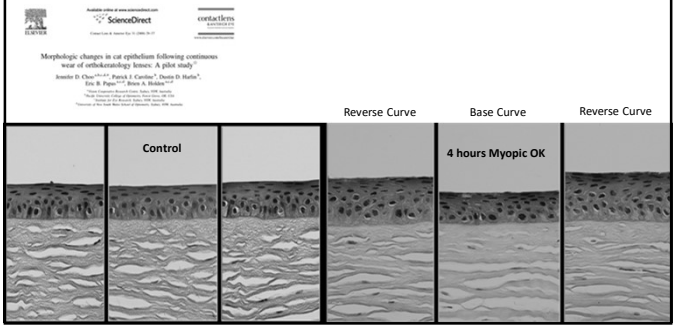


How does Orthokeratology Work?

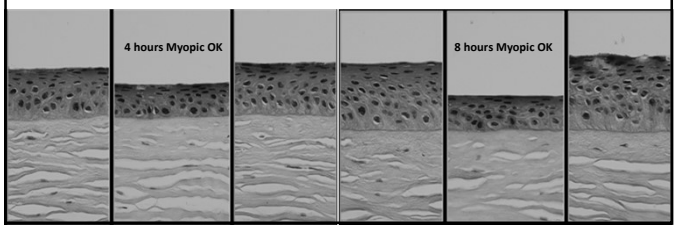
- What happens to the cornea during Orthokeratology?
- Human Epithelium
  - 50 µm
  - 75% water content
  - n = 1.376
- Connected by tight junctions, cadherins, and gap junctions



How does Orthokeratology Work?

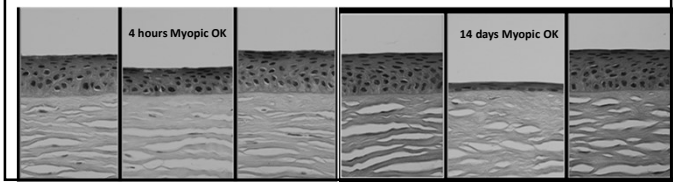


How does Orthokeratology Work?



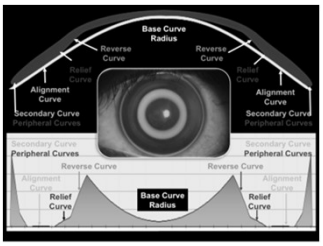
How Does Orthokeratology Work?

- Multifactorial
  - Cellular compression with intracellular fluid transfer
  - Increased Cell Mitosis
  - Increased Cell Retention
  - Localized Stromal Remodeling



Contemporary Orthokeratology Lenses Myopia

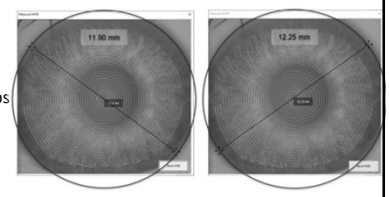
- Diameter
  - 90 to 95% of Horizontal Visible Iris Diameter (HVID)
  - 11.8mm x 0.95 = 11.00 mm
- Material
  - High-Dk needed for overnight wear
  - Oxygen Transmisibility (Dk/t) 87 (Holden and Mertz, 1984)



Designing Orthokeratology Lens

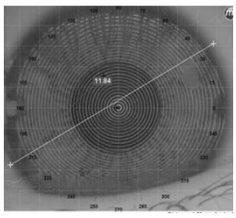
Capturing Best Topography

1. Capture 4-6 baseline maps
2. Assess maps: delete poor maps
3. Identify your best map
4. Measure OVID (Oblique Visual Iris Diameter)



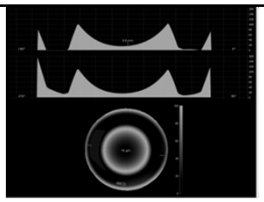
Designing and Ordering an Orthokeratology Lens

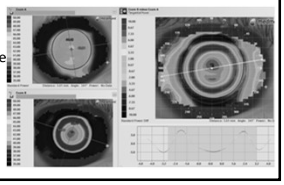
- Basic
  - Manifest Refraction
  - HVID
  - Topographer / Keratometry Values
- Custom Design
  - Customization of Tear Film Reservoir Underneath the Lens
  - e Value
  - Apical Radius of Curvature (R_o)
    - Corneal curvature at the apex
    - Where curvature/power is most constant



The Ideal Fit

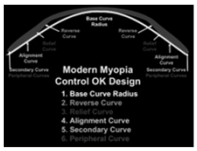
- On Eye
  - Centers well
  - Best lens acuity
  - Alignment of BOZR
  - Reverse zone clearance
  - Alignment zone landing
  - Peripheral zone clearance for tear exchange
- Topography
  - Classic bull's eye
  - Even treatment zone
  - Reverse curve zone within the pupillary circumference
    - Red Ring
  - Alignment curve visible
    - Blue Ring





1. Base Curve (BC)/Back Optic Zone Radius (BOZR)

- 5.0 to 6.8mm
- Treatment Zone
- Determined by amount of corneal flattening
  - Corneal Curvature
  - Myopia treatment required

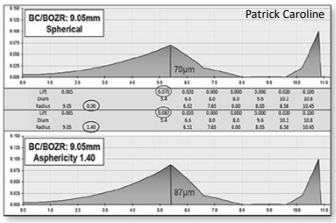


Base Curve (BC)/Back Optic Zone Radius (BOZR)

- Target Rx via the Jessen Formula
- K's 44.50@180/45.00D@090 (7.60/7.50mm)
- Manifest Spectacle -3.50-0.50X180
- Target is -3.75 + (-1.25) = -5.00 w/ adding Jessen factor of -1.25
- BOZR: 5.00D flatter than K (44.50D) = 39.50D (8.54mm)

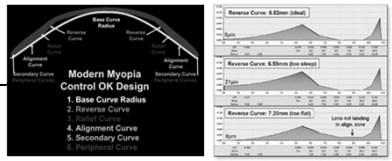
Base Curve (BC)/Back Optic Zone Radius (BOZR)

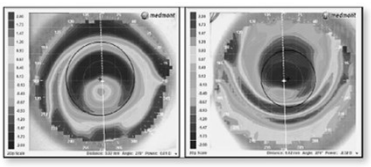
- Between 5 to 20 µm
- Typically Spherical
- Aspheric
  - Increased Myopic Defocus



2. Reverse Curve

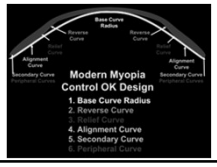
- 0.5mm to 1.0mm
- Typically Spherical
  - Spline or Tangent
- Depth increases with corrections of myopia
- Raises or lower apical clearance
  - Steep → Central Island
  - Flat → Decentration





3. Relief Curve

- 0.5mm to 0.7mm wide
- 10µm to 20µm
- Encourages epithelial cell changes from the alignment zone toward the tear film reservoir
- Effective overall treatment in higher degrees of myopia

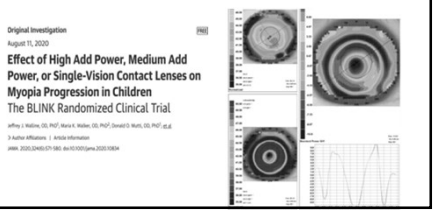


How much add / defocus power to prescribe?

Queiros A, Lopes-Ferreira D, Gonzalez-Meijome JM. Astigmatic peripheral defocus with different contact lenses: review and meta-analysis. *Curr Eye Res* 2016; 41: 1005–1015.

- magnitude of myopic relative peripheral refraction induced
- orthokeratology induced the greatest myopic shift in the periphery
  - peripheral gradient GP
  - gradient soft contact lenses
  - MF soft contact lenses with +3.00 D added

- OK, larger amounts of myopic peripheral defocus progressed less (Zhong et al, 2014)


Original Investigation

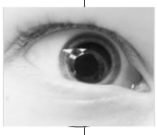
August 11, 2020

Effect of High Add Power, Medium Add Power, or Single-Vision Contact Lenses on Myopia Progression in Children

The BLINK Randomized Clinical Trial

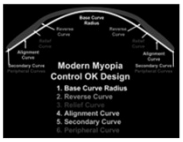
Pupil size ?

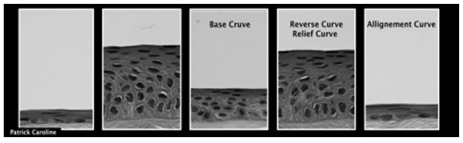
- Orthokeratology
  - Most effective if treatment zone inside pupil (Chen et al, 2012)



4. Alignment Curve

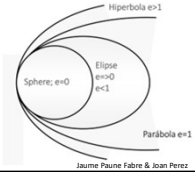
- 0.5mm to 1.0mm
- Spherical, Aspheric, or Tangent
- Lens centration
- Alignment is desired
- Greatest amount of epithelial thinning occurs underneath





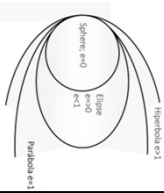
Alignment Curve

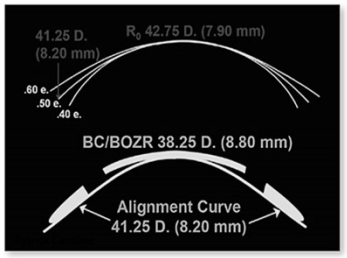
- Shape determined by eccentricity along flat meridian of mid-peripheral cornea
- Eccentricity (e Value)
  - Rate of corneal flattening moving away from corneal apex
  - 0 → sphere
  - Average is 0.4 to 0.6



Alignment Curve

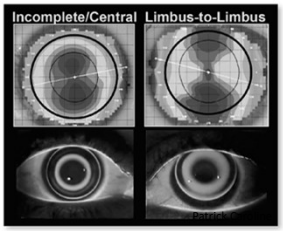
- Lower e value → Steeper
- Higher e value → Flatter





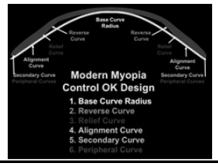
Toric Alignment Curve Orthokeratology Lens

- 30 µm difference at landing chord (Kojima et al, 2016)
  - ~8.00 to 9.00 mm
- Limbus to limbus astigmatism
- May occur in low astigmatism



5 & 6. Secondary/Peripheral Curve

- Edge lift
- Secondary
  - 0.2 to 0.5 mm
  - 20 µm
  - Presents a smooth transition to periphery
- Peripheral
  - 0.2 to 0.5 mm
  - 80 to 100 µm



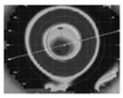
Orthokeratology Myopia Management in Practice

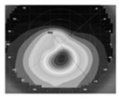
- Who are the appropriate candidates?
  - Corneal Topography
  - Cycloplegic Refraction
  - Lifestyle
  - Age Axial Length

Corneal Topography: Pediatric Keratoconus (PKC)

- Earliest case report age 4
- Orthokeratology based on reshaping epithelium
  - Corneal Thickness
- CLEK Study
  - Progression with poor fit
  - FADCL

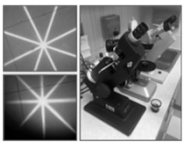
- More children will be seen due to increased popularity of myopia management





"If all current eye doctors saw children for MM they would have 278 each"

Equipment and Supplies



Equipment

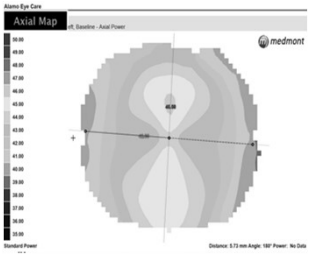
- **Topographer *****
- **Pachymeter*****
- **Optical biometer*****
- Lensometers and Radiuscopes
- OCT with anterior segment imaging
- Specular microscope
- Anterior segment camera

Supplies

- Fitting sets
- Mirrors
- Cleaning and storage solutions
- Contact lens cases
- Plungers
- Artificial tears
- **Genetic Tests**

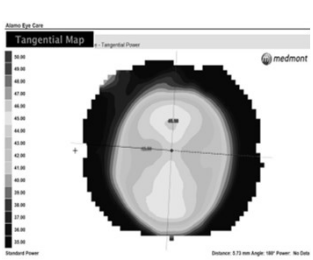
Axial Maps (Sagittal)

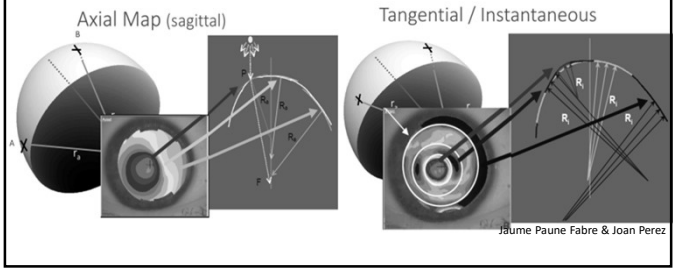
- Central information



Tangential Maps (Instantaneous or True Curvature)

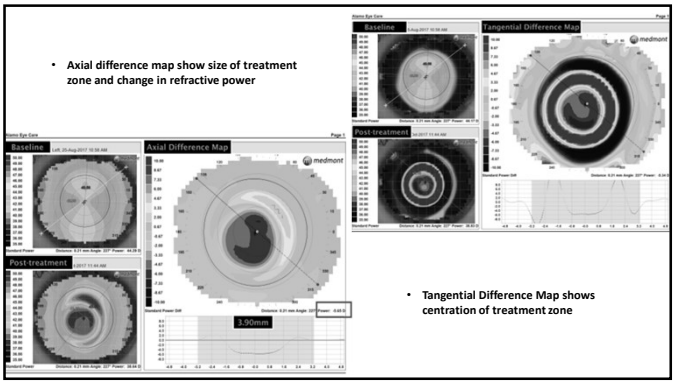
- Peripheral information
  - Excellent for showing centration after orthokeratology



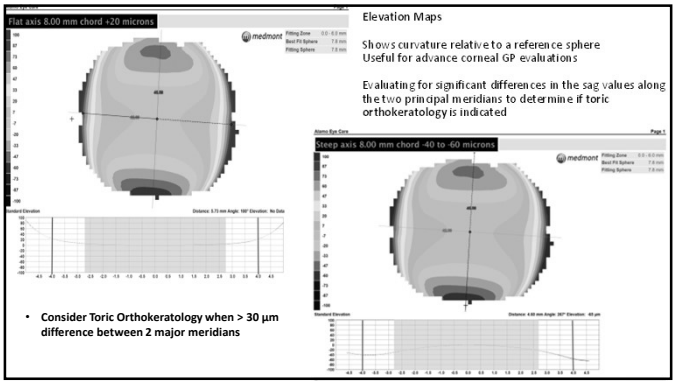


Jaume Paune Fabre & Joan Perez

- **Axial difference map show size of treatment zone and change in refractive power**



- **Tangential Difference Map shows centration of treatment zone**



Elevation Maps

Shows curvature relative to a reference sphere
Useful for advance corneal GP evaluations

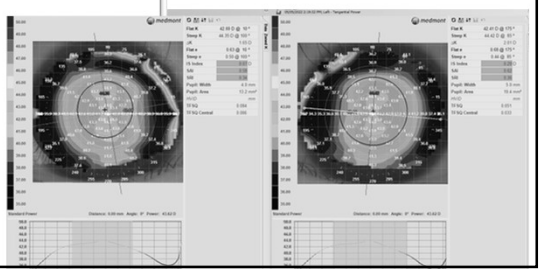
Evaluating for significant differences in the sag values along the two principal meridians to determine if toric orthokeratology is indicated

- **Consider Toric Orthokeratology when > 30 µm difference between 2 major meridians**

Patient Reason for Visit

Pt here for annual exam. Today is patients first exam, reports blurry vision started about 2 months ago. Pts mom is interested in ortho k lenses, states she doesn't want daughter to have to wear contact lenses. Pt has not worn any form of correction before. Pt's mom states she had to wear glasses and CLs for years before having eye surgery, and wants to be cautious for her daughter. Pt reports no other concerns at this time.

Cycloplegic Refraction: A 9-year-old Asian Female



Considerations for Orthokeratology vs Other Contact Lenses for MM

- Daytime wear is a burden
  - Activities
  - Allergens
  - Lifestyle and Culture
- Parents want to participate in care
- May be better for High Myopia
- OK slows growth of the eye by 45%

Randomized Controlled Trial > Optom Vis Sci. 2013 Jun;90(6):530-9.
doi: 10.1097/OPX.0b013e318293657d.

High myopia-partial reduction ortho-k: a 2-year randomized study

Jessie Charm [1], Pauline Cho

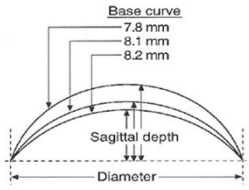
Conclusions: This single-masked randomized study showed that PR ortho-k effectively slowed myopic progression in high myopes. Axial length elongation was 63% slower in PR ortho-k-treated children compared with children wearing spectacles.

Age and axial length

- Globally, myopia has been reported to commence at around age six, the age at which children enter primary school
  - Mutti et al. showed that emmetropes who eventually became myopic started to exhibit hyperopic relative peripheral refraction two years before its onset
- At the end of two years, younger (6–8 years) subjects wearing single-vision spectacle lenses showed the greatest and most rapid axial elongation, and orthokeratology lens wear significantly reduced the risk of rapid progression by 89 per cent
- Most pediatric contact lens evaluations start at age 12 ???

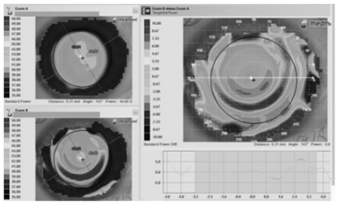
Recognizing and Troubleshooting Topographical Responses

- Smiley Face
- Frowny Face
- Lateral Displacement
- False Central Island
- True Central Island



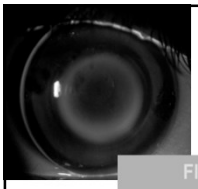
Smiley Face Response ☺

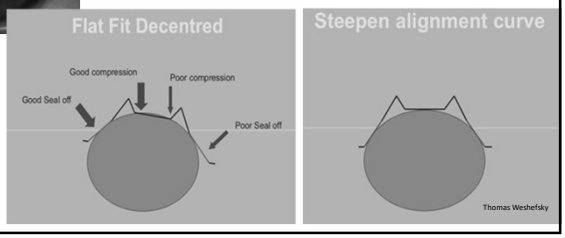
- Topography Pattern
  - "Red-ring" that decenters superior-temporally
  - Flat fitting lens (not enough sag)
  - Flat Rides High
- Patient Symptoms and Signs
  - Less myopic reduction less than expected
  - increase in with-the-rule astigmatism
  - Ghosting, glare and flare



How to Correct a Smiley Face Response

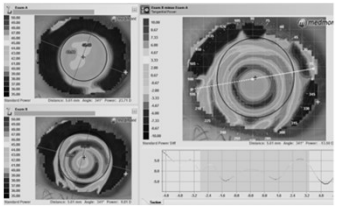
- under-estimation of the sagittal depth of the lens
  - underestimation of corneal sagittal depth
  - overestimation of corneal eccentricity
- Correction
  - Increase the sagittal depth of the lens
  - Steepening or Widening
    - alignment curve
    - BOZR
    - reverse curve zone





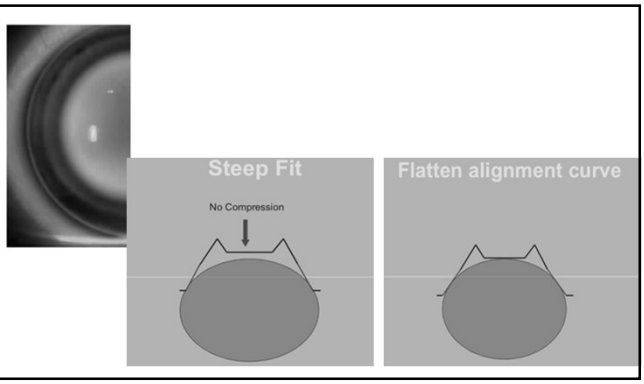
Frowny Face Response ☹

- Topography Pattern
  - Red-ring appearance that decenters inferiorly
  - Steep lens fit
  - Steep Rides low
  - Too Much Sag Depth
- Patient Symptoms and Signs
  - Less myopic reduction than expected
  - Increasing amount of astigmatism
  - Ghosting, glare, and flare



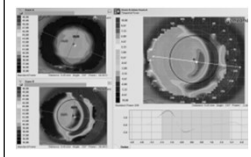
How to Correct a Frowny Face Response

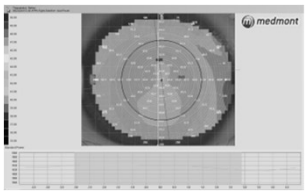
- Caused by the lens having too much sagittal depth
  - overestimation of the corneal sag
  - underestimation of corneal eccentricity
- Remedy
  - sagittal depth needs to be reduced
  - flattening or increasing width of the alignment curve, reverse curve or BOZR



Lateral Displacement Response

- Patient Symptoms and Signs
  - Red-ring that decenters nasally or temporally
- Patient Sings and Symptoms
  - Ghosting, glare, or flare, have induced astigmatism





Addressing Lateral Displacement

- Causes
  - Too steep or too flat fit
  - Lens is not large enough
  - Asymmetrical corneal curvature
    - Decentered corneal apex
- How to Fix It
  - Increasing or decreasing the sagittal depth
  - Increasing the lens diameter
  - Asymmetrical corneal curvature or decentered apex
    - Maybe altering the alignment curves or changing to a toric design lens

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Influence of Overnight Orthokeratology Lens Treatment Zone Decentration on Myopia Progression

Anken Wang [1], Chenhao Yang [1]

Affiliations + expand

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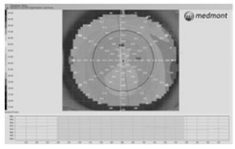
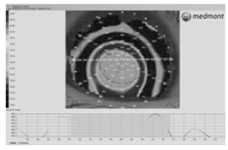
Free PMC article

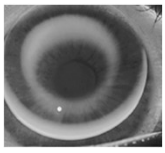
Conclusion: This self-control study without much interference factors shows that the decentration of OK lens can delay the development of myopia more effectively than being centric when uncorrected visual acuity was acceptable without obvious corneal complications, glare, or ghosting.

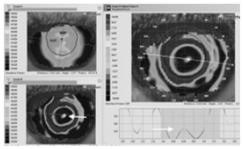




False Central Island Response

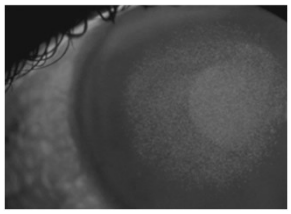
- Central peak within the treatment zone
- This is caused by a flat fitting lens
  - Maybe with smiley face topography pattern of superior lens displacement
- Patient Signs and Symptoms
  - Corneal staining upon lens removal from epithelial damage
  - Distortion of the placido disc mires
  - Ghosting, glare, and
  - Poor best corrected vision with staining

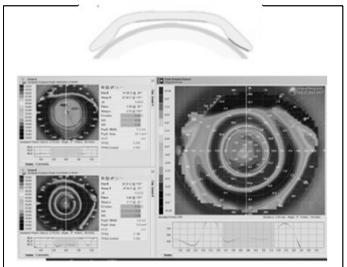




Correction of a False Central Island

- Heavy bearing of the lens and topography interprets the induced epithelial damage as an area of steepening!
- How to Fix it
  - Temporarily Discontinue Lens Wear
  - Increasing the lens sag
    - Steepen Reverse Curve



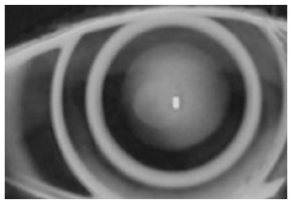


True Central Island Response

- red-ring perfectly centers and a central area of steeping is also seen on topography
- caused from a steep fitting lens
- no sign of epithelial damage upon lens removal
  - Too much Sag Depth
  - Steep fitting Lens

True Central Island Response

- Blur vision with over-refraction with no clear end-point
  - Minus over refraction
- Overestimated lens sag
- Overestimated corneal sag or underestimated corneal eccentricity
- Resolved by reducing the sagittal depth of the lens
  - Flattening the Reverse Curve Zone



Microbial Keratitis

Bullimore MA, Sinnott LT, Jones-Jordan LA. The risk of microbial keratitis with overnight corneal reshaping lenses. *Optom Vis Sci* 2013; 90: 937–944.

- Bullimore et al. who acknowledged the limitations of their study in view of the small number of cases reported. They investigated voluntary reports from practitioners on 1,317 orthokeratology wearers, about half of whom were children. The average orthokeratology treatment duration was two years and the only two incidents of microbial keratitis identified were in children. They estimated the risk of microbial keratitis to be 13.9 per 10,000 patient-years in children compared to 7.7 per 10,000 patient-years in all patients
- Microbial keratitis in orthokeratology is generally associated with poor practice, use, or compliance with care routines.

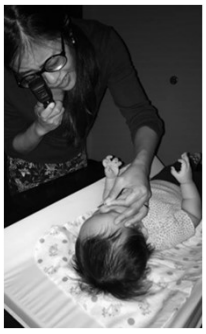
Rebound Effect?

Cho P, Cheung SW. Discontinuation of orthokeratology on eyeball elongation (DOEE). *Cont Lens Anterior Eye* 2017; 40: 82–87.

- orthokeratology treatment resumed the progression rate of myopia that they would likely have demonstrated if they did not receive orthokeratology treatment.
- Taking into account that this re-emergence of myopia progression was not worse than the rate in children wearing single-vision spectacle lenses during the preceding two-year trial, it cannot be defined as an actual rebound effect after discontinuation of the orthokeratology lens wear.

Normal Eye Growth

- Horizontal fissure adult-like at birth
- Most growth in 2 years
- Avg corneal diameter 10mm in newborns, 12 mm in adults
- K values avg 47-52D at birth, flatten to 42-44D in adulthood with most changes in first year of life
- Dilator muscle poorly developed at birth, so infants are usually miotic



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Brianna Rhue, OD, FAAO, FSLS
brhue@drcontactlens.com
Melanie Frogozo, OD, FAAO, FSLS
mfrogozood@gmail.com