

# Myopia Management 101: Atropine, SMFCL, OrthoK and More!

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1

## Financial Disclosure

I have no relevant financial relationships to disclose.

The content and format of this course is presented without commercial bias and does not claim the superiority of any commercial product or service.

2

## Identification of a Progressive Myope:

- Onset prior to age 9
- Lower than expected hyperopia at a young age
  - 6yo < +0.75D
- Axial length longer than expected at a young age
- Rapid progression of SE or axial length (greater than 1D change in a 12 month period)
- Parental myopia (prevalence of juvenile myopia)
  - 0 parents = 7.6%
  - 1 parent = 14.9%
  - 2 parents = 43.6%
- Ethnicity
  - Asian ethnicity = greater risk
- Near work
- Time spent outdoors
- Binocular Vision disorders

3

## Dr. Ian Flitcroft study: Every Diopter Matters

*"...in myopic maculopathy it appears there is no safe threshold for myopic refractive errors, although the absolute risk falls rapidly in low myopia."*

4

## Examination of the Progressive Myope:

Comprehensive Eye Exam, PLUS...

- Wet refraction (1% Tropicamide)
- Phoria status
- Lag of accommodation
- Vergence ranges
- Retinal photography
- OCT Imaging
- Topography
- Axial Length

5

## Myopia Management Available Therapies:

- Spectacle Lenses
- Atropine
- SMFCL
- Orthokeratology

6

# Spectacle Lenses

7

## Spectacle Lenses:

- Do NOT undercorrect
- Multifocals
  - PALS
  - Bifocals
  - Bifoals w/ 2BI prism
    - May be helpful if exophoric
- Considerations of Phoria Status and High Lag of Accommodation
  - Esophoria vs Exophoria
  - High Lag of Accommodation - cause or product of progressive myopia?

8

## Spectacle Lenses: The Future

- **D.I.M.S.** (MiyoSmart by HOYA): Defocus Incorporated Multiple Segments spectacle lenses
- **Stellest** (Essilor) spectacle lens: Incorporates H.A.L.T. (Highly Aspherical Lenslet Target)
- **D.O.T. lenses** (SightGlass Vision): Incorporating "Light diffusion technology"

9

# Atropine

10

## Atropine Mechanism of Action:

### Nonaccommodative mechanisms: (current prevailing theory)

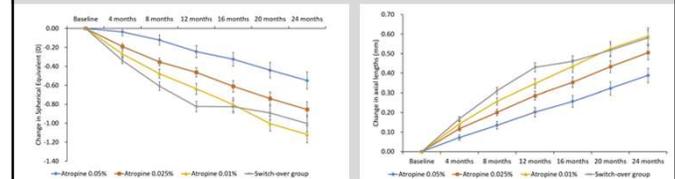
Multitude of cellular responses (affecting BOTH Sclera and Retina) - Shotgun Approach

- Anticholinergic - block the action of acetylcholine at the muscarinic receptors
- Increased dopamine release
- Effect on acetylcholine nicotinic receptors
- Other: non MRs, growth factors, etc

For more information: **REVIEW ARTICLE: Biological Mechanisms of Atropine Control of Myopia**  
Upadhyay, Aradhana Ph.D.; Beuerman, Roger W. Ph.D.

11

## LAMP Study (2 year data):



Yam, Jason & Li, Fen-Fen & Zhang, Xijuan & Tang, Shu Min & Yip, Benjamin & Kam, Ka Wai & ko, Simon & Young, Alvin & Tham, Clement & Chen, Li Jia & Pang, Chi. (2019). Two-Year Clinical Trial of the Low-Concentration Atropine for Myopia Progression (LAMP) Study: Phase 2 Report. *Ophthalmology*. 127. 10.1016/j.ophtha.2019.12.011.

12

## Atropine: How To Prescribe

- 0.025% or 0.05% (depends on ability to measure AXL)
- One drop QHS
- Cost
- Compounding pharmacies
- The Future: commercial availability
  - Vyluma: Phase 3 FDA trials

Transition lenses and BF lenses to help mitigate side effects

13

## Atropine: Follow-up protocol

- Monitor every 3 months:**
- Autorefraction**
  - Refraction**
  - Axial length**
  - Pupil size?**
  - Ask about side effects**
  - Ask about compliance**

14

## Atropine: Who is a good candidate

- Progressive myopes not eligible for CL therapies
- Dual therapies for patients still progressing with another method of myopia management
- Low hyperope at risk for transition into myopia

15

## Atropine: Contraindications

Who should NOT use atropine?

**Systemic Side effects:**

- Dry mouth and eyes
- Delirium or restlessness
- Tachycardia
- Flushed skin & face

**Exercise Caution When Prescribing:**

- Pre-existing heart conditions (congenital rubella syndrome & developmental delays)
- Congenital syndrome or heart condition
- History of asthma or other lung disease (due to thickening of mucous in lungs and drying of airways)
- Caution when taking other medications with anticholinergic or antimuscarinic effects (some medications used to treat depression and some antihistamines)

\*Consider punctual occlusion during administration to reduce systemic absorption

16

# Soft MF CL

17

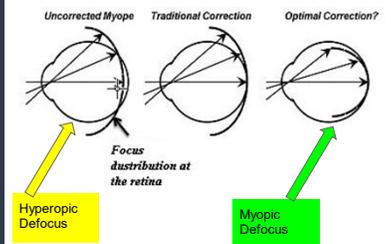
## Peripheral Retinal Defocus Theory

(Earl L. Smith, III, et al.)

Peripheral retinal **Hyperopic Defocus** is thought to stimulate axial elongation.

Myopia control is theorized to be achieved by causing **Myopic Defocus** on the peripheral retina.

The peripheral retinal light rays can be manipulated with Soft Multifocal lenses of specific designs to achieve **Peripheral Myopic Defocus**



18

### Soft Multifocal Contact Lenses for Myopia Control

- Extended Depth of Focus (NaturalVue)
- Dual Focus Concentric Contact Lens Design (MiSight)
- Center Distance Design

**MiSight by CooperVision**

Distance correction  
 Treatment zones, creating 2,000 of myopic retinal defocus  
 Distance correction focus  
 Treatment zone focus

Myopia defocus can slow down eyeball elongation, and as a result can slow down myopia progression<sup>SM</sup>

<https://coopervision.com/my/practitioner/fitting-tips-and-tools/tremis/step-three>

**Extended Depth of Focus (EDOF) and Dual Focus** lenses broaden the depth of focus to encompass a broader range of foci.

**Center Distance Design** is crucial to elicit myopic retinal defocus on the peripheral retina.

19

### Soft MFCL: Extended Depth of Focus

**NaturalVue by VTI**

Figure B illustrates the difference that the aperture makes to the depth of focus. A larger aperture results in a narrow depth of focus; a smaller aperture results in a wider depth of focus. The aperture can be physical such as an opaque pinhole occluder, or it can be created optically with a large power shift and be a 'virtual' aperture.

**Figure B**

20

### CooperVision: MiSight Lens

**Highlights:**

- 0.75-4.00 (sphere equivalent)
- ≤ 0.75 cylinder
- 8-12 years old
- Daily Disposal

**FDA Approval Details:**

- MiSight 1 Day (omafilcon A) Soft (Hydrophilic) Contact Lenses.
- Slow progression of **nearsightedness** in children ages 8-12.
- discarded each day after every use.
- The use of this contact lens requires periodic eye doctor's visits and a prescription.
- at the initiation of treatment have a refraction of -0.75 to -4.00 diopters (spherical equivalent) with ≤ 0.75 diopters of astigmatism (low to moderate nearsightedness).
- In a clinical study, children who wore the contact lenses over a three (3) year period did not increase their nearsightedness as much as children who wore conventional soft contact lenses, that only bends light so it focuses on the back of the eye.

21

### CooperVision: MiSight Lens

**When MiSight should not be used (according to FDA approval)...**

**FDA Approval Details:**

**When should it not be used?** The contact lens should not be used in children with any of the following:

- swelling or infection of the eye
- eye disease, injury, or abnormality that affects the eye surface or eyelids
- severe lack of tearing (dry eyes)
- numbness of the eye surface
- disease that may affect the eye or worsen by wearing contact lenses
- allergic reactions involving the eye or the skin surrounding the eye that can be triggered or made worse by wearing contact lenses or use of contact lens solutions
- active eye infection
- eyes become red or irritated
- inability to follow contact lens handling and lens wear instructions or unable to obtain assistance to do so

22

### Who is a good candidate for SMFCL

- Poor candidates for other options
- Outside parameter ranges for orthokeratology

23

**Other Center Distance Options:** (note: not all are strictly SMFCL, but most work with a similar principal.) EDOF should be considered for maximum myopia control compared to other SMFCL designs.

Lens	Manufacturer	Replacement Schedule	Notes
Biofinity MF D Lens	CooperVision	Monthly	
Proclear MF D Lens	CooperVision	Monthly	
MiSight 1 Day	CooperVision ( <b>Dual Focus Concentric Contact Lens Design</b> )	Daily	FDA approved in November, 2019
Acuvue Oasys for Presbyopia	Johnson & Johnson Vision	Bi-monthly	
NaturalVue MF 1 Day	VTI Vision ( <b>EDOF</b> )	Daily	
SpecialEyes 54 Multifocal	Special Eyes	Quarterly	center distance and toric available. Aspheric design.
Duette Progressive Center Distance	Synergeyes	Bi-annually	Hybrid lens
Scleral MF Contact Lens with Center Distance design	Available from various manufacturers, i.e. Acculens, Zenlens, GP Specialists, etc	Annually	

24

### Considerations w/ SMFCL

- Center Distance
- EDOF
- Higher Add Power
- Disposal Schedule
- Pupil Size
- Wearing time

- Center Distance: Required to elicit peripheral myopic defocus.
- EDOF: Theorized to provide more effective Myopia Control than simple Center Distance SMFCL designs (I.e. MiSight and NaturalVue).
- Higher Add Power: Theorized to provide better myopia control ( $\geq +2.00$  add).
- Disposal Schedule: Daily disposal when possible limits risk of adverse events such as microbial keratitis (I.e. MiSight and NaturalVue).
- Pupil Size: Peripheral strength profile of the lens should be within the pupillary margins.
- Wearing time:  $\geq 5+$  hours per day demonstrated better myopia control. Poor compliance w/ lens wear will limit myopia control.

25

### SMFCL: f/u protocol

**Monitor every 3-6 months:**

- Autofraction
- Refraction
- Axial length

- Ask about side effects
- Ask about compliance
- Review solutions/ disposal schedule/ lens hygiene

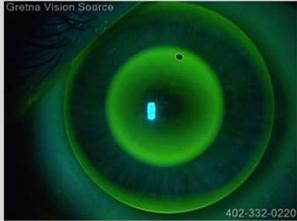
26

# Orthokeratology

27

### What is Orthokeratology

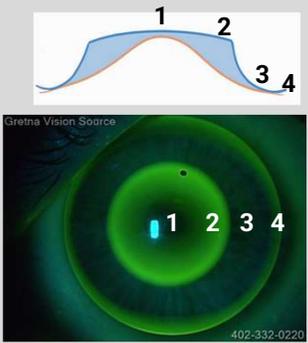
**Definition:** Use of specially designed (reverse geometry) gas permeable lenses to gently and temporarily reshape the anterior surface of the cornea to improve vision and slow progression of myopia.



28

### Orthokeratology Lens Design Basics:

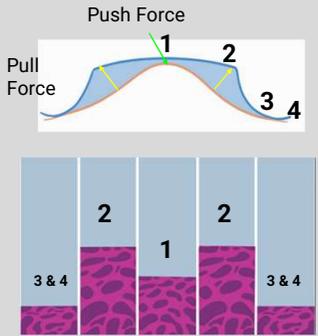
- Back optic zone radius
- Reverse curve
- Alignment curve
- Peripheral Curve



29

### Corneal Changes:

- Redistribution of Epithelium
- Hydraulic Forces



- Back optic zone radius
- Reverse curve
- Alignment curve
- Peripheral Curve

30

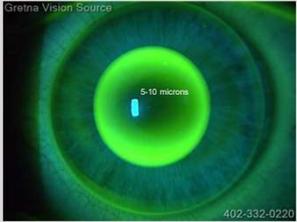
### Orthokeratology Lens Design Basics:

- Compression Factor (AKA Jessen Factor)
  - Refers to the amount of 'overtreatment' or flattening of the cornea above and beyond the patient's current refractive needs
  - Typically +0.75 to +1.25 dependent upon manufacturer
  - Allows for clear vision all day as cornea 'bounces back'
  - Central Tear Thickness

31

### Orthokeratology Lens Design Basics:

- Central Tear Thickness
  - NaFl visible when tear thickness >20 microns
  - Central Treatment zone appears to have bearing
    - 5-10 microns tear layer centrally



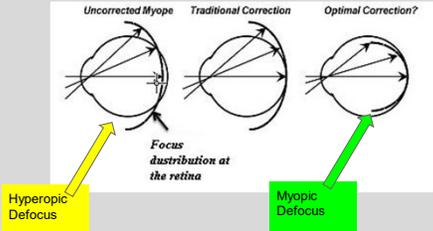
32

### Orthokeratology Mechanism of Action:

- Peripheral retinal defocus theory
- Spherical aberrations to retina
- Treatment zone size considerations

33

### Peripheral Retinal Defocus:



34

### Orthokeratology Efficacy Studies:

Subgroup analyses of pooled myopic control rate of different treatment duration.

	Number of studies	Pooled myopic control rate
6 months	5	55%
12 months	7	51%
18 months	5	51%
24 months	8	41%

Wen D. et al, 2015

35

### Orthokeratology Safety Studies:

“estimated incidence rate of MK as 7.7 cases per 10,000 patient years (95% CI, 0.9~27.8), and risk of MK with overnight OrthoK was similar to other overnight modalities.”

Bullimore MA, et al. 2013

36

## Orthokeratology FDA Approval:

- Typically 'Off Label'
- Johnson & Johnson
  - Abiliti Overnight: First overnight orthokeratology lens to achieve FDA approval for 'myopia management'

37

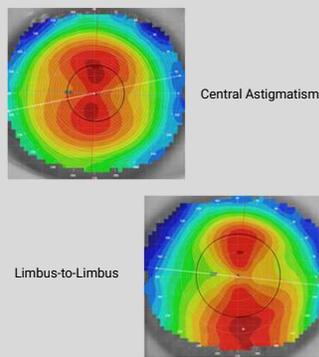
## Orthokeratology: Finding Good Candidates

- Low myope, -1.00 to -4.00
- Myopia > Astigmatism
- Astigmatism -0.75D or less
- Astigmatism WTR

38

## Orthokeratology: Finding Good Candidates

- Astigmatism
  - Central vs Limbus-to-Limbus
- Relatively normal K's  
41.00 to 45.00



39

## Orthokeratology: Other Considerations

- Dry eye - NOT a contraindication
- Sleep habits
- Hygiene and maturity
- Corneal health/ contraindications

40

## Orthokeratology: How to Start

- Equipment
  - Topographer
  - Anterior segment photography/ NaFl
- Optical biometry- optional?
- Diagnostic fit set
- Empirical fitting
- Software designed lenses

41

## Topography

- Types of Topographers
  - **Placido**
    - Ring jam
    - Influenced by tear film
  - **Scheimpflug**
    - Anterior and posterior corneal data
    - Better for identifying keratoconus- cones start on the posterior surface of the cornea
- Pristine baselines paramount
  - garbage in - garbage out
  - lid aperture

42

### Placido Topography

- Pros
  - More affordable purchase price compared to Scheimpflug Tomographers.
- Cons
  - Influenced by tear film
  - Harder to capture images on deep set eyes

43

### Scheimpflug Topography

- Pros
  - Anterior and posterior corneal data
  - Better for Keratoconus/Ectasia
  - Better for deep set eyes
  - NOT influenced by tear film
- Cons
  - Less affordable purchase price

44

### Pre-Treatment Topography Assessment

- axial map
- tangential map
- elevation map
- shape indices
- r/o KCN

45

### Post-Treatment Topography Assessment

Comparison maps (aka 'difference' or 'subtractive' maps)

Axial Subtractive Map  
Subtractive Map (Power)  
Tangential  
(Control - Treatment Zone Size)

46

### Orthokeratology: Fit Analysis

NaFl

Too Steep      Just Right      Too Flat

47

### Orthokeratology: Other Considerations

- VID (oval corneal shape is common: HVID vs VVID)
- Pupil size
- glare and halos
- Adult OK
- Presbyopic OK
- OK for myopia management
  - Treatment zone size
- Sphere vs Toric design
  - central 8mm or 9mm chord, change in sagittal depth (>25-30um)

48

### Orthokeratology: Follow Up Protocols

- 1 day
- 1 week
- 1 month
  - order spare pair
- Then quarterly or every 6 months (doctor's discretion)
- Tests performed
  - VA, refraction, AR or retinoscopy, SLE to check for stain, AXL if available
  - Examine fit of lenses on eye (if necessary)
  - Review hygiene, care and handling, teach digital removal

49

# Axial Length

50

### Axial Length (AL):

- Distance from anterior corneal surface to fovea
- Measured with A-Scan ultrasonography (old tech) or Optical Coherence Biometry (new tech)
- Average Adult Human Eye: 24 mm

51

### Axial Length (AL):

- Distance from anterior corneal surface to fovea
- Measured with A-Scan ultrasonography (old tech) or Optical Coherence Biometry (new tech)
- Average Emmetropic Adult Human Eye (Axial, Anteroposterior):
  - 22 to 24.8 mm

52

### AL and Increased Risk of Pathology:

Cross sectional study (Tideman et al. 2016)

- Analyzed study data from 1990-2012
- 15,404 eyes spherical equivalent data & 9,074 eyes axial length data

Axial Length	Incidence of Visual Impairment/Blindness after age 75 (VA < 20/40) Regardless of refractive error
≤ 26mm	3.8%
≥ 26mm	25%
≥ 30mm	90%

\*Suggestive that eyes with higher axial length need closer monitoring of fundus.

53

### AL and Increased Risk of Pathology:

- Posterior Staphyloma
- Myopic Foveoschisis (Myopic Tractional Maculopathy - MTM)
- Lacquer Cracks
- Retinal Holes, Retinal Tears, Retinal Detachments
- Lattice Degeneration
- Tigroid/Tessellated Fundus
- Myopic Crescents (Peripapillary Atrophy)
- Glaucoma
- Cataracts

54

### Axial Length and Refractive Error:

- **Refractive Error is a Summary Measurement**
  - Cornea, Crystalline Lens, Axial Length
- **Relationship of Axial Length to Refractive Error Varies Based on Study**
  - BLINK study, (Walline et al. 2020)
    - 1mm/1.44D to 1mm/1.63D
  - MiSight Study, (Chamberlain et al. 2019)
    - 1mm/2.4D

55

### Chinese Children:

#### Axial Length Data

Tai, LL, et al. Axial length and associated factors in children: the Shandong Children eye study; Ophthalmologica, 2016.

Age, years	n	AL, mm (boys)	AL, mm (girls)	AL, mm (total)
4	114	22.30±0.71	21.96±0.68	22.15±0.72
5	360	22.52±0.66	22.02±0.60	22.31±0.68
6	438	22.65±0.76	22.25±0.66	22.49±0.75
7	639	23.04±0.77	22.39±0.64	22.76±0.79
8	743	23.28±0.84	22.83±0.86	23.66±0.88
9	546	23.61±0.86	23.04±0.84	23.34±0.89
10	704	23.88±0.99	23.29±0.94	23.58±1.01
11	589	23.97±1.00	23.54±1.01	23.77±1.03
12	488	24.14±1.01	23.69±1.10	23.94±1.08
13	429	24.37±1.22	23.81±1.04	24.10±1.17
14	324	24.69±1.34	24.17±1.21	24.41±1.30
15	227	24.83±1.32	24.36±1.04	24.50±1.21
16	136	24.76±1.20	24.37±1.23	24.65±1.22
17	129	24.81±1.25	24.43±1.04	24.58±1.14
18	106	24.69±1.02	24.27±1.00	24.50±1.03
Total	5972	23.64±1.19	23.24±1.18	23.45±1.20
Region of residence				
Rural	3069	23.41±1.11	23.06±1.09	23.25±1.11
Urban	2910	23.91±1.22	23.41±1.23	23.66±1.25

56

### Comparison of Growth among Refractive Error Groups

Jones et al. 2005  
Figure 8  
(Population 85% Caucasian)

Legend:
 

- Myopes
- Emmetropes
- Emmetropizing Hyperopes
- Persistent Hyperopes

Myopes:
 

- Age < 10.5 y = 18.144 + 2.391\*ln(age)
- Age > 10.5 y = 17.808 + 2.560\*ln(age)

Emmetropizing Hyperopes:
 

- Age < 10.5 y = 20.189 + 1.258\*ln(age)
- Age > 10.5 y = 21.353 + 0.759\*ln(age)

Emmetropes:
 

- Age < 10.5 y = 19.660 + 1.366\*ln(age)
- Age > 10.5 y = 21.180 + 0.719\*ln(age)

Persistent Hyperopes:
 

- Age < 10.5 y = 19.926 + 0.970\*ln(age)
- Age > 10.5 y = 19.825 + 1.010\*ln(age)

57

### MyopiaCare: Online Myopia Calculators

- Axial Length
- Refractive Data

58

### Monitoring AL Can Aid Clinical Decision Making in Myopia Management Patients

#### What is 'Progression'?

- 0.06mm in 3 months (not always so simple)
  - Experience: with AL, you will start to develop a clinical sense
  - Comparison: Rate of growth prior to and during treatment
- Change therapy or add dual therapy
  - Increase concentration of atropine drops
  - Change from Atropine therapy to Orthokeratology or SMFCL
  - Add Atropine therapy to Orthokeratology or SMFCL

59

### Choroidal Thickening in Myopia Management

- When myopia management is achieved, choroidal thickening happens.
- Diurnal Variations in Choroidal Thickness and Considerations on Axial Length Measurements
  - Eye is shorter in the morning/ Longer in the evening
  - Phase length: 11-12 hours
  - 0.02 to 0.04 mm difference

60

## Pro-Tip: Start Measuring AL to Grow Your Practice Faster

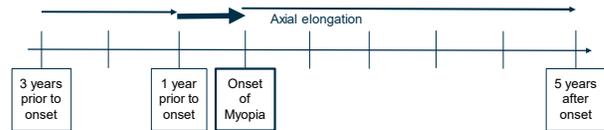
- **Start the Conversation**
  - Easier to transition patients into myopia management
  - Parents understand millimeters, not diopters
  - Identify progressive myopes earlier
- Be a leader, get ahead of the curve to carve out your niche in your area

*Analogy: Imagine trying to treat glaucoma without OCT*

61

## Monitoring AL Can Lend Predictive Value Regarding Onset of Myopia

Axial elongation occurs at an accelerated pace in younger children (age 6-10) compared to older children (Age 12-16). **Breslin et al. 2013**



**Growth trends of an eye destined for Myopia:** Accelerated growth 3 years prior to and 5 years after onset of myopia. Greatest acceleration occurs one year prior to onset of myopia. **Mutti et al. 2007**

62

## How to Measure Axial Length:

### Ultrasound Biometry (AKA 'A-Scan' or 'Applanation')

- Older Technology, 1950, non-preferred
- Pros
  - Less expensive
- Cons
  - Limited in reliability to about 0.1mm (approx. 0.30D margin of error\*) (Wolffson et al. 2019)
  - Requires contact with the eye (applanation or immersion)
    - *Corneal compression can compromise data*
  - User dependent
  - Time Consuming

\*Compare this to refraction - Cycloplegic autorefraction has a repeatability of  $\pm 0.21D$  (Moore et al. 2014)

63

## How to Measure Axial Length:

### Optical Biometry

Based upon Optical Partial Coherence Interferometry (PCI)

- Newer technology - preferred
- Pros
  - Non-Contact
  - Superior reliability around 0.01mm (or 0.03D) (Wolffson et al. 2019)
  - Repeatability
  - Faster, many measurements in less time
  - Easy to use, not user dependent
- Cons
  - More expensive

64

## Equipment for Measuring Axial Length: *Special Considerations*

### Older generation Ultrasound instruments (non-preferred) vs Newer generation optical biometers (preferred)

- **Check compatibility with current computers, software, EMR**
  - If it is multifunction instrument with topography, are you able to view the topography from other computers?
- **Early Model Optical Biometers**
  - Beware buying older models on non-dealer sites (i.e. e-bay)
    - Really old models may not work on new computer systems (i.e. may require Windows 7 or older to run it.)
    - Old models often no longer supported by the manufacturer
    - Talk to your cataract surgeons - they might be selling a good instrument if they are upgrading

65

## Examples of Old Generation Ultrasound Instruments (NON-Preferred)

- DGH
- Nidek US 500
- Accutome
- etc

66

### New Generation Interferometry Optical Biometer Instruments (Preferred)

- Haag Streit: LenStar 900
- Nidek: AL-Scan
- Zeiss: IOLMaster 500

67

### Multi-Function Instruments

<b>Haag Streit: LenStar Myopia</b> Lenstar 900 biometer plus EyeSuite Myopia Software Platform	<b>Oculus: Myopia Master</b> (FDA approved August, 2021) Refraction, Keratometry, AL	<b>Tomey: OA 2000</b> (Not currently available in USA) Topography, Pachymetry, pupil diam, white to white, AL
<b>Oculus: Pentacam AXL Wave (OD Version)</b> Topography, tomography, pachymetry, AL, Aberrometry & Refraction	<b>Heidelberg: Anterior</b> Topography, tomography, anterior seg metrics, AL, iol calculations	<b>Topcon: Myah</b> (Not currently available in USA) Topography, AL, pupillometry, dry eye suite
<b>Topcon: Aladdin-M</b> Same as Myah minus the dry eye suite. Exclusive software platform monitor & display trends in Rx and AL	<b>Zeiss: IOLMaster 700</b> Topography (only central 4.5 mm), AL	

68

### Patient Education Software

- Haag Streit, LenStar Myopia: EyeSuite Myopia Software Platform utilizes growth curves to measure axial length and help manage progression. It also creates graphics to help track past and present treatment plans.
- Topcon, Aladdin-M: Exclusive software tracks changes in Rx and Axial length measurements over time to show progression and response to treatment.

69

### Can ECP's Practice Myopia Management Without Axial Length?

**Short Answer: Yes**

- In the clinical setting (AL required for research setting)

**Long Answer:**

- Be prepared to move in the direction of adoption of AL measurements in your protocols.
- Will become standard of care
  - AL is 5-10 times more accurate than refraction (Wolffsohn et al. 2019 & Moore et al. 2014)
  - Increased availability of instrumentation
  - Improved knowledge regarding eye growth and development of normative databases

70

# Other Considerations

71

### Other Considerations

- Staff Training
- Patient education
- Setting Fees
  - Global fee vs 'pay as you go'
- Informed Consents

72

# Thank You!

To learn more:

**AAOMC Vision By Design Conference and Beginner's Bootcamp**

**Bellevue, Washington**

**September 28th - October 2nd, 2022**