Refractive Therapy: The Regulation of Refractive Error Development

Idaho Optometric Physicians
October 12, 2013

Disclosures
• Consultant: Paragon Vision Sciences
• Consultant: Carl Zeiss Vision
• Shareholder: VICOH, LLC
• Shareholder: Myolite, Inc.

My Journey
• 26 years in Private Practice
• 19 years in product development
• 38 Issued US Patents; 53 pending applications
  – 3 Alcon (PBH-WinCiba); Multifocal contact lenses
  – 2 AMO (VISX); Presbyopia laser surgery
  – 13 Paragon Vision Sciences; Paragon CRT®, Refractive Error
    Regulation, NormalEye® 15.5 mini-scleral lenses
  – 11 Synergeyes®; Family of lenses and processes
  – 2 Preventive Ophthalmics, Inc; DxAMD™ Early detection AMD
  – 1 Innovega, Inc; iOptik™ wearable computer
  – 5 VICOH, LLC; Family of contact lens designs
  – 1 Eye Care for Humanity; low cost spectacle eyewear

“My Journey

It is time for a name change:
There are emerging technologies that complement orthokeratology that demand a category name

My choice: Refractive Therapy

Myopia

Can we arrest the progression of myopia or prevent myopia from developing?
If so, it’s time to start practicing Refractive Therapy

“it’s not that I’m so smart, it’s just that I stay with problems longer.”
--Albert Einstein
Epidemiologic Study of Ocular Refraction Among School Children in C. Taipei in 1995

Prevalence of Myopia (All ages)

Why is it Important to Halt Myopia Progression?
- High myopia causes
- ↓ quality of life
- ↑ risk of complications
- High myopia has a higher prevalence of
  - myopic retinopathy
  - Cataract
  - Glaucoma
  - retinal detachment

Impact of Visual Impairment
- Important because it is often:
  - bilateral
  - irreversible
  - affects individuals during their productive years
- Duration of blindness from:
  - myopic retinopathy - 17 years
  - diabetes - 5 years
  - age-related maculopathy - 5 years
  - glaucoma - 10 years

My Position
- Myopia progression can be regulated in the majority of cases.
- Screening methods can determine who is at risk.
- Intervention using Refractive Therapy has broad sight saving potential and market potential.
- It’s time to start a Refractive Therapy service in Optometric Practices
Key Take-away from This Presentation

1. Peer reviewed literature supports the ability to regulate the development of myopia
2. Instruments are available for assessment and follow up metrology
3. Methods are available with other labeling for treatment
4. University of California Berkeley has opened the first University based Myopia Control Clinic
5. It is time for the early adopters and early majority to do the same

Current Methods with Established Efficacy

• Corneal Refractive Therapy
• Contact Lens Refractive Therapy - Center Distance Multifocal Lenses (CDM)
• Pharmaceutical Refractive Therapy – 0.1% Atropine
• Electromagnetic Radiation Refractive Therapy - Outdoor light or Psuedo-Outdoor Light

Myopia Control

Current Methods with Established Efficacy

• Corneal Refractive Therapy
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Historical Myopia Control Strategies and Proposed Mechanisms

Bifocal Lenses

Relaxing accommodation

Rigid Contact Lenses

Improving retinal imagery

Myopia under-correction

Full focal plane in front of retina

Pharmacologic Intervention

Ocular delivery to reduce accommodation

Pharmacologic Intervention

Oral delivery, target specific anatomic structures i.e. sclera

Optical Interventions

Modification of wavefront

Bifocal Spectacle Studies

• Fulk et. al. IOVS (2000)
  0.25 D. Difference

• Edwards et. al. IOVS (2002)
  <0.25 D. Difference

COMET Trial

Gwiazda et.al. 2003 Three Year Results

SV Spec -1.40 D. BF Spec -1.20 D. < Myopia = 0.20
Do Bifocal Spectacle Lenses Decrease Myopia Progression in Children?

**More Consistent, Full Time, Correction**
All previous studies plagued with patient non-compliance

Under correction of Myopia Enhances, Rather than Inhibits Myopia Progression

- Under-corrected to 20/40 (~+0.75 D)
- The under corrected group showed *INCREASED* myopia and axial length compared to the fully corrected group.

Rigid Contact Lens and Myopia Control

**Katz (2003)**
*Am J Ophthalmology*

**Walline (2004)**
*Arch of Ophthalmology*

Subjects wearing RGP’s 8 hours, or more, a day N=37

CL Group: 0.07 D. decrease in myopia progression compared to control
CL Group: 0.05 mm *increase* in axial length compared to control

A Randomized Trial of the Effects of Rigid Contact Lenses on Myopia Progression

J. J. Walline, OD, PhD., L.A. Jones PhD, D.O. Mutti OD, PhD., K. Zadnik OD, PhD.

Axial Length Growth Results
Change in Axial Length

![Graph showing change in axial length over visits.](image)

RGP = 0.81 mm  SCL = 0.76 mm  Difference = 0.05 mm

Corneal GP Change in Axial Eye Growth

![Bar chart showing two-year data.](image)

Katz Study  Walline Study

RGP Group  Controls  N = 57  N = 59
RGP Group  Controls  N = 184  N = 57

Pharmacological Intervention

*Medications that target specific anatomic structures of the eye.*

1. Retinal neurotransmitters linked to eye growth.
2. Scleral remodeling enzymes and growth factors.
3. Intraocular pressure

Muscarinic Antagonists

- **Atropine 1%**
  - Used for decades and increasing in use
    - Undesired side effects
      - Photophobia with mydriasis
      - Cycloplegia requiring bifocal or PAL
      - Follicular hypertrophy
      - Ocular and systemic toxicity
    - Reported rebound effect

**0.01% Atropine: Chia, Ophthalmology; 2011**

Atropine for the Treatment of Childhood Myopia: Safety and Efficacy of 0.5%, 0.1%, and 0.01% Doses (Atropine for the Treatment of Myopia 2)

Conclusions: Atropine 0.01% has minimal side effects compared with atropine at 0.1% and 0.05% and retains comparable efficacy in controlling myopia progression

Clinical Suggestion: Prescribe 0.01% Atropine for patients with emerging and progressing myopia

The Role of Vitamin D

*Mutti and Co-workers*

- Correlation of lower blood serum levels of Vitamin D in patients with Myopia

Clinical Suggestion: Test the blood serum level of children and recommend increased Vitamin D intake for patients with emerging and progressing myopia
Summary: Are Current Refractive Correction Methods Effective in Myopia Control?

Spectacle Plane Lenses (SPL)
- Conventional – No evidence
- Bifocal and Progressive Addition Lenses – Anecdotal to mild evidence

Contact Lenses
- Soft Lenses – No, greater progression than SPL
- RGP – Possibly less preferred to SCL, except in high myopia

Surgery and Pharmaceutical Intervention
- No surgical methods envisioned (safety issues for children)
- Pharmaceutical intervention – Promising

Role of Peripheral Defocus

Well documented and presented following animal studies and use of Corneal Refractive Therapy

- Two discussions:
  - “Peri-Form”: Peripheral defocus derived from reshaping the peripheral cornea relative to the central cornea
  - “Peri-Focus”: Peripheral defocus from primary optical design of a spectacle or contact lens

• Carl Zeiss Vision: spectacle lenses (Licensed Patents)
• Alcon (CibaVision): contact lenses (Licensed Patents + Proprietary pending cases)
• SynergEyes: hybrid contact lens (Issued Patent)

Clinical Instrumentation and Metrology

- Corneal Topography
  - For Peri-form to monitor peripheral corneal shape and power

- Peripheral Refraction
  - Key baseline and follow-up measure to determine amount of peripheral defocus treatment per eye
  - Eyes of equal refractive error do NOT have equal peripheral retinal position or peripheral corneal and crystalline lens optics

- Ultrasound Scan
  - Key baseline measure and follow up to determine efficacy of treatment

Corneal Topography

Peripheral Refraction

- Use of existing autorefractors and wavefront refractors
  - Off axis refraction
  - Head turn versus eye-turn
  - Sampling using horizontal meridian
  - Advantage of small bundle measurement

Ultrasound Scans

Gold Standard is Grand Seiko Wide Field Auto Refractor

Gold Standard is Zeiss IOL Master
Effective Regulation of Myopia

2002 - 2004
Discovery that overnight corneal reshaping resulted in apparent myopia control
At the same time animal model studies demonstrated role of peripheral defocus on refractive error development by way of axial length growth stimulus

The Longitudinal Orthokeratology Research In Children (LORIC) study in Hong Kong

A pilot study on refractive changes and myopic control in 35 children 7-12

Pauline Cho, PhD, Associate Professor
Sin Wan Cheung, MPhil, Research Associate
Marion Edwards, PhD
Department of Optometry and Radiography
Hong Kong Polytechnic University

Vitreous Chamber Elongation
Two Year Follow-Up

6 Months 12 Months 18 Months 24 Months
CRT Control

Crayon Study
Jeffrey J. Walline, OD, PhD
Ohio State University

Inclusion Criteria
• Ages 9 to 12 years
• Sphere -0.75 D to -4.00 D
• Cylinder less than -1.00 D
• 20/20 OU
• No previous RGP wear

Contact Lenses
• Corneal Refractive therapy / Paragon CRT
• CIBA Vision Focus 2 Week (SCL)

Walline One Year Results
Vitreous Chamber Depth

Walline and Cho One Year Results
Vitreous Chamber Depth
What is the Mechanism for CRT and Myopia Control?

Mechanical to the cornea to inhibit growth?
- Not likely. The change at the corneal plane due to CRT is only a fraction of what is needed.

Change in peripheral corneal thickness with resultant change in hysteresis?
- Possible benefit

Change in aberration structure when eyes are in use during the day?
- Highly probable. CRT induces a significant increase in positive spherical aberration that lasts the full waking hours.
- Rapid change in refractive error may cause change in accommodative patterns. Previous lag may be negated with reduced myopia.

Literature Review – Role of Higher Order Aberrations

Charman — best overview of field
- Investigators primarily looked for large differences in HOA in myopic eyes
  - No significant large HOA differences in myopic versus non myopic eyes
  - Aberration pattern in myopic eyes changes with age. Generally lower SA.
- Credit given to “skiascopy” observations in the ’30s. Myopic eyes have peripheral focus behind retina.
- SA known to shift negative upon accommodation
  - Believed to be due to crystalline lens optics
- Accommodative lag more common in young myopic eyes than hyperopic eyes
- No reported studies of HOA measurement or change of HOA with accommodation, or role of hysteresis, or change in topography with accommodation in young eyes.
- “Longitudinal studies are required to confirm whether the retinal defocus associated with the peripheral hyperopia can cause patterns of eyeball growth which lead to axial myopia.”

Myopia Control Through Optical Intervention

Peripheral Form Deprivation

Form Deprivation Myopia

Work Repeated with Foveal Ablation

Primates with laser ablated maculae demonstrated axial length changes from focal plane shifts with lens induced changes.
Conclusions

- A functioning fovea is not essential for emmetropization.
- An intact periphery is essential for emmetropization.

Researchers’ Conclusion

These data demonstrate that the fovea **DOES NOT** play the dominate role in refractive development.

Instead peripheral retinal image plays the **MAJOR** role in determining overall eye growth.

Corneal Refractive Therapy

Ideal Optical System

Refracted light from an object is focused precisely along the image-receiving surface. Typically, for conventional optical systems, the imaging-receiving surface is a flat surface i.e. a camera with film.

Peripheral Refraction in CRT Patients

W. Neil Charman, John Mountford, David Atchison, Emma Markwell

University of Manchester, Queensland University

Optometry and Vision Science, September 2006
Eye growth may possibly be retarded, or halted through:

“A precise and pre-determined optical system at the corneal plane that will manipulate the peripheral optics of the eye.”

Summary

Myopia Controlling device should maintain axial alignment “centered” with the eye regardless of the position of gaze.

The ideal system would be one that could be easily changed as the ocular power and peripheral aberration profiles change.

- Contact lenses
- Corneal Refractive Therapy
- Refractive surgery
- Intraocular lens
- Corneal implants

Where do we go from here?

Proof of concept study:

- Is there a statistically and clinically significant reduction in the progression of myopia and concomitant reduction in axial length growth when MPC lenses are worn compared to a demographically matched historical control group?

THE OPPORTUNITY

Intervene appropriately to control progression of myopia
**PREVALENCE - urban china**

![Graph showing prevalence of myopia by age in China](graph_url)

**KEY POINT:** Need to intervene at an early age to be effective

*He et al., 2004*

Determination of Need for Refractive Therapy

Method of determining child at risk:
- Case History:
  - Parental history of myopia
  - Sustained near centered tasks
  - Low time outdoors (less than 420 minutes/week)
- Refractive Data and Peripheral Refraction
  - Myopic shift over previous 12 months
  - Measured hyperopic defocus
- Esophoria with Accommodative lag
- Low or negative spherical aberration
- Vitreous chamber depth change in last 12 months > 0.12 mm
- Low Vitamin D blood serum level

Corneal Refractive Therapy

- The standard for the regulation of myopia
  - 40% to 70% regulation of progression
  - FDA approved modality for the temporary reduction of myopia
  - Dual benefit of clear vision during daytime activity without wearing spectacle or contact lenses while regulating progression

Suggested Treatment Strategies

- Today:
  - Paragon CRT at first measured myopic shift
  - Multifocal contact lenses with distance center:

**JM OD**

**MS OS**

**JM 10 Y/O F**

Pre-treat:
-3.00 –0.50 X 010 20/20
Sim Ks:
45.25 @ 095
44.62 @ 005

Post-treat: 1 week
Plano: –0.25 X 175 20/20
Sim Ks:
42.75 @ 090
42.37 @ 180

**MS 12 Y/O F**

Pre-treat:
-2.25 –0.25 X 180 20/20
Sim Ks:
43.37 @ 090
42.87 @ 180

Post-treat:
-2.00 –0.25 X 175 20/20
Sim Ks:
41.87 @ 074
41.25 @ 164
How Does Corneal Refractive Therapy Work?

- Topographical changes in corneal (epithelial) thickness
- Stromal changes?

Where is cornea anatomically altered?

- Epithelial Redistribution
- Epithelial Compression

Mid-Peripheral Steepening

Approximate Total Thickness

- Epithelium: 50 Microns
- Bowmans Layer: 10 Microns
- Stroma: 460 Microns
- Descemets Membrane: 10 Microns
- Endothelium: 5 Microns

Total Thickness: 540 Microns

Corneal Response to Orthokeratology
Swarbrick, Wong and O’Leary

Change in epithelial thickness (um) vs. Corneal location (mm)

Day 1
Day 7
Day 14
Day 28
FDA Approval

June 13, 2002, Paragon Vision Sciences received FDA market clearance for Paragon CRT for overnight Corneal Refractive Therapy

- The approval includes up to ~6.00D of myopia
- with or without up to ~1.75D of astigmatism
- There are no age restrictions

The FDA Study Data

FDA Overnight Clinical Trial

- Efficacy
  - Accuracy/ predictability
  - Uncorrected visual acuity
  - Stability
  - Safety
  - Permanent loss of BSCVA
  - Corneal ulcers and other adverse events
  - Increase in refractive cylinder
  - Persistent irregular astigmatism

FDA Overnight Clinical Trial

- Multi-site IDE - 11 sites
- 205 patients ages 12 and above
- - 6.00 sph. with -1.75 refractive cylinder
- Single lens treatment, overnight only
- 9 months follow up
- Safety and efficacy
- First enrollment June 15, 2000

Achieved vs. Attempted
(109 Patients)

Uncorrected Visual Acuity (UCVA) at the 9 Month Visit
Stratified by Pretreatment Manifest Refraction Spherical Equivalent.

- 67.4% =20/20 or Better
- 94.3% =20/32 or Better
- 95.7% =20/40 or Better

Patients targeted for Emmetropia and with Pretreatment BSCVA of 20/20 or Better
Demographic Information of All Enrolled and Treated Subjects

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<td>33.7</td>
<td>± 12.4</td>
<td>12</td>
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PRODUCT DESCRIPTION

**Paragon CRT**

- Optic Zone 6 mm (fixed)
- Return Zone 1mm (fixed)
- Landing Zone
- Posterior Edge Ellipse (fixed)
- Overall Diameter (OAD)

**PRODUCT DESCRIPTION**

**PARAGON CRT® with HDS Technology®**

- Base Curve Radius
  - (7.9= 79)
- Return Zone
  - Depth (0.525 = 53)
- Landing Zone
  - Angle (- 33 = 33)
  - = 795333

**Laser Marked ID**

- **BC:** Base Curve (Treatment Zone)
  - Fixed 6.0mm OZ
- **RZD:** Return Zone
  - Fixed 1mm width
- **LZA:** Landing Zone

**“MIRRORED, HARMONIC SURFACES”**

- Thicker “standard” designs
- Thinner “standard” designs

**Paragon CRT**

- Oxygen Permeability (Paragon HDS® 100) Dk = 150 Fatt
- Oxygen Permeability (Paragon HDS) Dk = 60 Fatt

Both materials are FDA approved for 7 day extended/overnight wearing
The Base Curve (treatment curve) provides the "mold" for treatment and is derived by calculation only using the Initial lens Selector. The Base Curve is not adjusted to change the fit.

Return Zone Depth

Precise Control of Applied Treatment through Proximity Control Technology™

Return Zone Depth (RZD)

The Return Zone "returns" the lens design to the peripheral corneal surface and is the primary controller of centration through sagittal depth management.

Paragon CRT

The Landing Zone is a flat flap with a radius of infinity and is available in varying degrees of angle to accommodate the local slope of the individual peripheral cornea.

Paragon CRT

"Safe" Landing Zone

The Landing Zone can only be tangent
Traditional Designs
Mechanical Trauma Potential

Landing Zone Angle

Landing Zone Angle (LZA)

• The Landing Zone Angle controls:
  – Edge lift
  – Incremental changes to Sagittal depth
    • Centration
    • Treatment zone width

Landing Zone Angle

The Correct Landing Zone provides Edge lift and aids in Centration

Lower angle - Excessive edge lift

Appropriate edge lift

Higher angle - Minimal/no edge lift

The Correct Landing Zone provides Edge lift and aids in Centration
Reducing Chair Time

100 Lens Diagnostic Dispensing System (DDS)
- Immediate fit evaluation and success probability assessment
- Same-day dispense and treatment initiation
- Fewer visits
  - Cost savings
  - Practitioner and patient convenience
- One-day treatment, “wow-factor” patient response

The Paragon CRT Diagnostic Dispensing System

Understanding the Paragon CRT Diagnostic Dispensing System

Based on outcomes analysis
100 Paragon CRT lenses
- A Range of Base Curves
- One Power - +0.50
- One Diameter - 10.5mm
- Range of RZDs and LZAs
- Paragon HDS®100
Approx. 80 % Dispensability

Reducing the Cost of Care

- Inventory fitting management
  - Fit adjustments made with diagnostic/dispensing inventory
  - no-re-order waiting period
  - Manageable, predictable COGs
Dispensing with the Paragon CRT Diagnostic Dispensing System

Example:  
- \( K_s = 43.25 \) @ 180  
- \( 44.25 \) @ 90  
- \( MR = -3.50 \) -0.50 X 180

It’s as simple as . . .

Calculate Initial Diagnostic Lens—
Find a lens that has:
- Centration
- 3-4mm Treatment Zone
- Appropriate Edge Lift

Diagnostic Dispensing

- If initial lens centers but does not provide sufficient central applanation—
  - Step #1 Check edge lift, if insufficient—reduce LZA 1°
  - Step #2 Decrease RZD in 25 micron increments until sufficient applanation is achieved*

*Always confirm centration with each parameter change

Centration and Treatment

Return Zone Depth is the primary controller of overall sagittal depth—
Centration and effective treatment applanation.

Proximity Control Technology™

- \( 0.575 \text{ RZD} = 575\text{microns} \)
- \( 0.550 \text{ RZD} = 550\text{microns} \)
- \( 0.525 \text{ RZD} = 525\text{microns} \)

Return Zone Depth

Too Deep Return Zone Depth
**Return Zone Depth**

![Images showing Return Zone Depth]

**Sagittal Depth changes with RZD**

.550 RZD, .525 RZD, .500 RZD

**Diagnostic Dispensing Guidelines**

Centration is the primary goal

Sagittal depth can be reduced to increase treatment applanation at next follow-up.

**Paragon CRT® Dispensability Summary**

- Determine Initial Diagnostic Lens
- Find a lens that has:
  - Centration
  - 3-4mm Treatment Zone
  - Adjust Edge Lift, if necessary

Centration is the key to success with CRT

**The Optic Zone Myth**

True or False:
- A larger optic zone will give you a larger treatment zone.

**FALSE**
- A CRT lens has its first touch at greater than 8 mm.
Tips

• Proceed with caution:
  – Over 0.75D of ATR Astigmatism
  – Final treatment takes Cornea Curves below 37.00D
    • Example:
      – Flat K= 41.00
      – MRS = -4.00D
      – Target treatment= 37.00 Flat K
    – Cylinder is Greater than Sphere (Requires Dual Axis Design)
      • Example: -0.75 – 1.75 X180

Myopia Above 4.00 D

• Higher myopes require centration first, treatment second
  – Always sacrifice initial applanation for centration
  – “Two Stepping”
    • After moderate treatment, subsequent/reduced sagittal depth lenses will center and provide full treatment
    • Second lens at 7 to 10 days of treatment

Diagnostic Dispensing Guidelines

1. Centration is the primary goal
2. Central applanation (3-4mm) is secondary goal
3. Appropriate edge lift
4. Plano Over-refraction

The CRT® SureFit® Delivery System

Single-use, 3 lens per eye, fitting system

– High probability of first fit success for select candidates.
  • Flat K readings from 41.00 D (8.23 mm) to 45.00 D (7.50mm)
  • Spectacle refraction of -4.00 D and below
  • Up to 1.00 D of astigmatism (WTR)
– Immediate or subsequent parameter changes without interruption of treatment
– Valuable chair time saver

Topography is Valuable

Efficiency and Follow-up

Making Changes Based on Clinical Findings

• Lens centration is essential
  – Parameter adjustments to improve centration should be at one day follow-up
Lateral Decentration

- Step #1
  - Increase RZD 25 microns until centration is achieved

- Step #2
  - A diameter change may be indicated

- If the lens is still decentered, call authorized Paragon CRT consultant

Inferior Decentration

- Step #1
  - Decrease the LZA 1°
  - If centration is not achieved, proceed to:

- Step #2
  - Increase the RZD in 25 micron increments until centration is achieved

Nasal/Superior Decentration

- Step #1
  - Increase the RZD in 25 micron increments until centration is achieved.

- Step #2
  - A diameter change may be indicated.

Insufficient Edge Lift

- Replace with 1° less LZA
- Confirm centration

Example:

- -33° LZA
- -32° LZA

Excessive Edge Lift

- Replace with 1° greater LZA
- Confirm centration

Example:

- -31° LZA
- -32° LZA

Dual Axis Design for Corneal Elevation Differences

A design allowing the modulation of the elevation of the back surface of the lens to align with the steeper meridian for eyes having an elevation difference of greater than 15 microns at a chord of 8 mm measured with corneal topography.
Why Paragon CRT Dual Axis?

• Existing CRT wearers with sub optimal fits
• Previous CRT drop-outs
• Patients that have pre-treatment corneal astigmatism with average elevation differences of >15 microns can be considered as prime candidates.

Paragon CRT® Dual Axis™

• CRT Dual Axis alters the peripheral lens shape to mimic the shape of the astigmatic cornea.
• A solution for CRT patients that display problematic reshaping issues pertaining to improper centration or under treatment.

Paragon CRT Dual Axis

What is it not?

• A toric design.
  – The central treatment curve (BC) is spherical and round
  – The edge remains round and planar

The Paragon CRT proximity control technology allows modulation of the RZD and/or the LZA in different meridians without changing the treatment curve (BC).

Paragon CRT® Dual Axis™

Depending on the average elevation differences in the shallow and deep meridians, it is possible to have;

• Two different RZD’s (525 & 575)
• Two different LZA’s (-33 & -34)
• Different RZD’s and LZA’s (525 & 575/-33 & -34)

Limitations – only available in +0.50 power and 10.5 or 11.0 mm diameters

CRT Lens Showing Normal Tear Pattern
What Does This Have To Do With Astigmatism?

CRT Lens on Astigmatic Eye

Paragon Dual Axis Design

OD Corneal Cylinder 2.87 D.  OS Corneal Cylinder 2.87 D.

CRT Dual Axis on Astigmatic Eye

Right Eye: 8.6 .525  33
Fitting Philosophy

- Fit standard CRT lens (from slide rule)
- Follow appropriate parameter changes for proper centration and/or treatment patterns

If the standard CRT lens does not provide;
- Proper positioning
- “Bulls eye” pattern
- Incomplete treatment

Consider CRT Dual Axis

Fitting the CRT Dual Axis Design

There are two methods for designing the Dual Axis lens;

Method 1
- The Manual Calculation method: Take data points from the pre-treatment elevation map from the topographer and calculate the average elevation difference in the flat and steep meridian. This result will determine the RZD difference in the lens.
Fitting the CRT Dual Axis Design

Method 1: Manual Calculation from Elevation Map

Using axial elevation differences from elevation topography:
- Place cursor at points 4 mm on both sides from reference center on the shallow (red) meridian & record the values.
- Place cursor at points 4 mm on both sides from reference center on the deepest (blue) meridian and record the values.
- Average the two values in each meridian and add them algebraically.

This result shows the average micron saggital differences between the meridians.

Fitting CRT Dual Axis

If the initial spherical CRT lens doesn’t provide desirable results, consider CRT Dual Axis

- If the calculated average elevation difference is:
  - > 15 - 30 microns;
  - Choose an RZD difference of 25 microns (550 & 575) with same LZA
  - > 30 to 60 microns
  - Choose an RZD difference of 50 microns (550 & 600) with same LZA
  - > Above 60 microns
  - Choose an RZD difference of 75 microns (550 & 625) with same LZA

Patient SC

45.12 @ 012 / 47.00 @ 102
2.00 D. Corneal Astigmatism

Elevation Map BFS 7.43

Elevation Map Deep and Shallow

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<thead>
<tr>
<th>Shallow Meridian</th>
<th>Deep Meridian</th>
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<tr>
<td>Nasal = +12 microns</td>
<td>Superior = -42 microns</td>
</tr>
<tr>
<td>Temporal = +16 microns</td>
<td>Inferior = -26 microns</td>
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<tr>
<td>Total = +28 microns</td>
<td>Total = -68 microns</td>
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<tr>
<td>Divided by 2 = +14</td>
<td>Divided by 2 = -34</td>
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Difference between Horizontal and Vertical Meridians

+14 - (-34) = 48 microns

Fitting the CRT Dual Axis Design

Method 2: Topography Software

- Enter the pre-treatment topography into a CRT design software to view the simulated tear pattern and the suggested lens parameters. You may adjust the lens parameters to maximize the desired tear pattern.
Fitting CRT Dual Axis

Prescribing CRT DA in the Absence of Elevation Data

• Evaluate the CRT best fit spherical lens
  – From DDS or initial warranty order \( 8.70/550/-33 \)

  If the spherical lens results in improper positioning or incomplete treatment, order CRT Dual Axis with a 50 micron default difference in RZD. \( 8.70/550 \& 600/-33 \)

  Average elevation difference is between 30 – 60 microns

  Evaluate performance as usual.

The Initial CRT Lens

1. Calculate the initial CRT lens from the Flat K and manifest refraction sphere.
2. Trial the initial lens for proper centration and “bulls eye” pattern.
3. If necessary, make any parameter adjustments according to the troubleshooting guide
4. Evaluate the edge lift appearance in all meridians.

Fitting CRT Dual Axis

Best fit spherical CRT showing excessive pooling in deep meridian and decentered

Dual Axis CRT with 50 micron difference in RZD w/single LZA

Emerging Myopia Design

Create peripheral steeper zone without significant change to the central cornea

– Base curve having higher eccentricity than cornea
– Landing zone tangential or convex to the eye with medial clearance

Original Paragon CRT Patents claimed Dual-Axis and Single-Axis features to enhance centration of treatment

Clinical and manufacturing metrology and rotationally asymmetric diamond turning will usher in precision products for excellent Peri-Form accuracy to the level of control of the corneal shape of a single half meridian centrally or in the mid-periphery.
Peri-Form Regulation of Astigmatism

- Corneal shape determines peripheral retinal defocus
- Regional peripheral defocus impacts regional growth
- Regional axial growth influences corneal shape

Smart Lenses for Refractive Therapy

“Let there be light . . . “

Unmet Medical Need

Effective non-invasive method of protecting and preventing the development of myopia, high hyperopia and astigmatism
- Free of unintended long term side effects
- Not impacted by historical non-compliance
- Compatible with other strategies for multivariate utility

Antecedents

- Increase in incidence and prevalence of myopia of epidemic proportion
- Increased urbanization along with indoor life style
- Rising cost of energy and response toward reduction of indoor lighting in homes and schools
- Miniaturization allowing for electronic components in spectacle and contact lenses
- Eye-wear borne imaging sources and lens-borne films for selective reflection
- Precision metrology and manufacturing allowing for enhanced control of optical path

Eye-wear Borne Electromagnetic Radiation Refractive Therapy

- Passive or Active elements eye-wear which direct radiation to a predetermined ocular component for the purpose of regulating growth or resultant optical characteristics.
  - Passive: Deflective, reflective, refractive, birefringent, fiber optic for collecting or directing ambient radiation or radiation from radiation source.
  - Active: Pre-determined or programmable radiation sources within the frame or spectacle lens or contact lens
Predicate Technology

- Parallel technology development supports utility and feasibility
  - Electronic components in spectacle lenses
    - LED
    - Sensors
    - Controller/processors
    - Power sources
    - Antenna
  - Frame borne radiation sources
    - LCOS micro-projector with optics
    - Laser pico-projection
  - Precision passive optics
    - Birefringence
    - Fiber optics
    - Reflective optics
    - Deflective optics
    - Nano-precision manufacturing
    - Spectral filters

Supportive Reported Research

Role of illumination on emmetropization

- Jones: Outdoor daytime activity correlates with lower probability of developing myopia
- Wildsoet: Light protects against lens induced myopia and wavelength matters (Blue protects)
- Sherwin: Ultraviolet Auto-Fluorescence a biomarker for decreased prevalence of myopia
- Neitz: Wavelength matters (Blue protects)
- Smith: Light protects
- Siegwart: Elevated light levels from fluorescent bulbs that emit minimal UV radiation, may become a useful tool to slow the progression of environmentally-induced myopia in children.

Role of Outdoor Activity

Jones, LA Parental History of Myopia, Sports and Outdoor Activities, and Future Myopia Invest Ophthalmol Vis Sci. 2007;48:3524–3532 DOI:10.1167/iovs.06-1118

“The chance of becoming myopic for children with no myopic parents appears lowest in the children with the highest amount of sports and outdoor activity . . . . .”

Light at night inhibits lens-induced but not form deprivation myopia

Role of Spectral Characteristics

Kroger & Wagner 1996

Increased eye growth under RED LIGHT

Possible mechanism for value of outdoor activity? Near visible blue light good for children while not good for adults?

University of Washington

20110313058 Neitz

METHOD AND APPARATUS FOR LIMITING GROWTH OF EYE LENGTH

17. A therapeutic device for preventing, ameliorating, or reversing eye-length-related disorders, the therapeutic device comprising one of: blur-inducing glasses; blur-inducing contact lenses; blur-inducing glasses that incorporate wavelength-dependent filters; blur-inducing contact lenses that incorporate wavelength-dependent filters; glasses that incorporate wavelength-dependent filters; and contact lenses that incorporate wavelength-dependent filters;
Conclusions and Theory

- Jones teaches value of outdoor daytime activity
- Wildeset and Neitz teach the role of wavelength
- Wildeset and Smith teach the role of light
- Neitz teaches subtractive modulation of ambient light along with peripheral defocus
- Neitz teaches loop is at the retinal level and specific to cone response
- Smith teaches peripheral defocus and peripheral illumination have regional effects
- Siegwart teaches elevated light levels with UV protects

Unsolved problem: Neitz is limited in the event the ambient lighting does not contain the desired wavelength or amplitude. Further, Neitz does not provide directional control or duration which may be important

Clinical Opportunity: Incorporate radiation source in eye-wear (frame, spectacle lens or contact lens) which collects and directs ambient light which would otherwise not pass through the pupil OR has an active radiation source which directs the radiation toward an ocular component for the purpose of regulating refractive error development.

Predicate Technology

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    - Deflective optics
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    - Spectral filters

Eye-wear Borne Electromagnetic Refractive Therapy

- Intra-ocular radiation appears to be a protective factor
- Positive benefit appears to be wavelength specific
- Radiation effect on crystalline lens may also have a role in emmetropization
- Electronics can be placed and powered in contact or spectacle lenses or eyewear frame
- Passive optics and off-axis projection can deliver and modulate radiation of ocular components

Hypothesis: Lens-borne or lens modulated radiation can replace the absence of outdoor daytime activity
Radiation can be modulated with a contact lens with passive “light collection” of ambient light or active radiation source(s).

Apparatus for Electromagnetic Radiation Refractive Therapy

Let’s Pull the Pieces Together

Illumination Refractive Therapy
- Retinal illumination (Glare) appears to be a protective factor
- Electronics can be placed and powered in contact lenses
- Passive optics and off-axis projection can direct electromagnetic radiation to crystalline lens and retina

Purpose: Lens-borne or lens modulated radiation can replace the absence of outdoor daytime activity

My Position
- Myopia progression can be controlled or prevented in the majority of cases.
- Screening methods can determine who is at risk.
- Intervention using Refractive Therapy has broad sight saving potential and market potential.
- It’s time to start a Refractive Therapy service in Optometric Practices

Other Contact Lens Embodiments
- Birefringence
- Reflective Folded Optics
- Deflective light collection
- Fiber optic light collection

Current Refractive Therapy Strategies
- Corneal Refractive Therapy
- Multifocal Contact Lenses
- Muscarinic Antagonists
- Environmental and illumination engineering

Key Take-away from This Presentation
1. Peer reviewed literature supports the ability to regulate the development of myopia
2. Instruments are available for assessment and follow up metrology
3. Methods are available with other labeling for treatment
4. University of California Berkeley has opened the first University based Myopia Control Clinic
5. It is time for the early adopters and early majority to do the same
Current Methods with Established Efficacy

- Corneal Refractive Therapy
- Contact Lens Refractive Therapy - Center Distance Multifocal Lenses (CDM)
- Pharmaceutical Refractive Therapy – 0.1% Atropine
- Electromagnetic Radiation Refractive Therapy
  - Outdoor light or Psuedo-Outdoor Light

Thank you