A Deep Dive into Corneal and Scleral Shape Relationships

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1

Disclosures

- Bausch and Lomb
- Oculus
- Ovitz
- Esslior
- Tangible Sciences
- Eaglet Eye

2

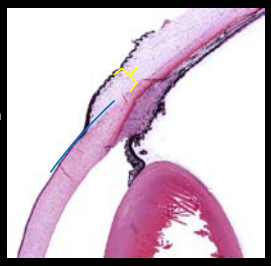
Corneal and Scleral Topography

- Topography shows the landscape of the cornea
- It can tell us:
  - The rate of change of curve across the cornea
  - The high and low points
  - Whether the eye is optically regular or irregular

3

The anterior eye

- The cornea and sclera are relatively continuous
- The conjunctiva overlying the sclera is somewhat unpredictable
- When we image the ocular surface we are imaging the cornea and the conjunctiva surfaces
- **The sclera gives its shape to the eye, but ultimately, the conjunctiva has an influence**

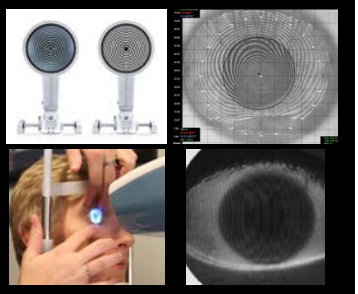


Digital Histology - VCU

4

Reflection Based Topography

- Reflects a series of rings or a grid off the front of the eye
- Measures how the curvature affects the reflection of the rings of grid back
- Interprets corneal and scleral shape based on these reflections
- Measures curvature and extrapolates elevation
- Tear layer dependent!



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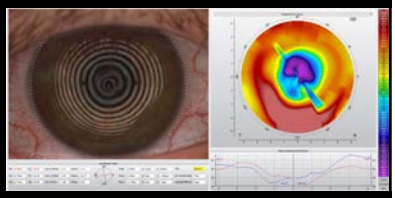
Placido Disc Topography

Tear layer dependent means we don't always get accurate data

But it does help us to understand the impact of dryness and surface irregularities on the patient's vision



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Scheimpflug Topography

- Uses a slit beam and Scheimpflug camera to take several cross-sectional images of the anterior segment of the eye
- Measures Elevation and extrapolates curvature

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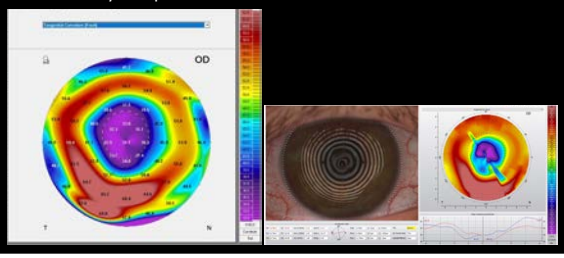
Scheimpflug Imaging

- Not Tear Layer Dependent



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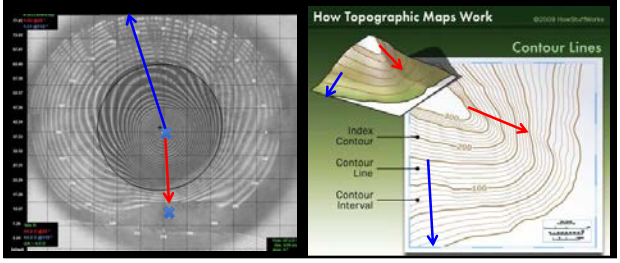
Corneal Topography



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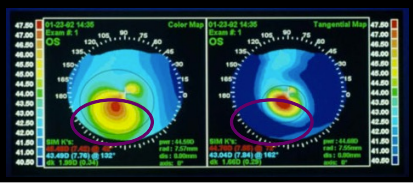
Curvature Maps

- Tells us how the cornea is changing and the rate of that change at any given point
- Axial maps give a broader overview of the cornea
- Tangential maps accentuate localized changes



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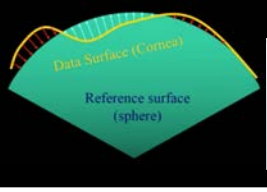
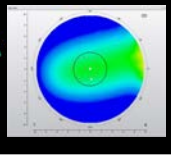
Elevation

Shows areas of elevation and depression relative to a "reference sphere" generated by the average height of the cornea

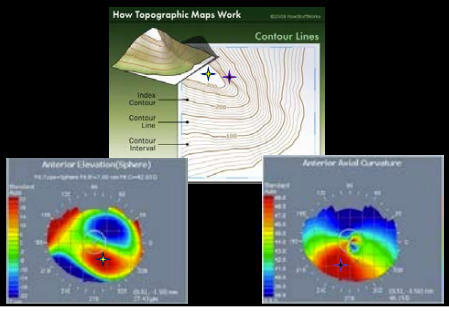


With the Rule Astigmatism



11

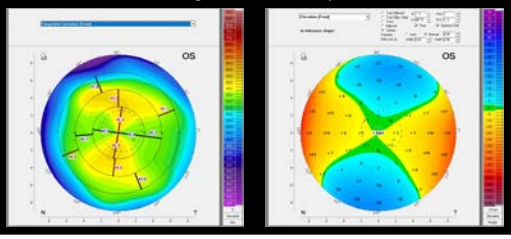
Elevation



12

Corneal Shape

- Differentiate rate of change from actual shape



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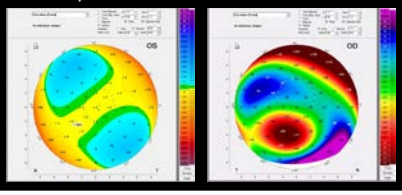
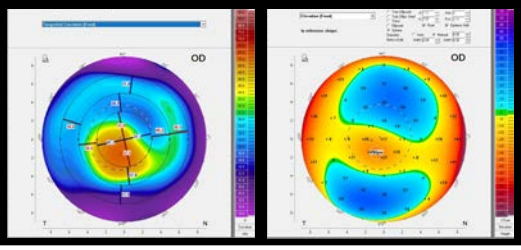
Corneal Shape

- Regular corneas should be relatively symmetric as they approach the limbus
- Irregular corneas may NOT



14

Elevation topography is more useful for scleral lens fitting – so get used to using it!



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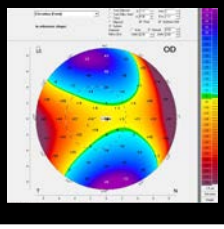
Elevation topography and scleral lenses

- Areas of lower elevation will have more clearance and vise versa



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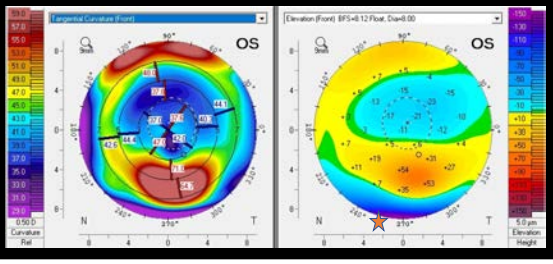

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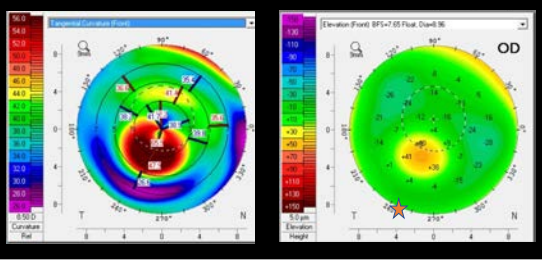

18

SCHOOL OF OPTOMETRY

Meridional Differences in Sagittal Height at 12 mm and 16 mm chords

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RESULTS

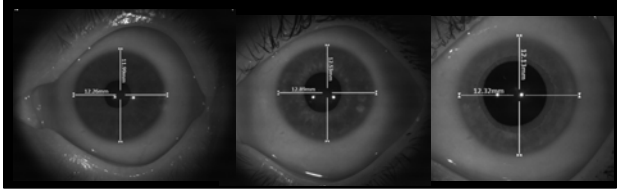
The mean difference in elevation at a 12 mm chord was 122 microns with a standard deviation of 76 microns. The mean elevation difference at a 16 mm chord was 185 microns with a standard deviation of 83 microns. On average, 2/3 of the sagittal height difference between the principle meridians was contributed by the corneal shape.

The cornea contributes a significant percentage of the elevation difference in the anterior segment of the eye. Because most scleral lenses compensate for this elevation difference in the scleral landing zone, this can often create suboptimal fitting outcomes.

19

Corneal diameter

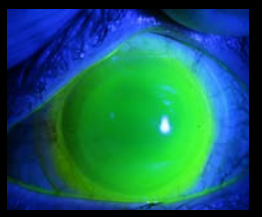
- The cornea is not round – it is nearly always oval to an extent
- This means that landing precisely the same distance from the limbus is not possible without oval zones – but the difference is very small so really not necessary



20

Corneal Shape

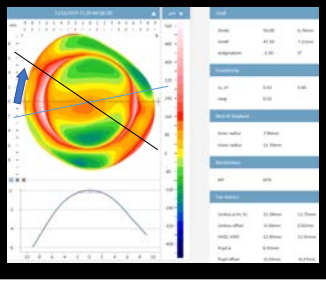
- So the cornea is usually steeper and therefor DEEPER in one meridian, and it is also smaller
- Therefor standard scleral lenses will almost always OVERVAULT the limbus in one meridian unless something compensates



21

Cornea to Scleral Transition

- While more often than not a cornea is deeper vertically and shallower horizontally, there is a degree of reversal of that in the sclera in a large number of patients



22

Corneal to Scleral Transition

Utilizing Corneal Topography to Aid in Predicting Scleral Topograhy for the Purpose of Fitting Scleral Contact Lenses

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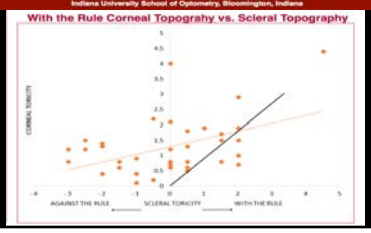
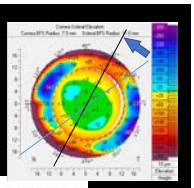


23

Scleral shape vs corneal shape

- Again, scleras tend to be more ATR than corneas
- The farther peripherally we go, the more ATR tendencies

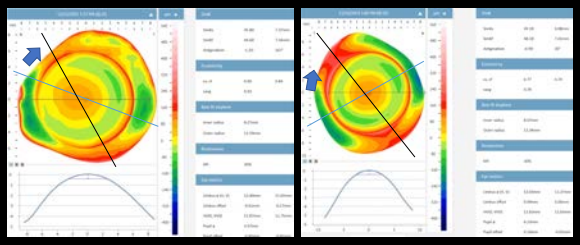


Scleral Toricity (D) at Varying Chord Diameters

Keratoconus	14mm	15mm	16mm	17mm
"WTR (n=6)	1.83 ± 1.20	1.94 ± 1.33	2.06 ± 1.36	2.06 ± 1.40
ATR (n=6)	0.88 ± 0.52	1.00 ± 0.65	1.31 ± 0.70	1.50 ± 0.65
Oblique (n=6)	0.80 ± 0.57	1.10 ± 0.82	1.10 ± 0.55	1.30 ± 0.76
All (n=20)	1.25 ± 0.97	1.41 ± 1.08	1.57 ± 1.05	1.68 ± 1.06
Normal				
"WTR (n=10)	0.60 ± 0.57	0.65 ± 0.58	0.60 ± 0.46	0.55 ± 0.37
ATR (n=10)	1.03 ± 0.52	1.13 ± 0.67	1.23 ± 0.75	1.30 ± 0.75
Oblique (n=6)	0.70 ± 0.27	1.00 ± 0.36	1.00 ± 0.36	1.00 ± 0.36
All (n=30)	0.83 ± 0.53	0.95 ± 0.62	0.98 ± 0.66	1.00 ± 0.67

24

Corneal Astigmatism vs Scleral Astigmatism



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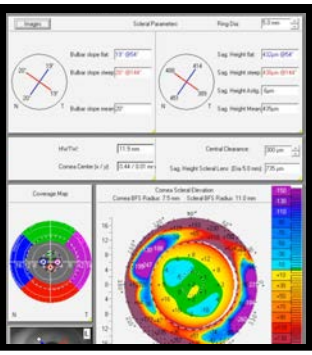
Limbal Shape

- The limbal zone can be an area of significant change in shape



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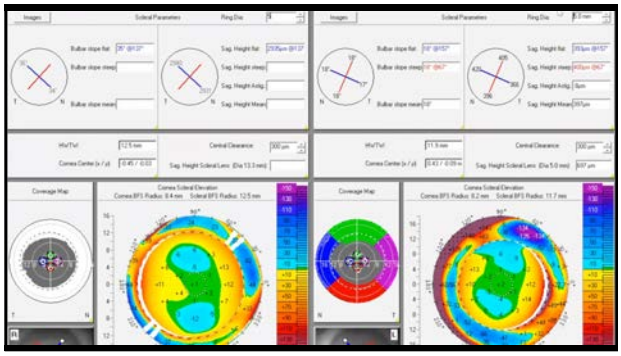

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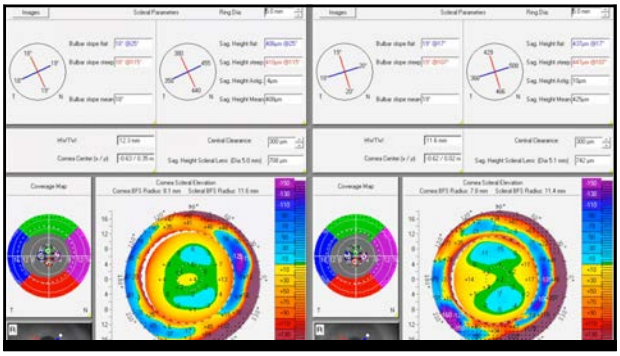


28

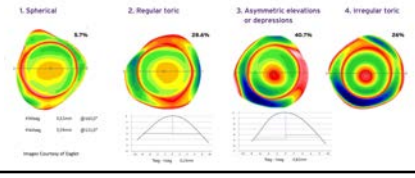
Scleral Shape

- Tend to be more against the rule than corneas
- Toricity and asymmetry increase with diameter particularly in against the rule scleras
- Irregular corneas will have more irregular scleras as well
  - Corneal structural weaknesses will impact the sclera as well since they are a continuous layer

29

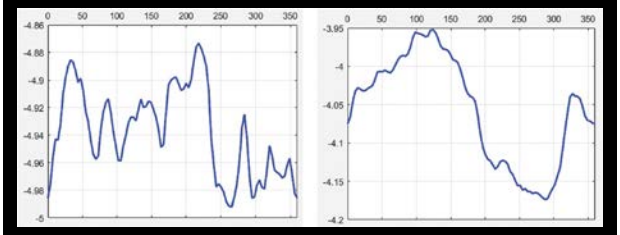
QUALITATIVE ASSESSMENT OF SCLERAL SHAPE PATTERNS USING A NEW WIDE FIELD OCULAR SURFACE ELEVATION TOPOGRAPHER: THE SSSG STUDY

- 140 eyes measured at 16 mm chord
  - 5.7% "spherical"
  - 28.6% "regularly toric"
  - 40.7% "asymmetric toric"
  - 26% "irregular"



30

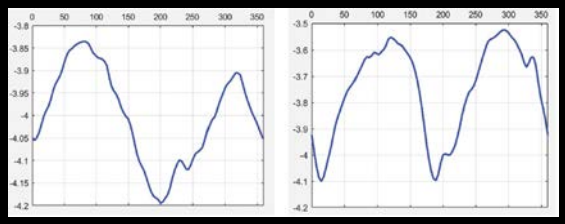
Quantifying Scleral Shape



Spherical

31

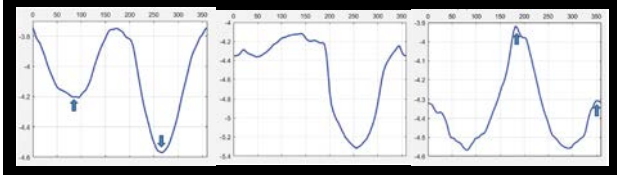
Quantifying Scleral Shape



Regular Toricity

32

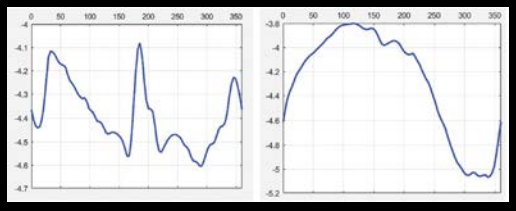
Quantifying Scleral Shape



Asymmetric Toric

33

Quantifying Scleral Shape



Irregular

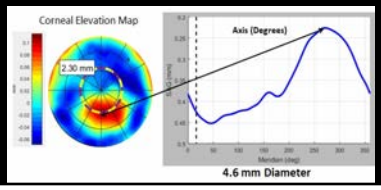
34

SSSG 2019 – First Study to Look at Pathologic Corneas

- Patients presenting with corneal ectasia have abnormal scleral shape compared to those with no corneal irregularities, largely presenting as a quadrant specific effect

Greater ectasia decentration

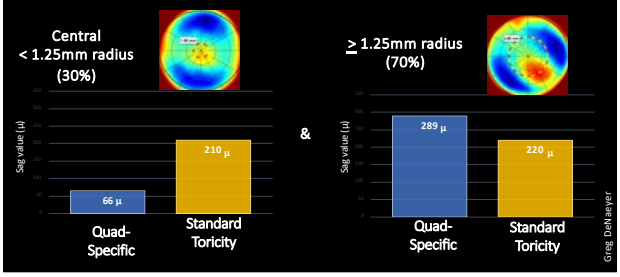
= more asymmetric scleral shape



35

Delta (Δ) Sag (16mm)

Quadrant-Specific vs Standard Toricity



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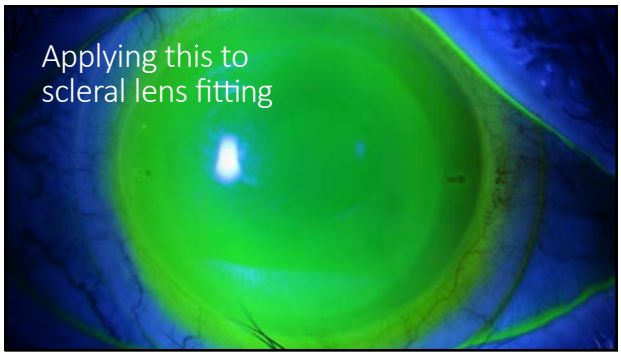

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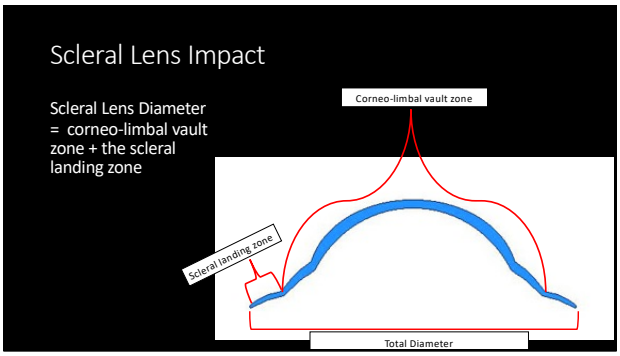

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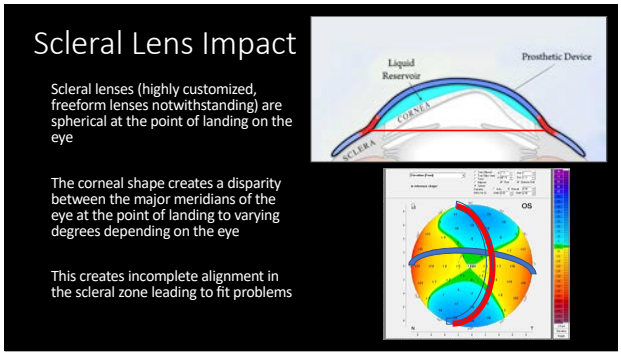

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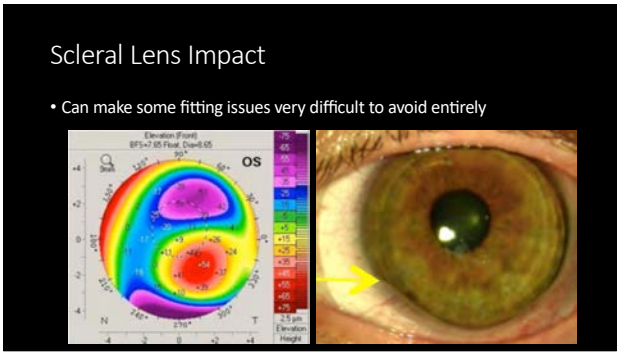

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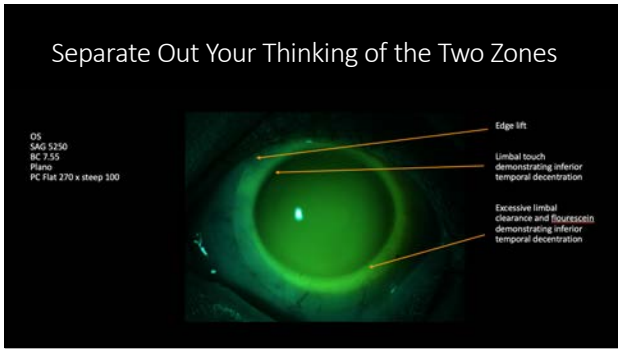

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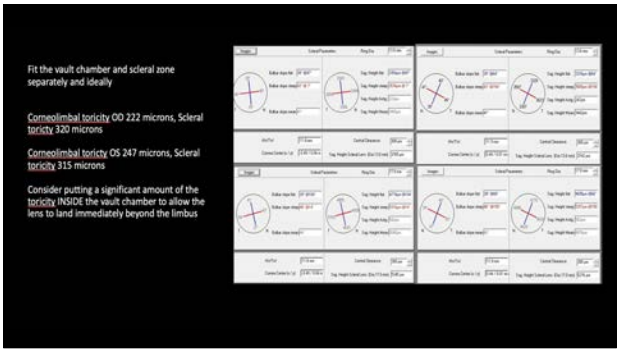

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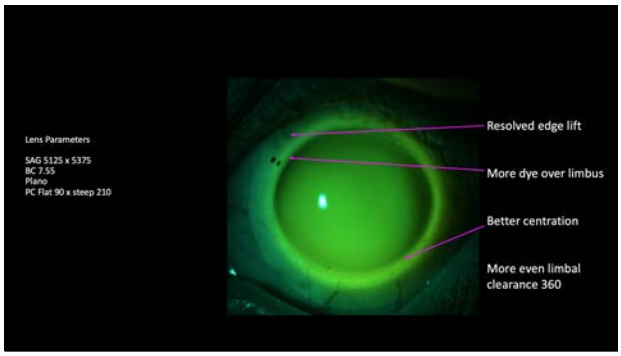

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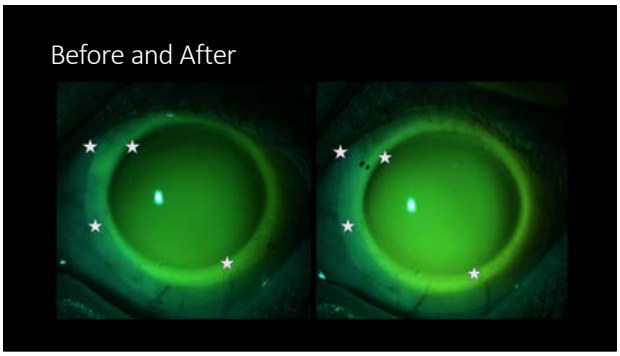

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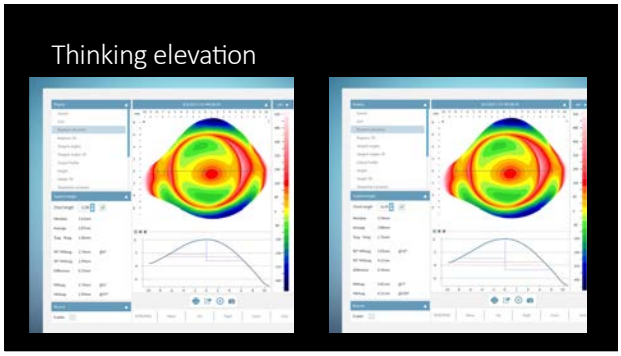

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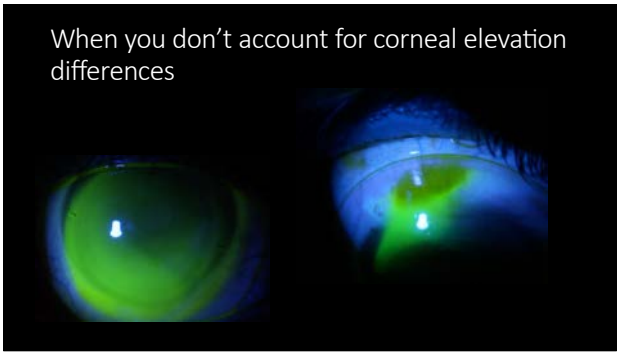

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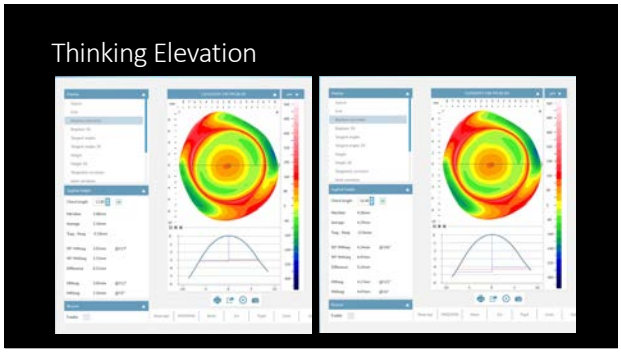

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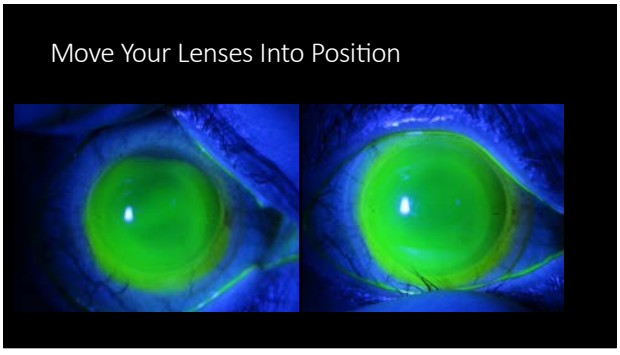
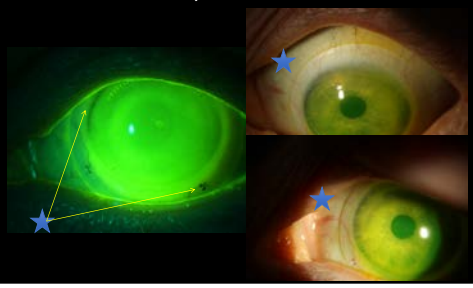


48

Evaluate in Primary Gaze



49

So to summarize

- Consider the shape of the cornea under your scleral lens
  - To land the lens properly, you should be putting toricity INSIDE the landing zone probably at least half your fits
  - When the cornea has high and low zones, don't assume you can fix things – you may be limited in what you can do
- Utililze elevation maps to know what to expect
- Recognize that the limbus is an area of shape change in many patients
- The scleral likes to be more against the rule and increasingly irregular

50

So to summarize…

- Scleral lenses are really 2 lenses in one, the vaulting chamber and the landing zone
- To get the best fit, we should try to make the vaulting chamber "end" as uniformly to the sclera as possible
- Think about the corneal zone as a separate area of fit than the scleral zone
- Evaluate in primary gaze, no looking up or down or to the sides (especially when you take an OCT!)
- Push the lens into the position you want it to sit, THEN evaluate the fitting relationship of lens to eye

51