Battling Astigmatism

Woo University
March 9, 2023

Tom Arnold, OD, FSLS

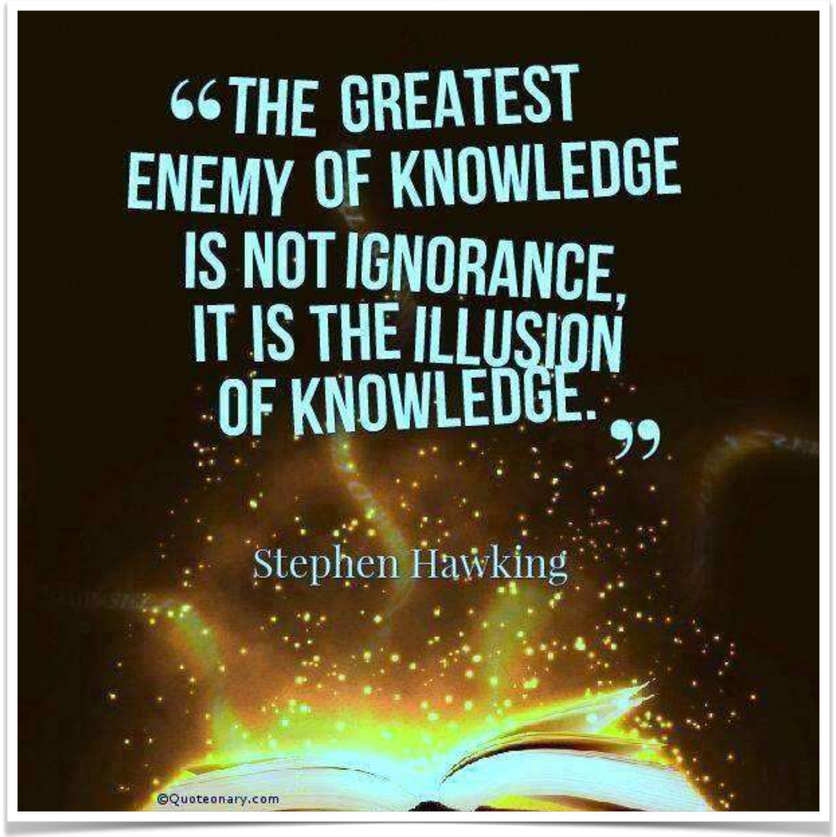
Off the coast of Antarctica

Disclosures

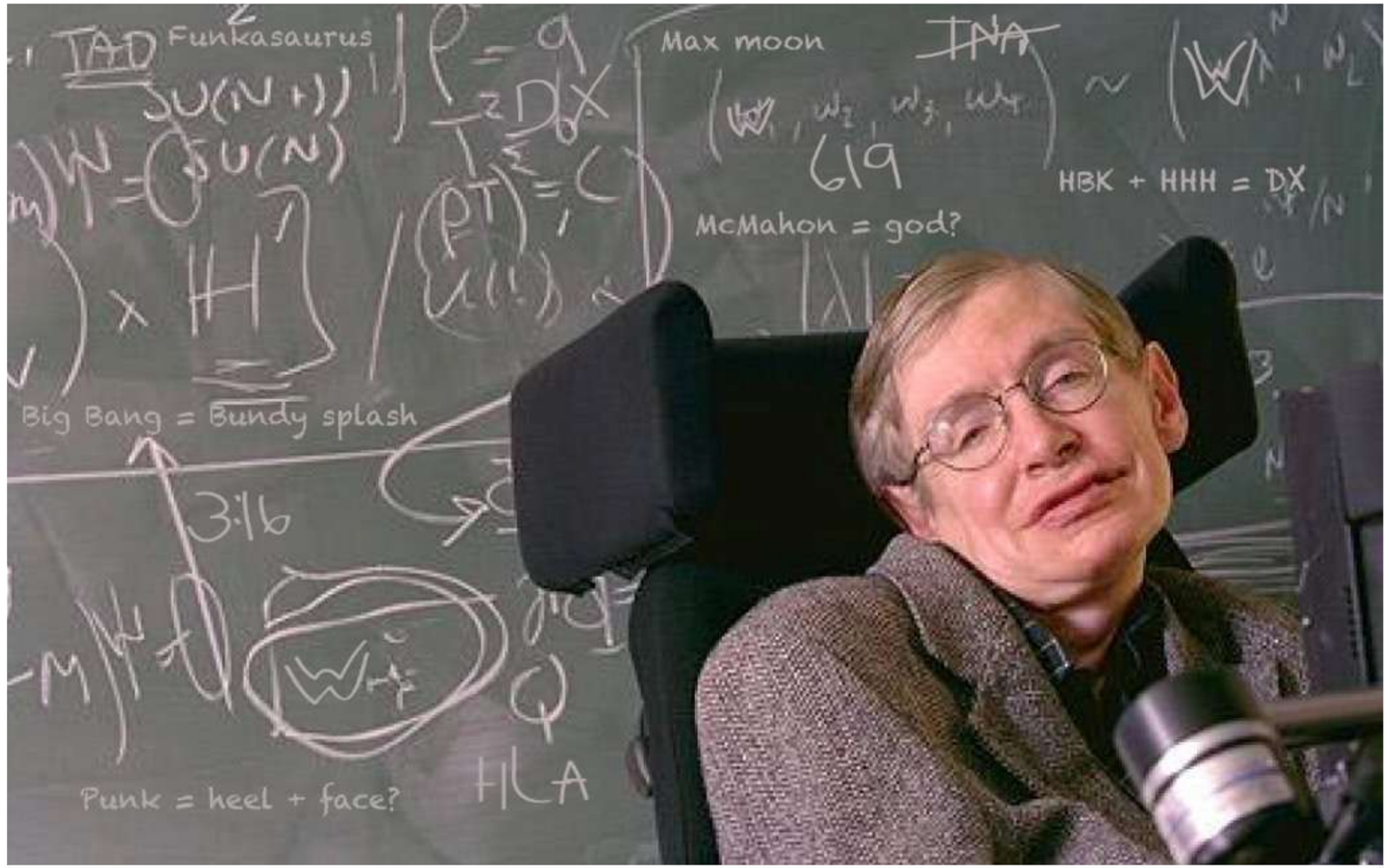
Eaglet-Eye
AEG Vision
GPLI Advisory Board
Co-chair ICSC Meeting
Raconteur

Torres del Paine, Patagonia

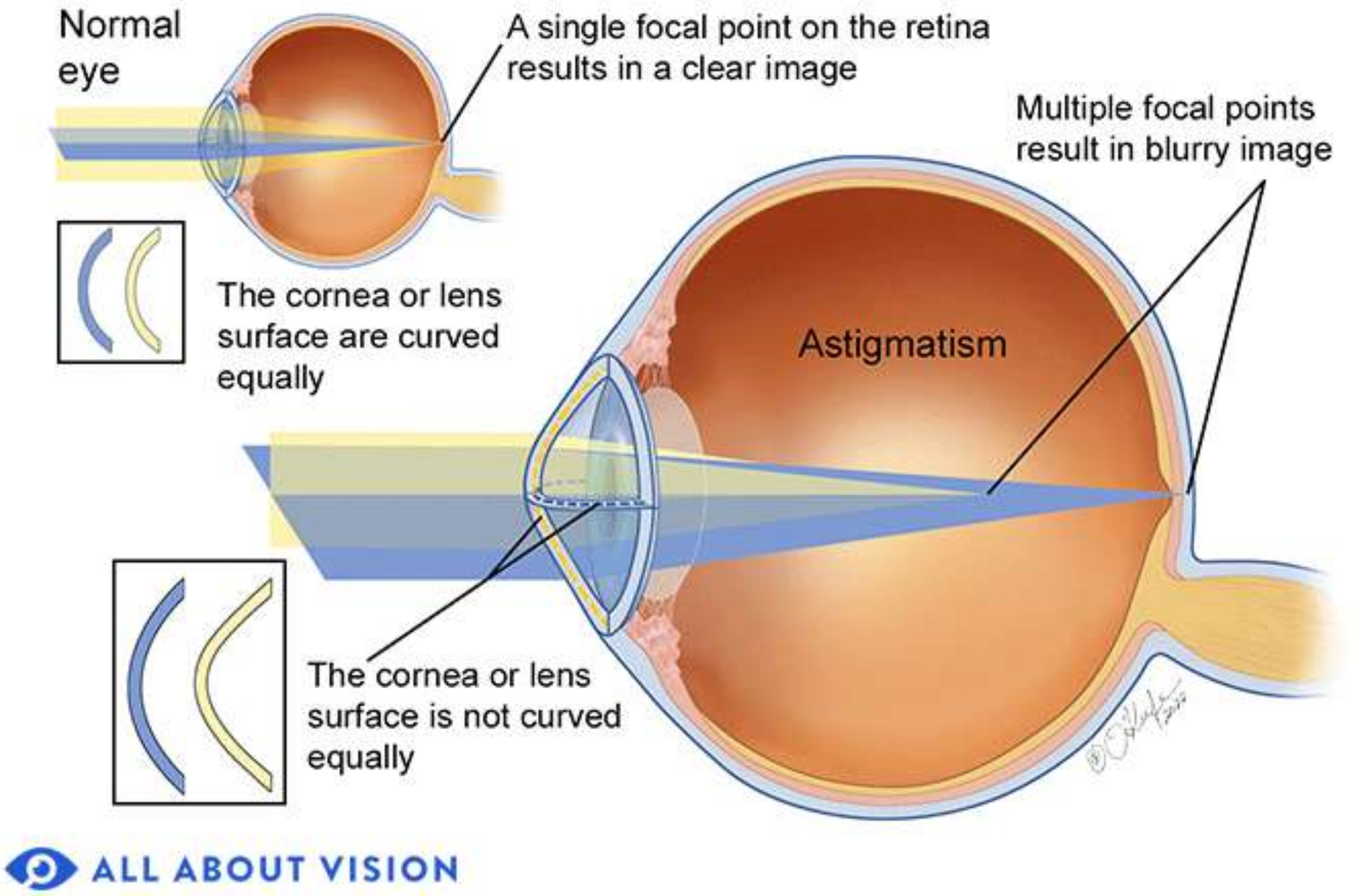

CHOOSE YOUR DEATH:
1. FIRING SQUAD
2. BATTLE AXE
3. ASTIGMATISM



Why are we here?



“There’s always something, always a little more, that we can do for our patients.”
-Donald Ezekiel
GlobalEyes podcast

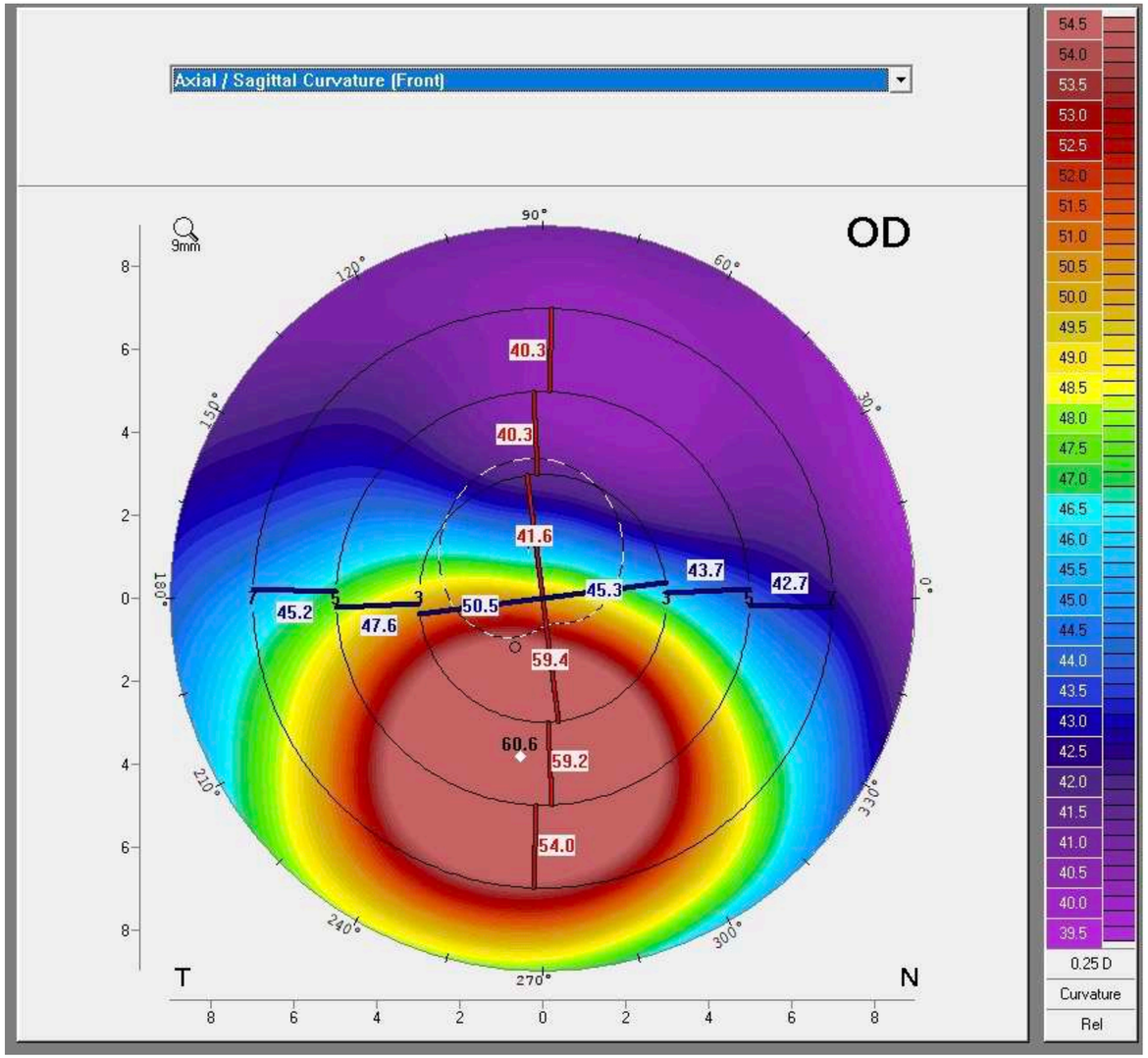


(Image used with permission from AllAboutVision.com)

www.allaboutvision.com

Astigmatism - “without a point”

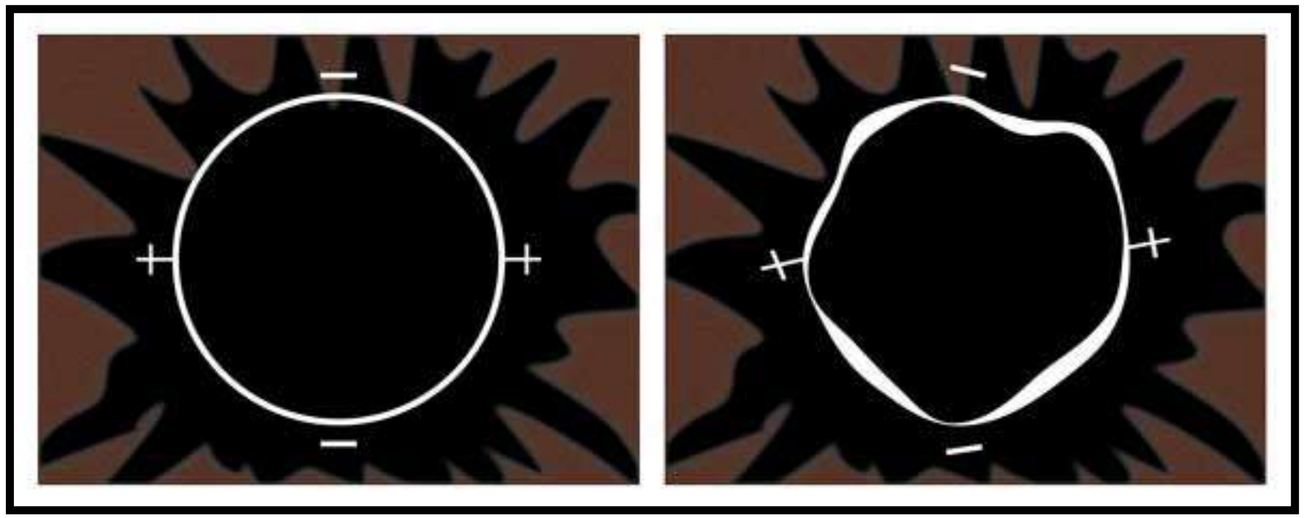
- Where is it?
    - Corneal (anterior- posterior)
    - Internal (lenticular)
    - Combined
- What is it?
    - Regular - myopic; hyperopic; mixed
    - Irregular
    - Asymmetrical



Astigmatism - “without a point”

- How do we diagnose it?

- Keratometry - limited to central cornea
- Retinoscopy - with/against motion
- “scissors reflex”
- Topography -
  - measures larger corneal surface
  - still limited to anterior cornea
  - axial/tangential/elevation maps



(Courtesy - Dr. Barry Leonard)

Every patient is unique.

“What would Picasso do?”

Corneal astigmatism = Refractive>> Corneal RGP

Corneal astigmatism ≠ Refractive >> Soft toric

Cornea essentially spherical w/Refractive astigmatism
> lenticular or posterior corneal toricity

Corneal vs. internal astigmatism

Example 1

Spectacle Rx: OD -2.00 -1.00x 090
OS -3.25 - 1.75 x 010

Keratometry: OD 43.50/44.87 x 085
OS 44.50/46.12 x 180

Assessment: Corneal astigmatism

RGP candidate

Example 2

Spectacle Rx: OD -3.25 -2.25 x 090
OS -2.50- 1.75 x 010

Keratometry: OD 45.12/ 45.50 x 085
OS 44.50/45.00 x 180

Assessment: Internal astigmatism

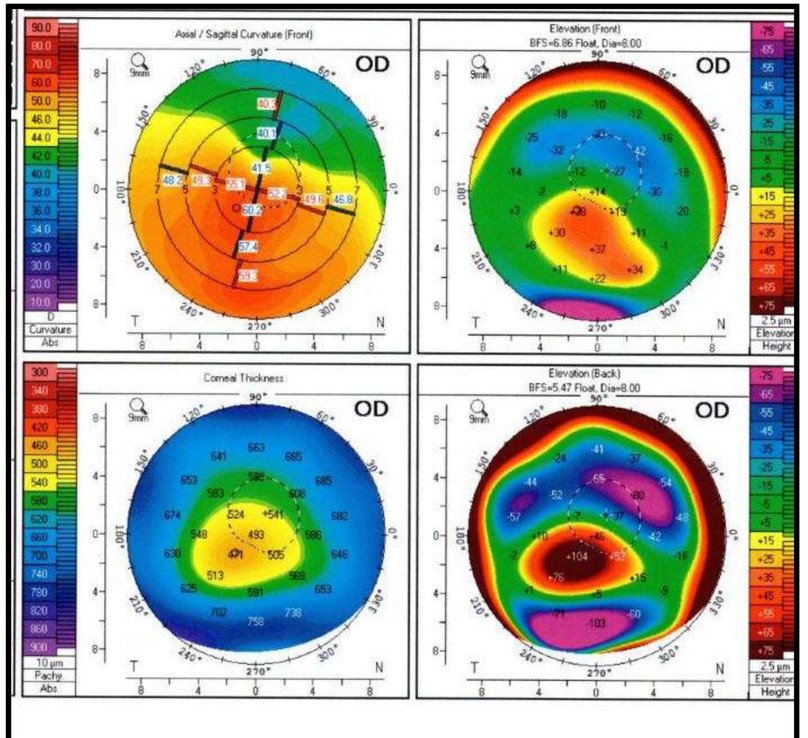
Soft toric candidate

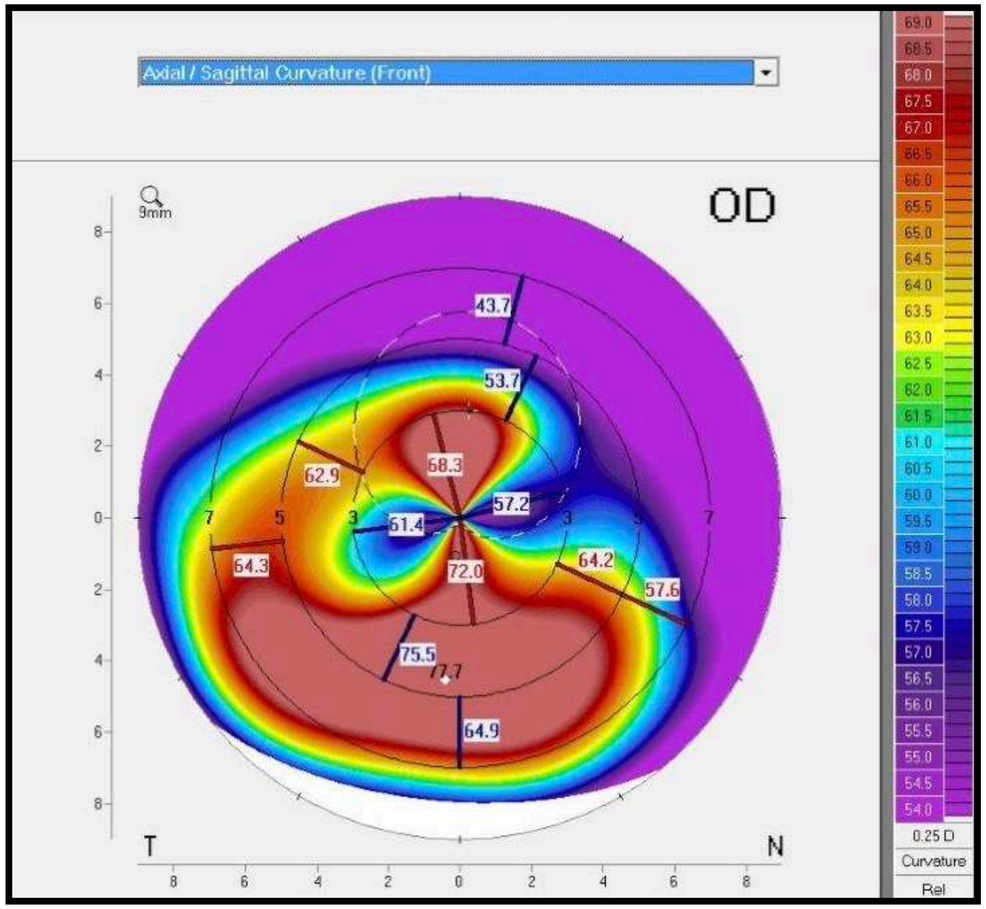
Example 3

Spectacle Rx: OD -1.25 -6.00 x 063
OS +0.75 -4.00 x 108

Keratometry: OD 49.5/53.8 x 084
OS 45.6/49.4 x 112

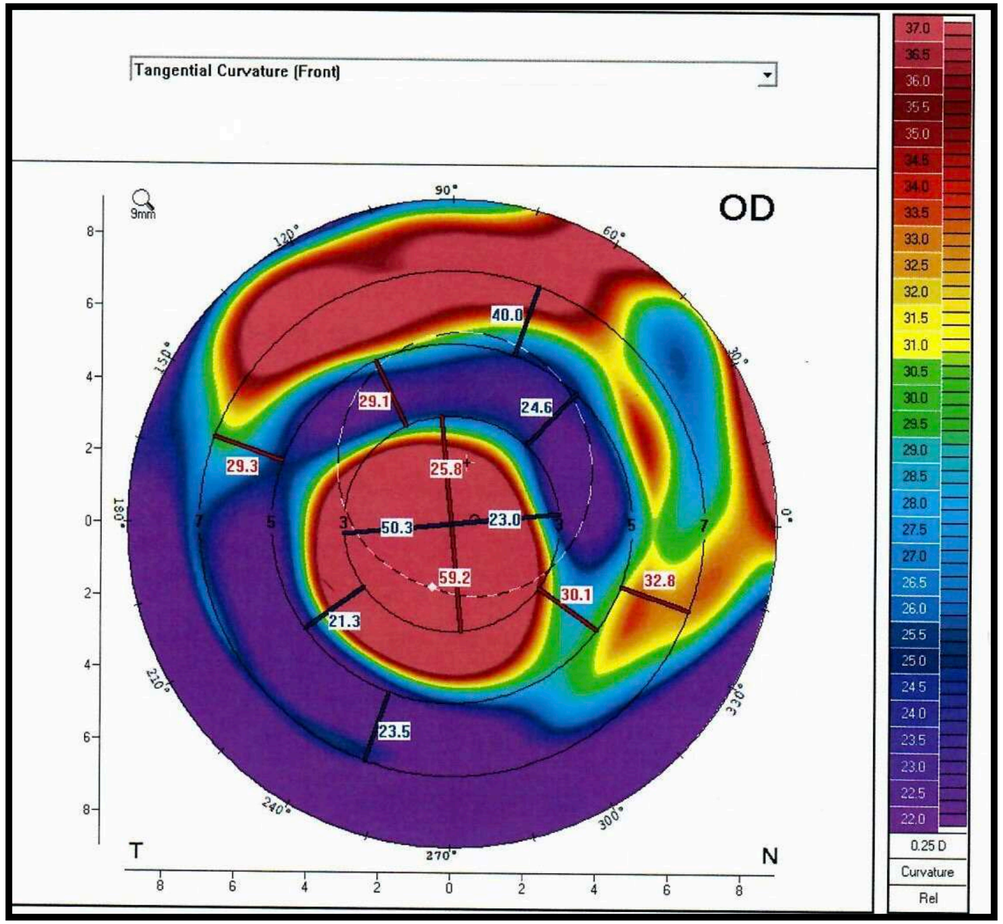
Assessment: “Crazy Town”

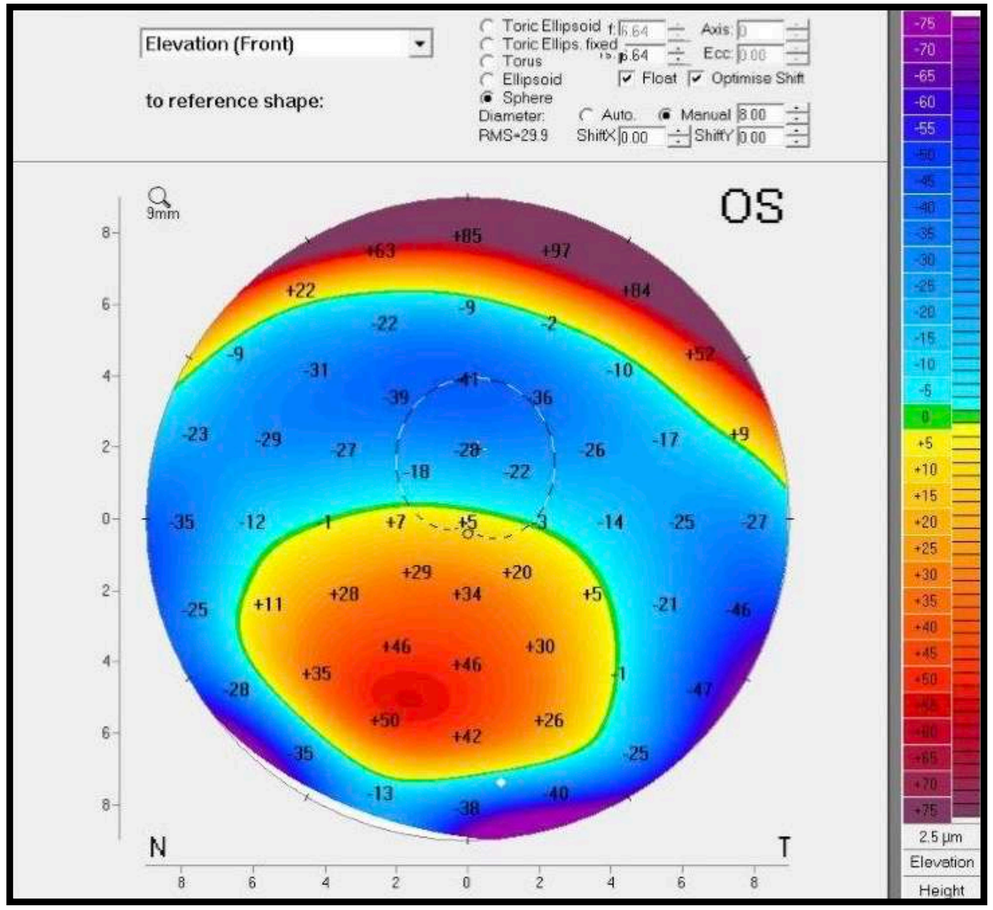




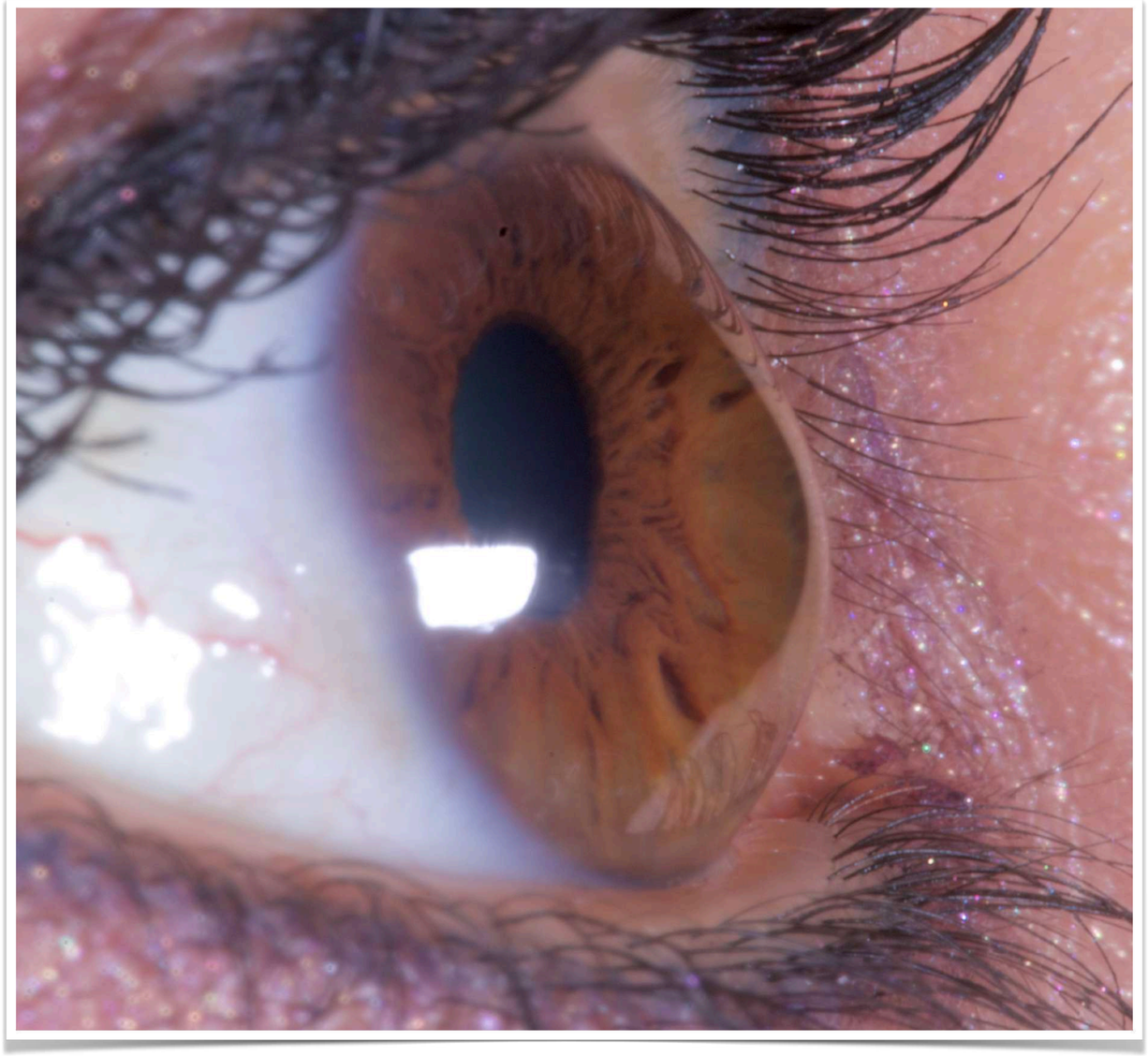
Axial map - single radius

Tangential map - multiple radii



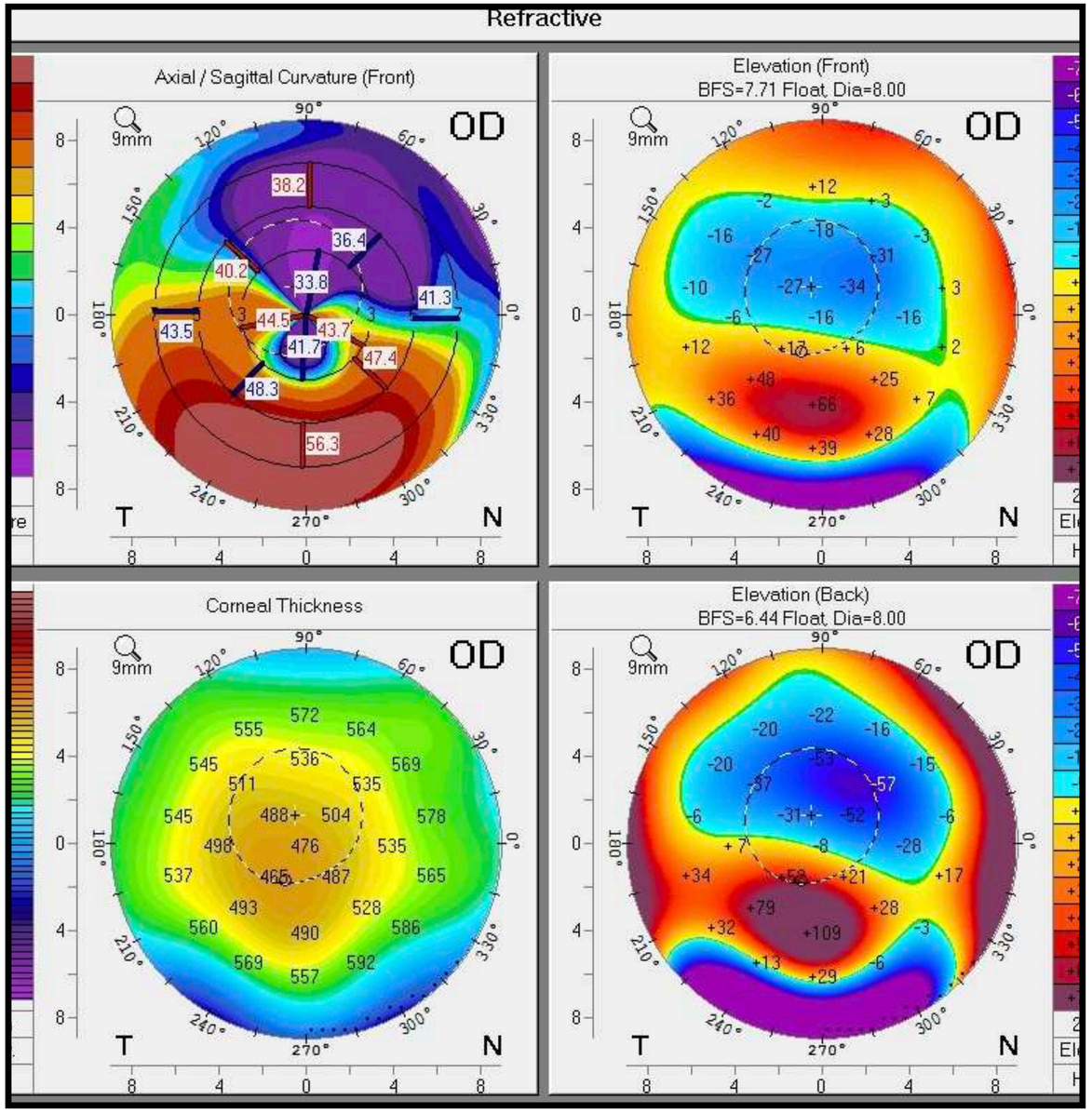


Elevation- map



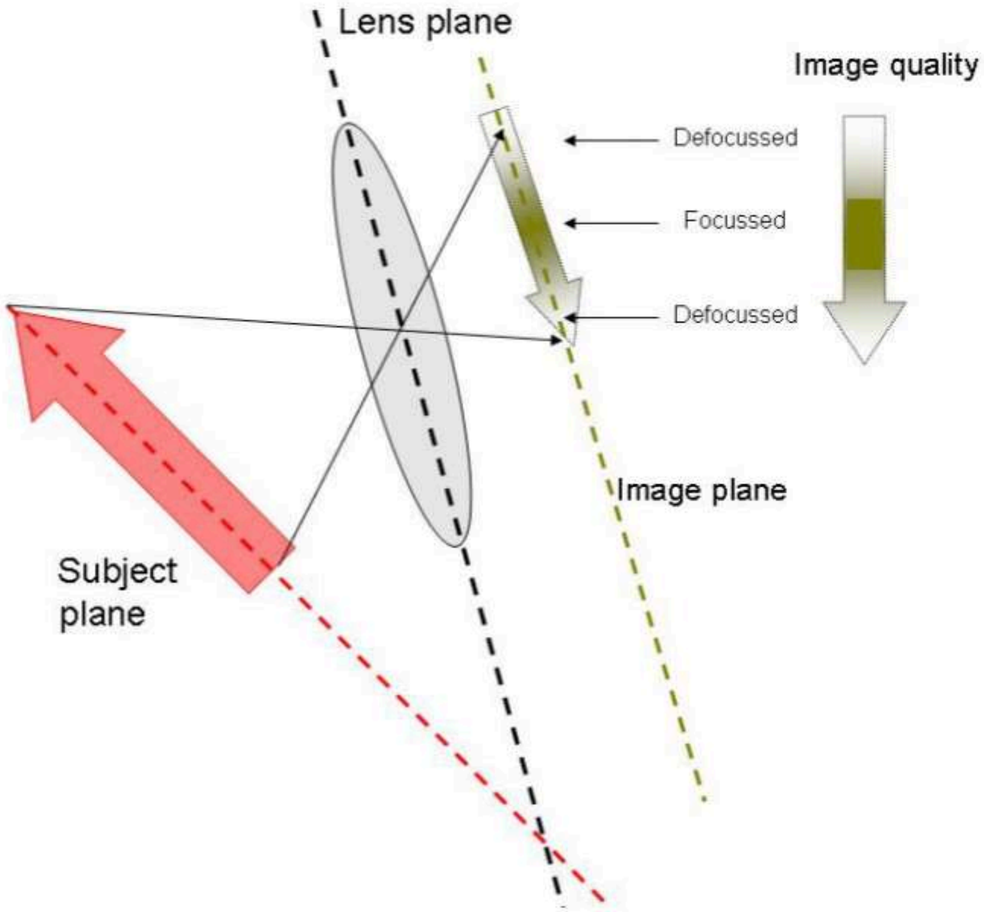
Tomography - Scheimpflug Imaging

Measures anterior AND posterior curvature

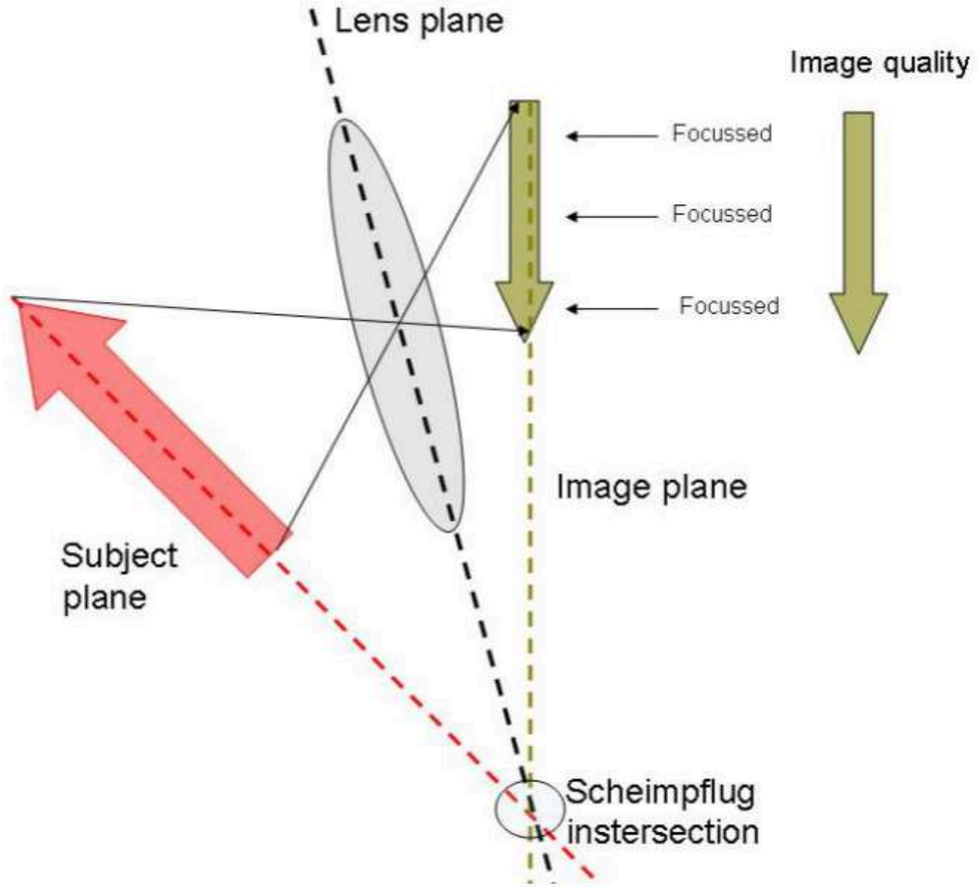


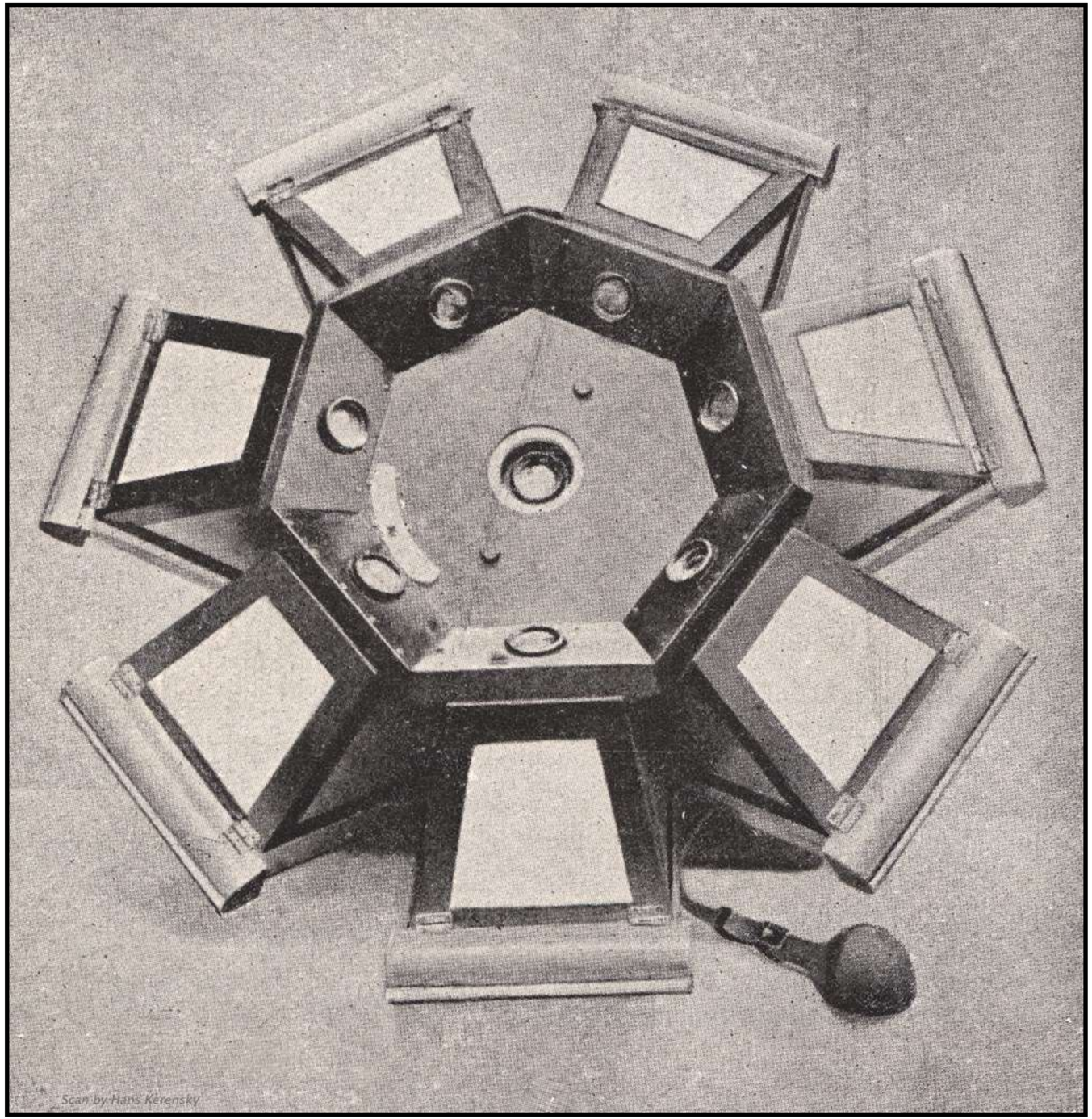
Scheimpflug intersection

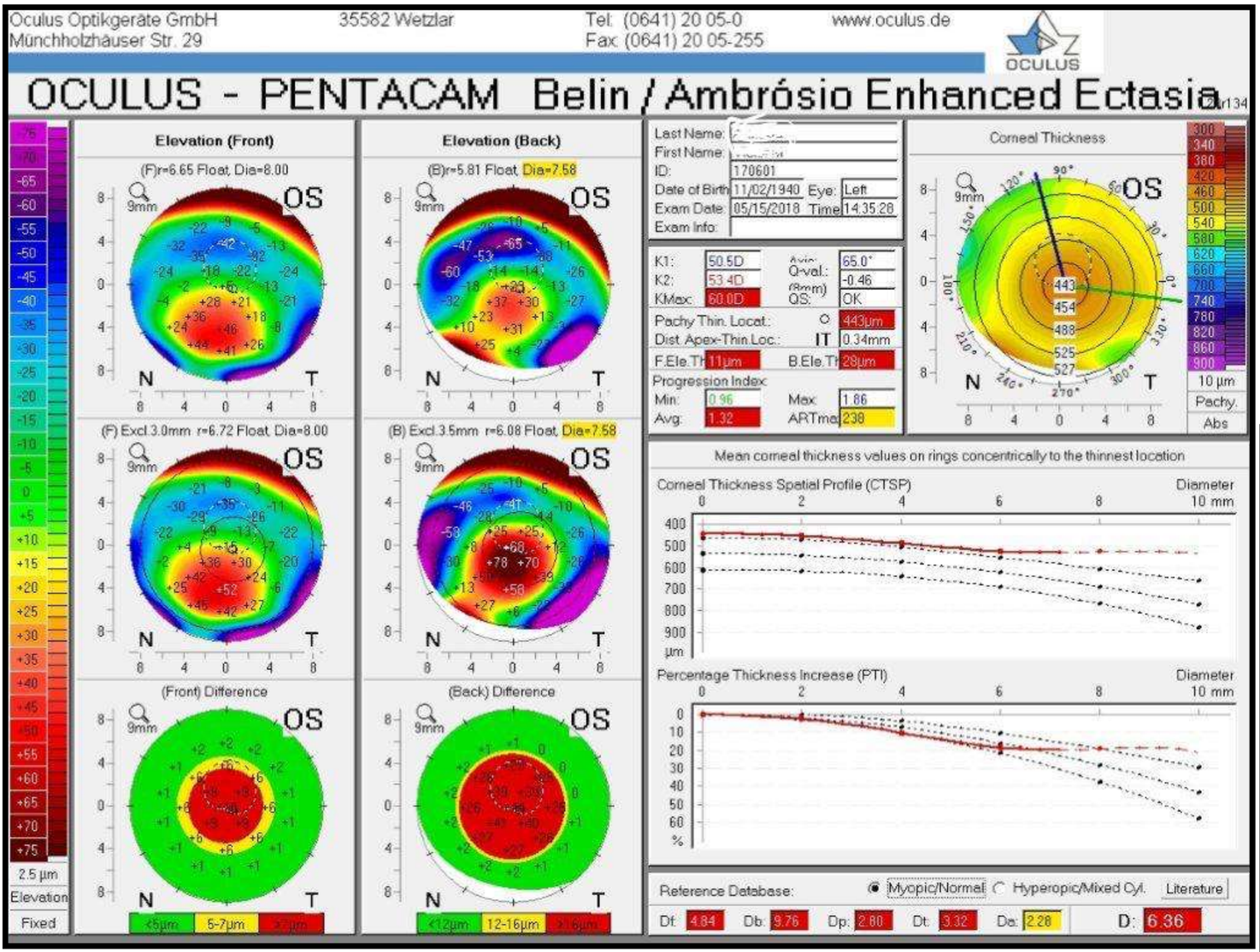
(b) Subject plane is not parallel to image plane, poor focus at periphery



(c) Subject plane is still not parallel to image plane , however image plane is manipulated according to Scheimpflug principle : sharp focus overall



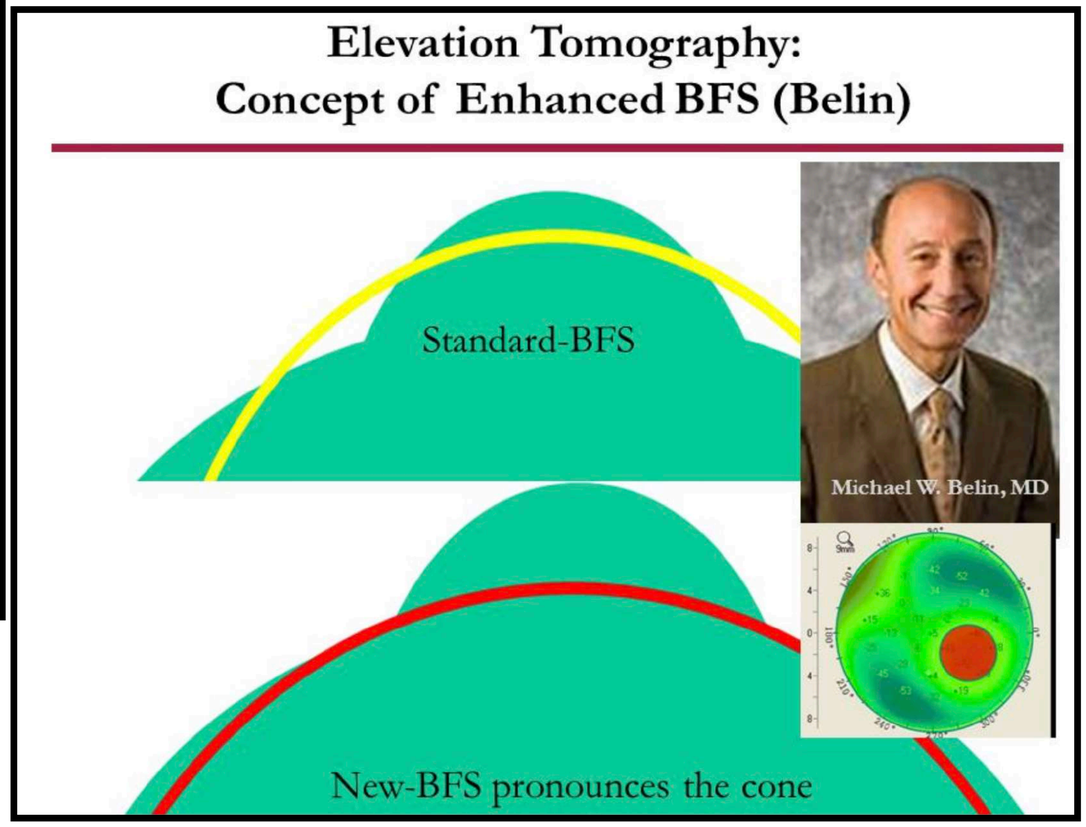

Scan by Hans Kerensky



Belin/ Ambrósio Enhanced Ectasia

Removes 3-4 mm of most ectatic region

Gives a true picture of the distortion

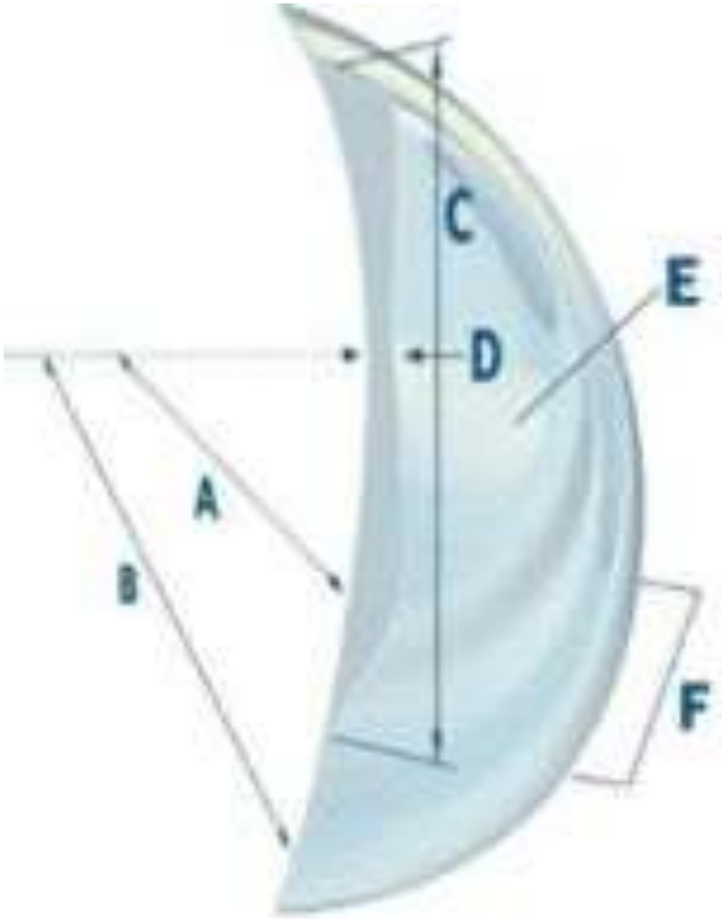


Soft Contact Lens Options

Custom Soft Lenses

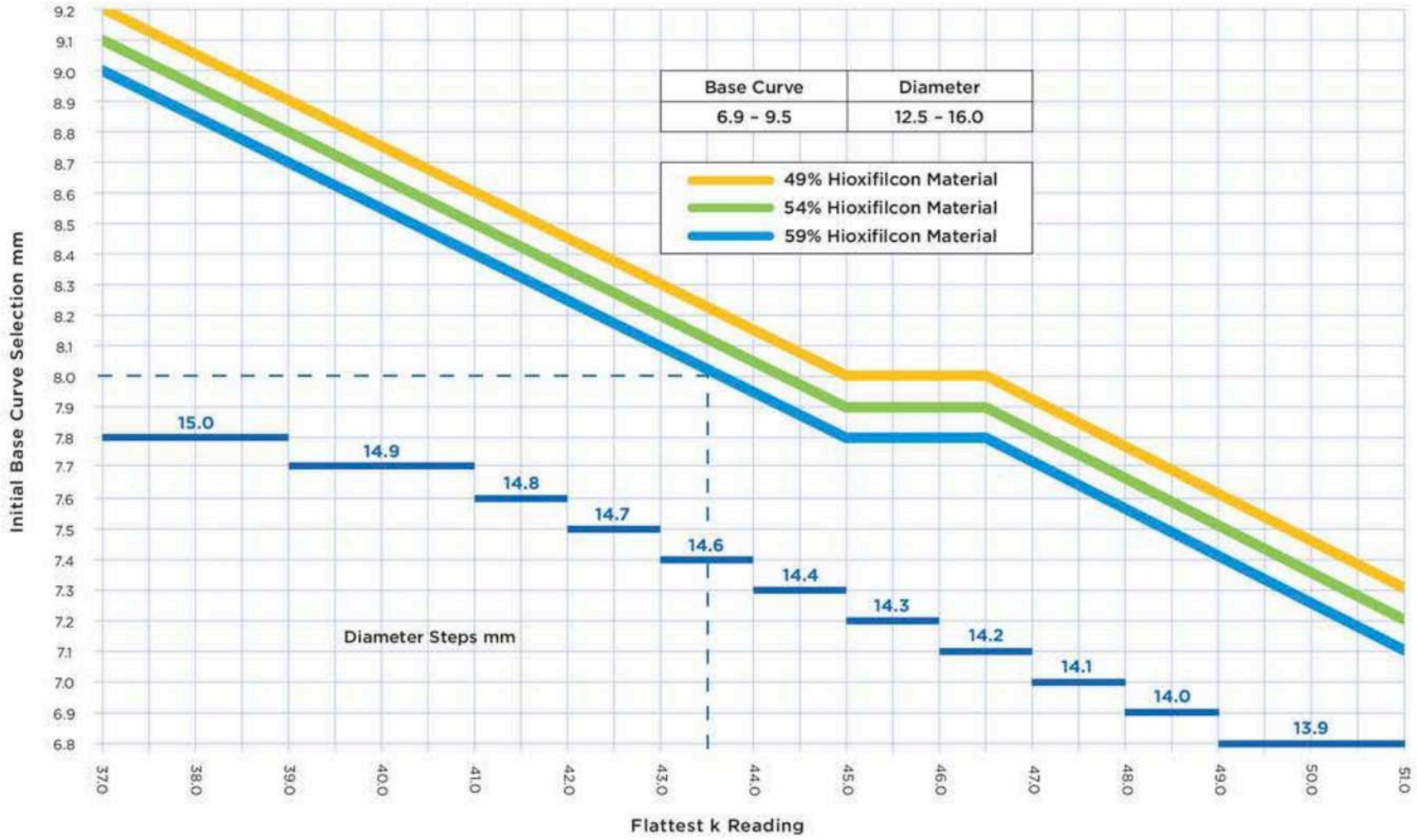
- Lenses designed for true custom fit and Rx
  - Wide range of diameters
  - Wide range of base curves (sag)
  - Extended power range of spheres/cylinders
  - Cylinder axis to 1 degree
  - Custom lens thickness and prism
  - Custom add powers and multifocal optic zones

Base Curve	6.9 to 9.5 mm	0.1 mm	increments
Diameter	12.5 to 16.0 mm	0.1 mm	increments
Sphere	+/- 25.00 Diopters	0.1 D	increments
Cylinder	-0.5 to -8.00 Diopters	0.1 D	increments
Axis	around the clock	1.0°	increments
Optic Zone	8.0 to 10.0 mm	0.5 mm	increments
Prism	1.0 to 4.0 PDBD	0.1 D	increments
Add Power	Up to 4.0 Diopters	0.1 D	increments



Prescribing Nomogram Guide

Iris Diameter 11.6 to 12.0

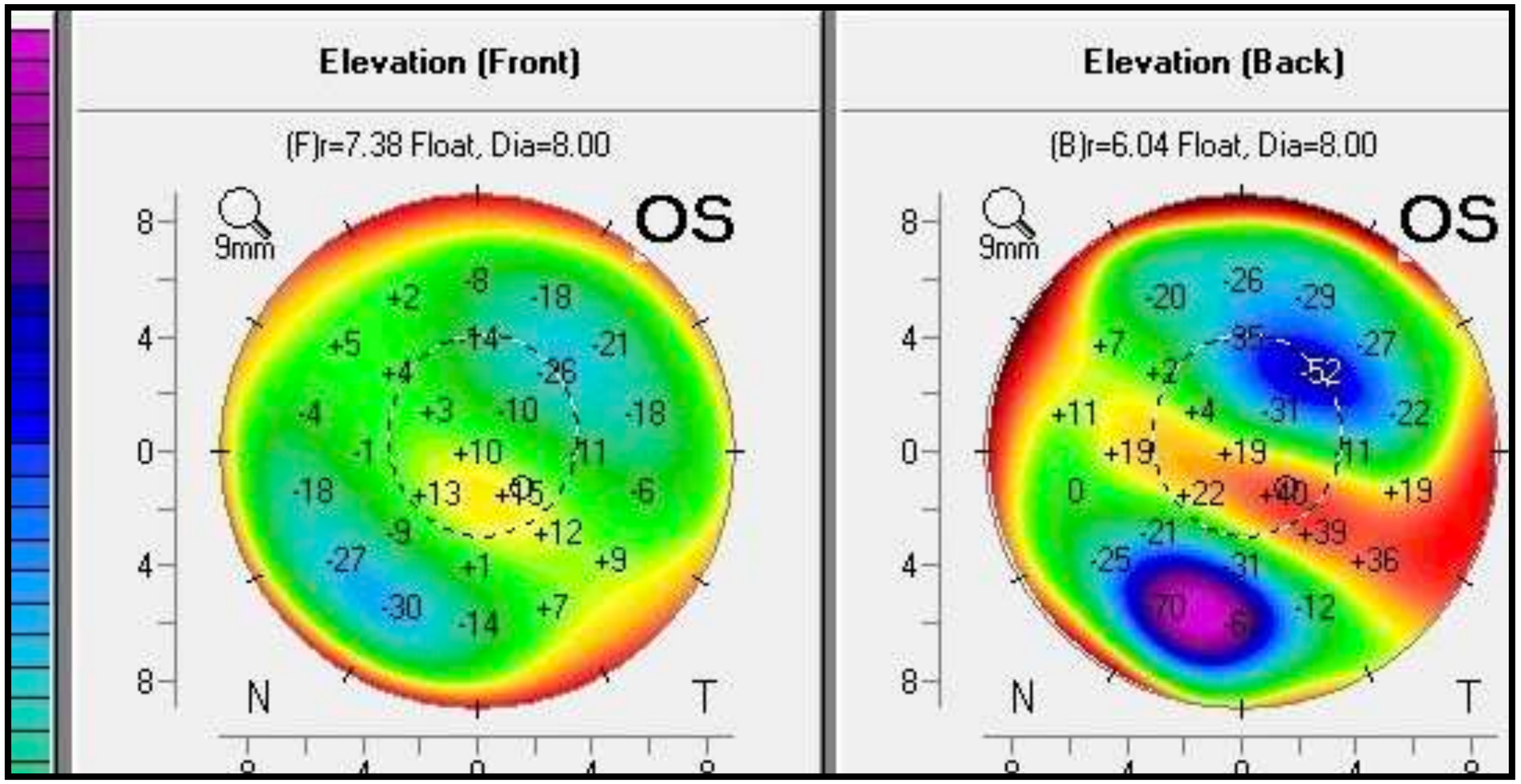


Early keratoconus - soft “kone” lenses

- Thicker - masks corneal ectasia
- Less oxygen available due to increased CT
- Available in very small increments

K's 46.00/49.80
Kmax - 54.8

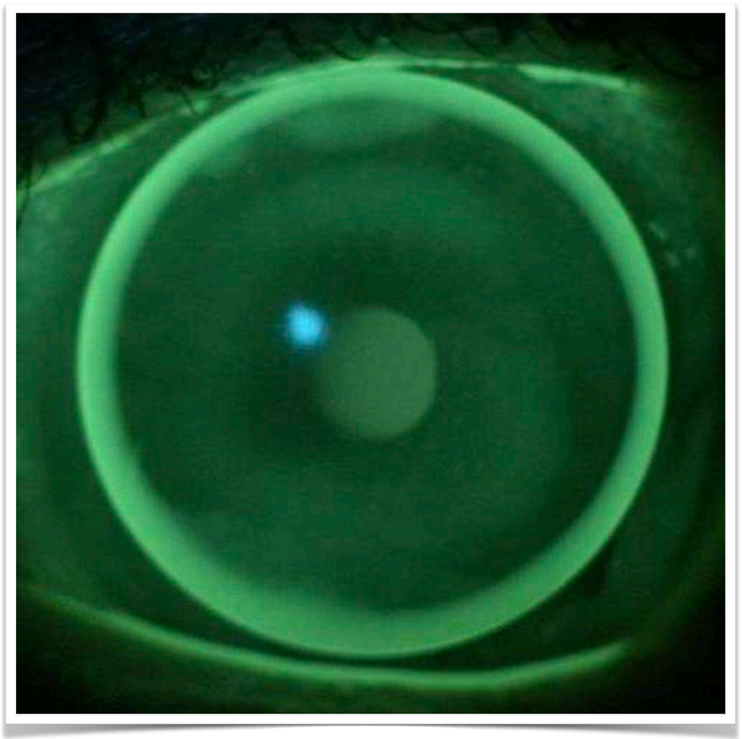
Rx -2.50 - 2.50 x 107



Custom "kone" lens - 7.80 BC/15.0 MM/-2.50 - 2.25 x 100

A moment in praise of corneal gas-perms

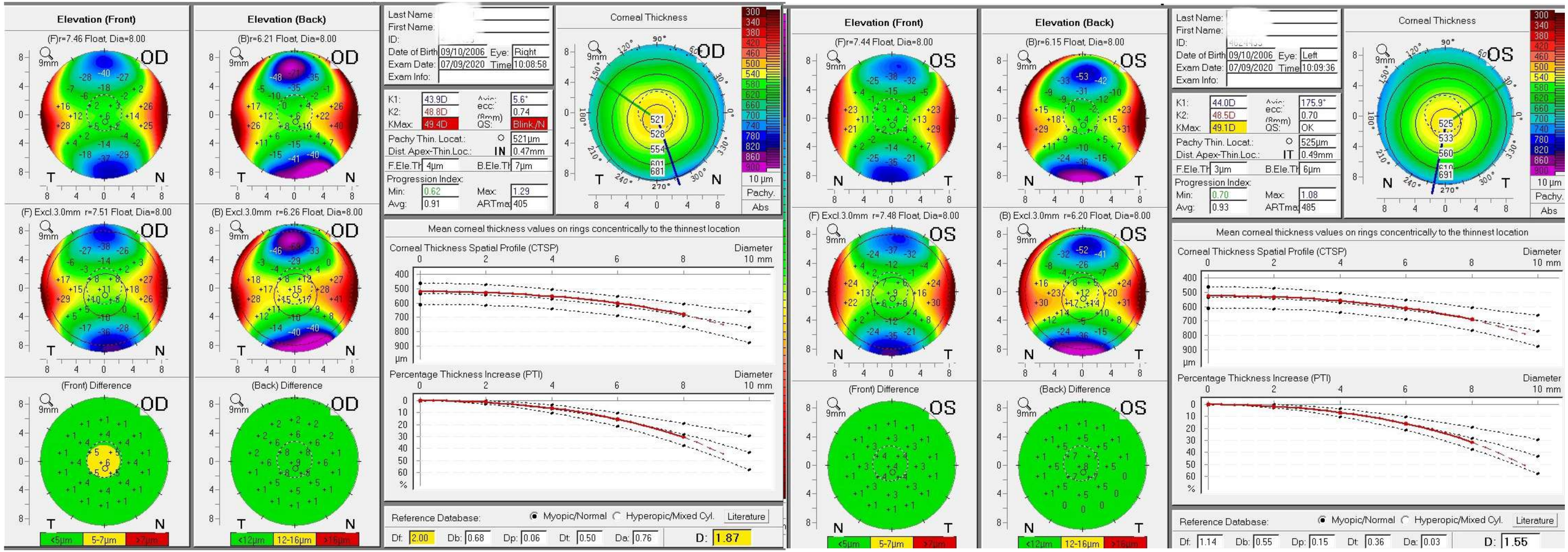
- Appropriate when corneal cylinder is approximately equal to refractive cylinder
- RGP's can correct high degrees of astigmatism
- Less expensive; easier to maintain; excellent visual acuity
- In cases where anterior corneal astigmatism is greater than 2.5 diopters, a bitoric design is often indicated
  (ref. Troy Miller - personal communication)



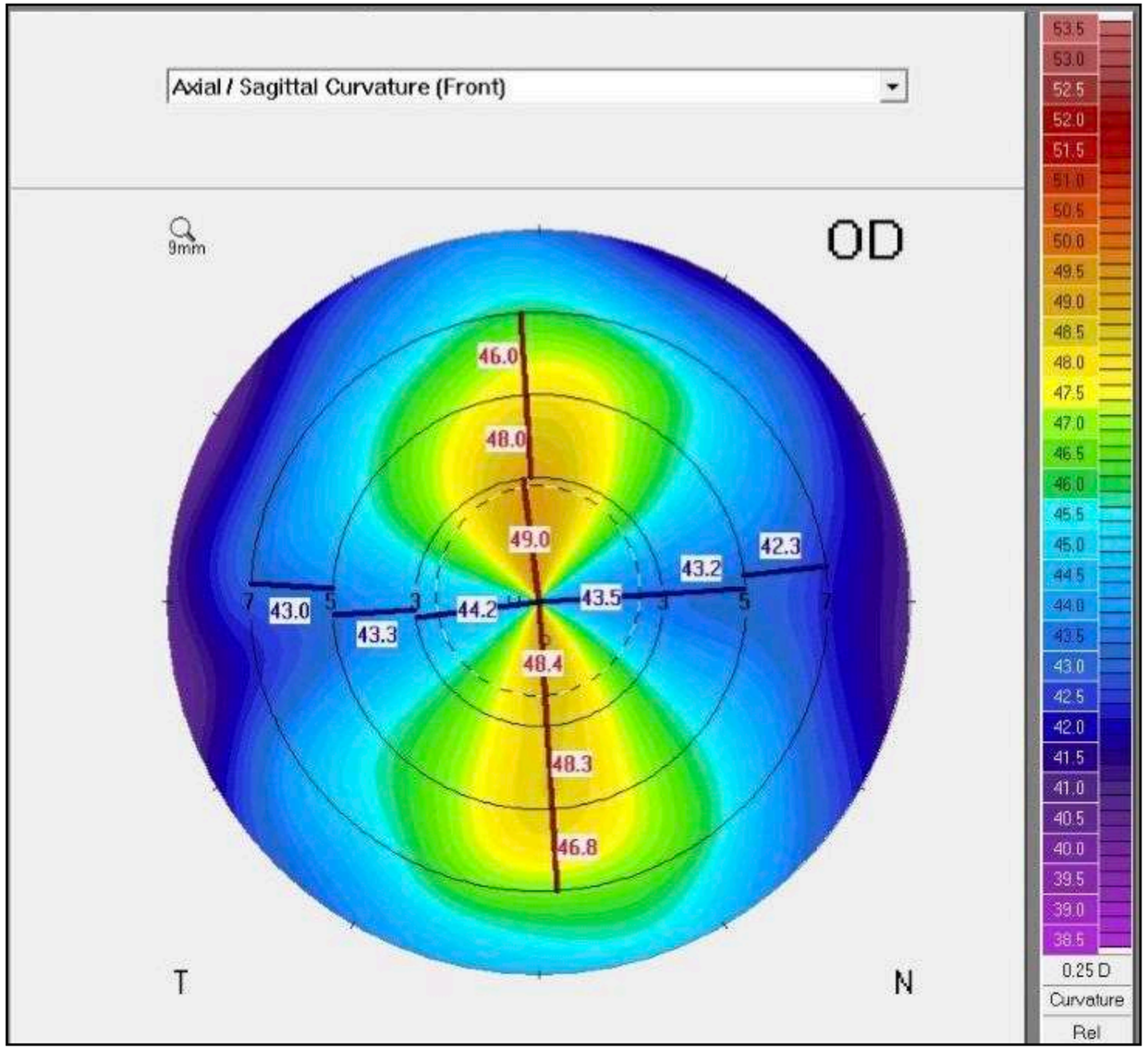
The “kone” that wasn’t

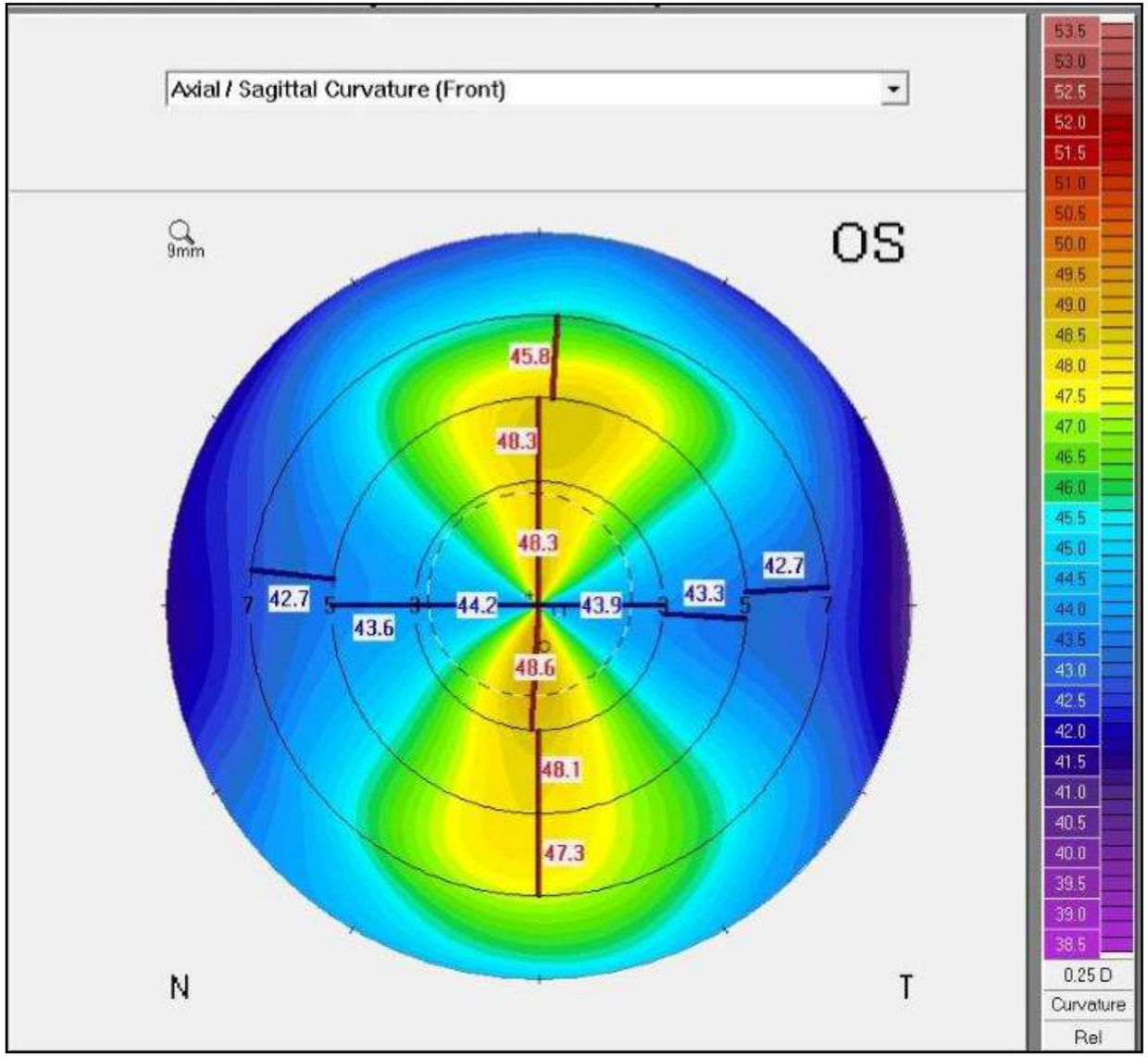
- Fifteen year-old African-American male referred for keratoconus workup and scleral lens fitting
- Manifest Rx: OD -15.50 -5.50 x 180 20/70
  OS -8.75 - 5.25 X 005 20/25-
- K’s: OD 43.9/48.8 Kmax 49.4
  OS 44.0/48.5 Kmax 49.1

Belin/Ambrósio results:



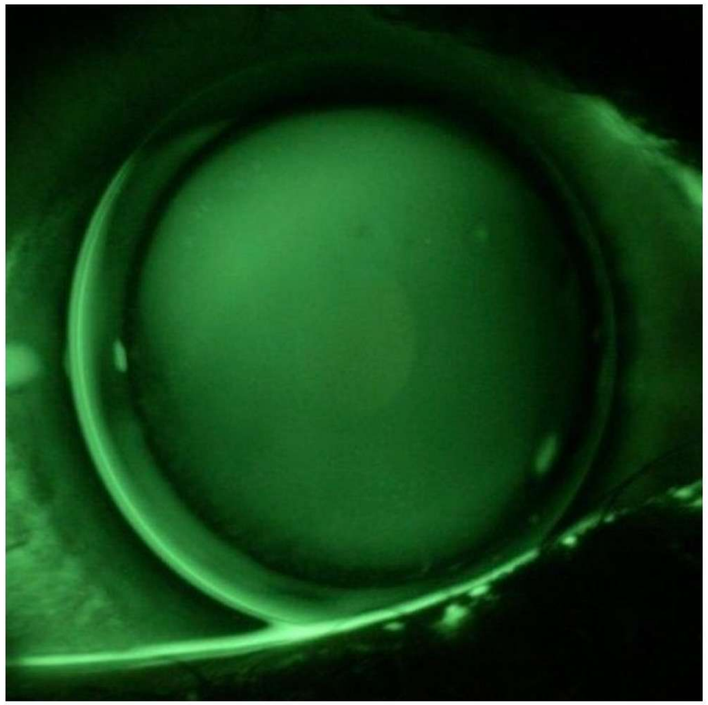
Keratometry:

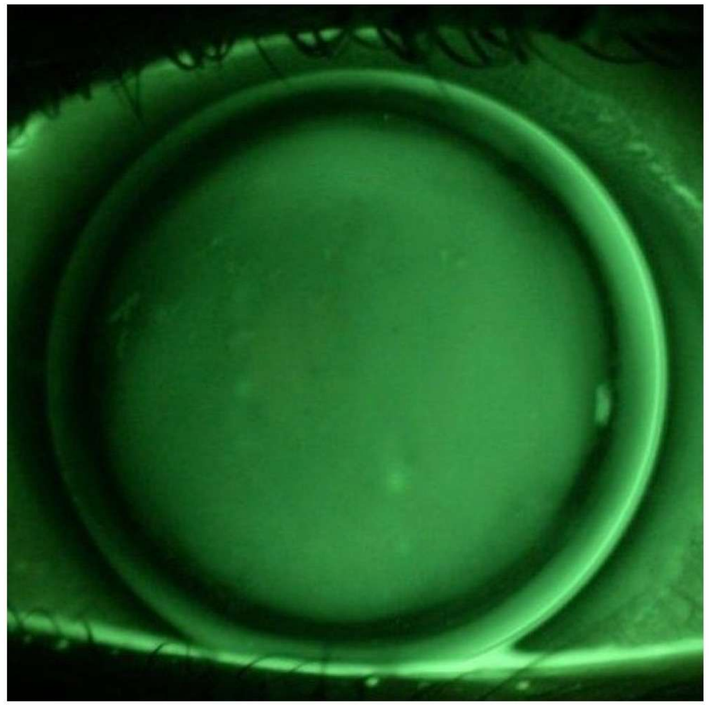


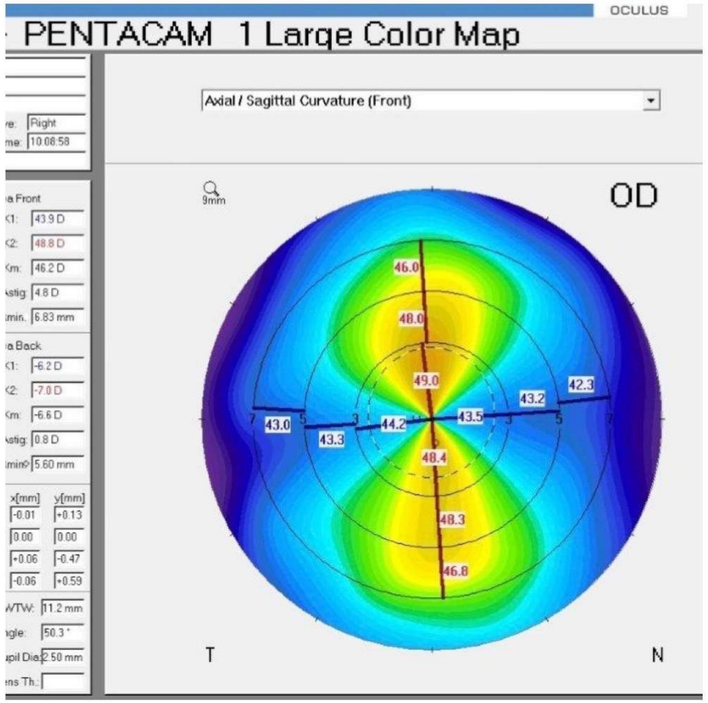


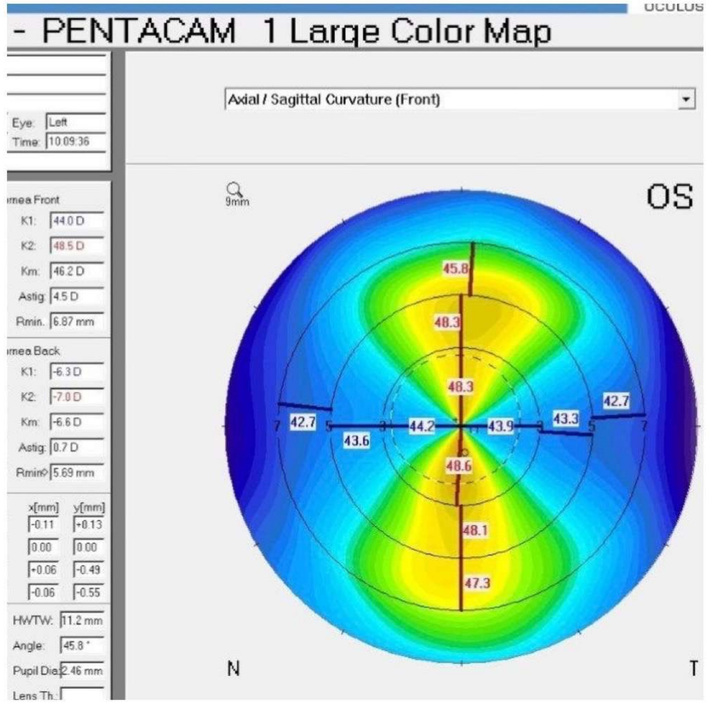
Q: What would Picasso do?

A: A bitoric RGP, of course!





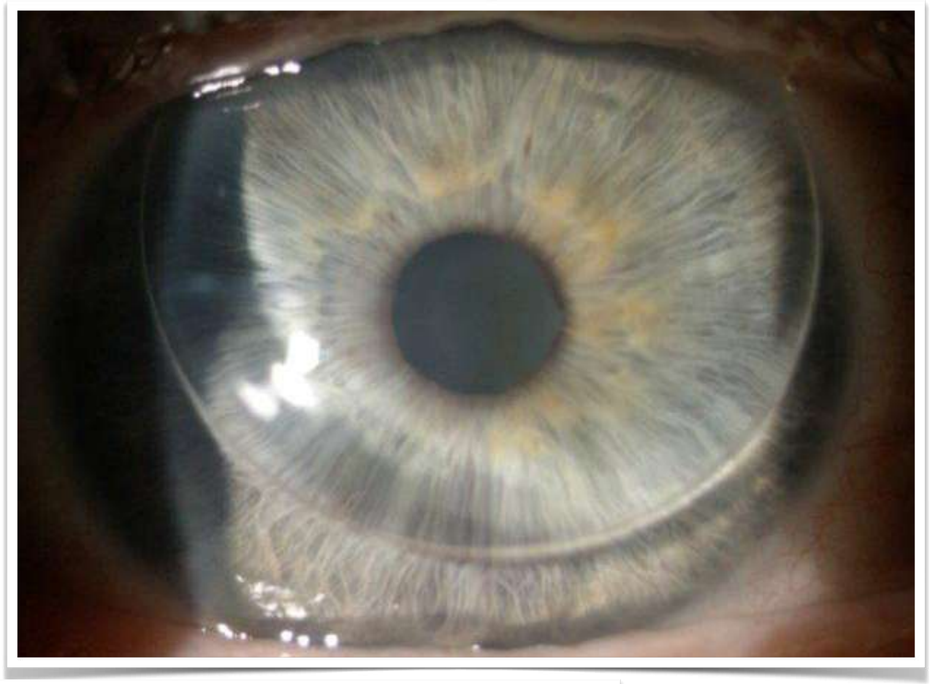


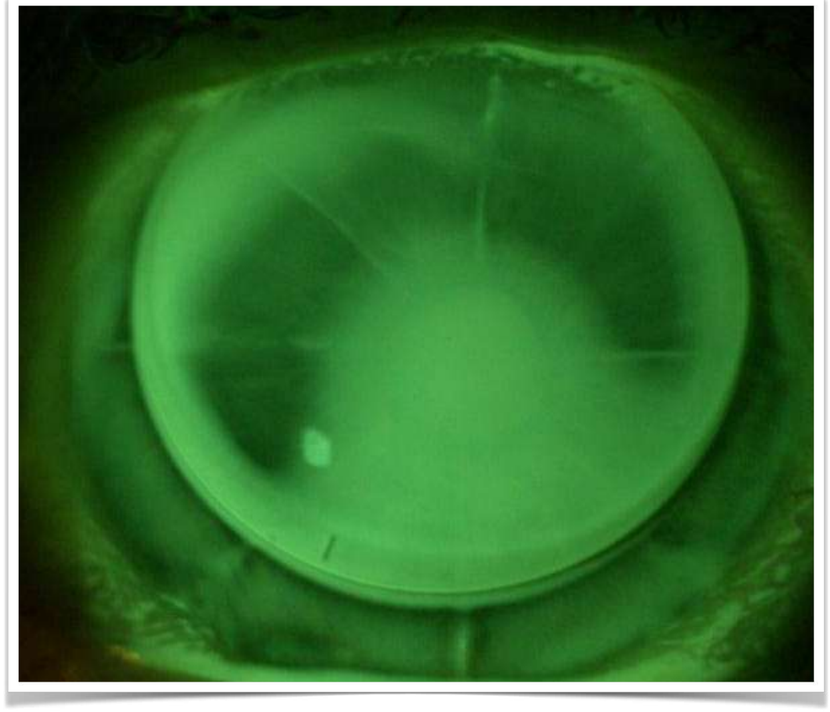


OD: 7.67/7.03 BC/9.50 OAD/-9.87/-14.87

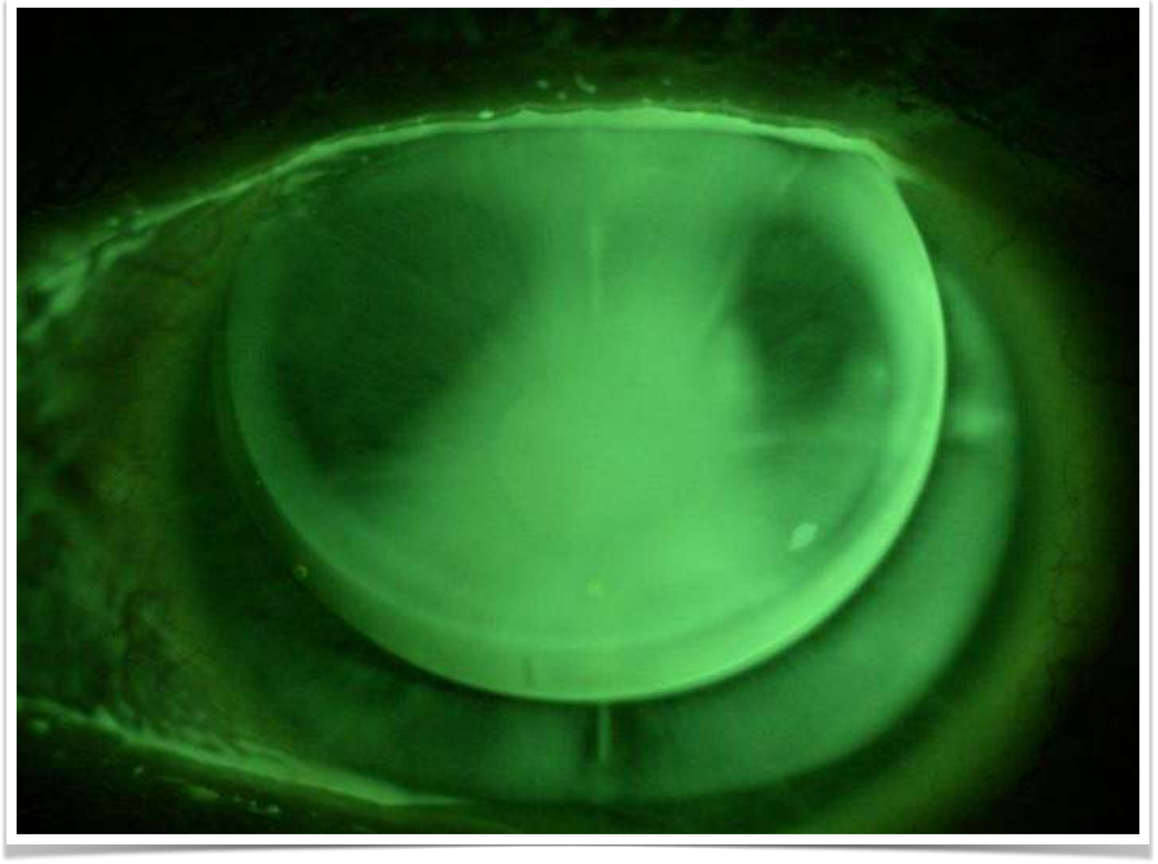
OS: 7.67/7.03 BC/9.50 OAD/-8.12/-11.12

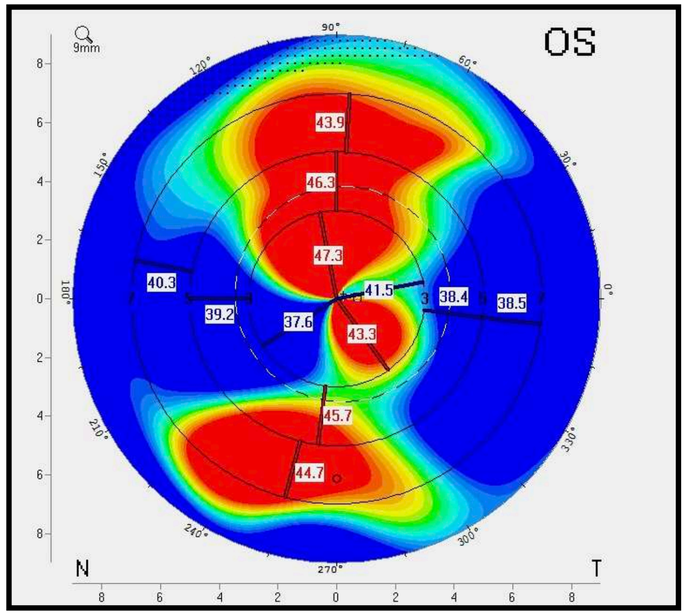
BVA OD 20/25; OS 20/25; OU 20/25+





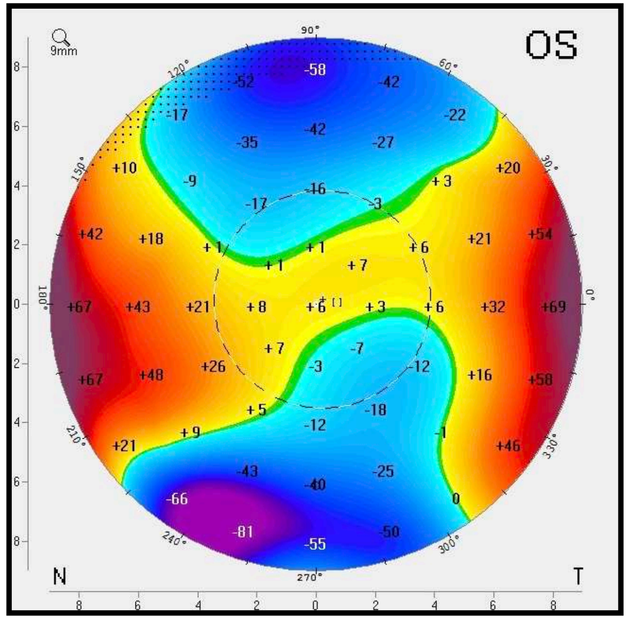
RGP over post-RK



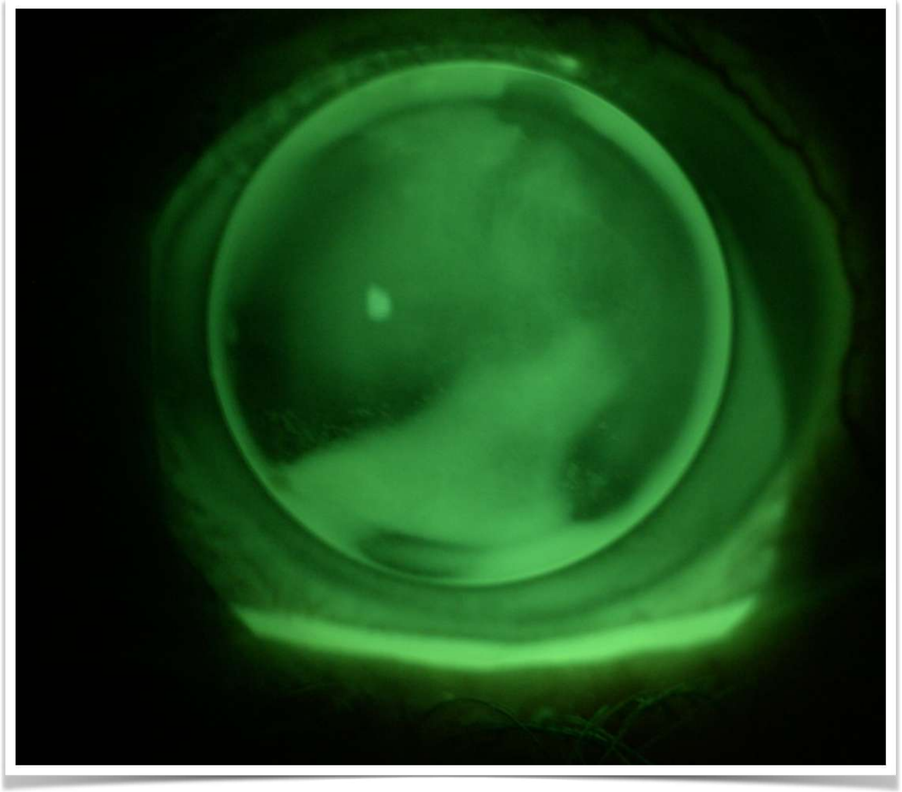


Yet, another case.....

K's - 39.00/44.25



Elevation

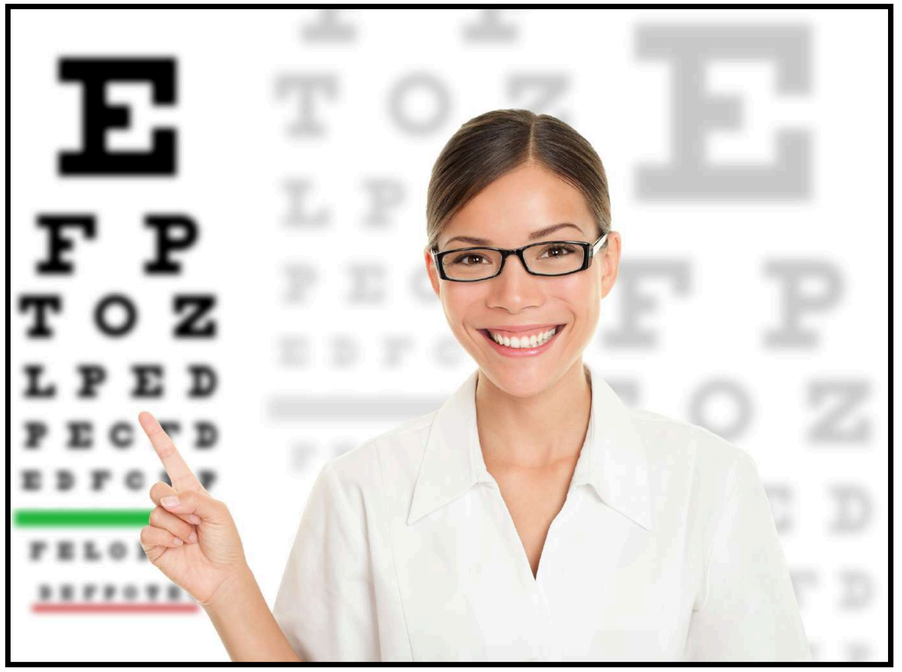


8.26/7.58 BC/ 9.50 OAD
-0.12/-3.75

"See how the vegetation has been trampled flat here, Jimmy? That tells me where a deer bedded down for the night. After a while, you'll develop an eye for these things yourself."

Advantages of RGP's

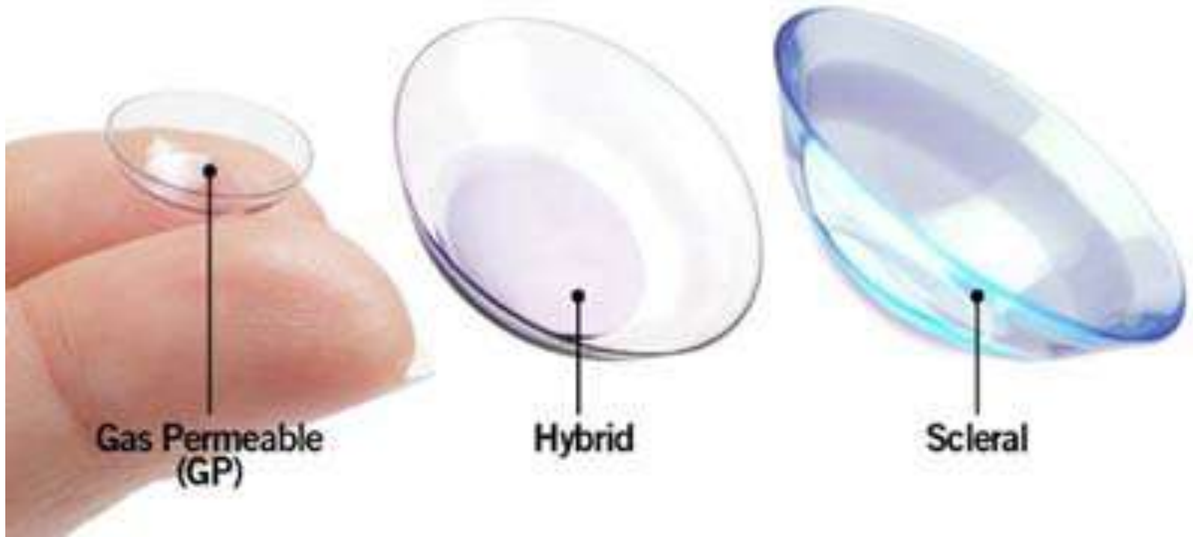
- Topography makes empirical fitting possible - high success rate
- Many practitioners prefer corneal lenses for penetrating keratoplasty
- Patients may resist adaption period
  - Prescribe "boldly"
  - The power of the pen
  - The Four R's (Dr. Gary Gerber): Repeat; Review; Recommend; Recall



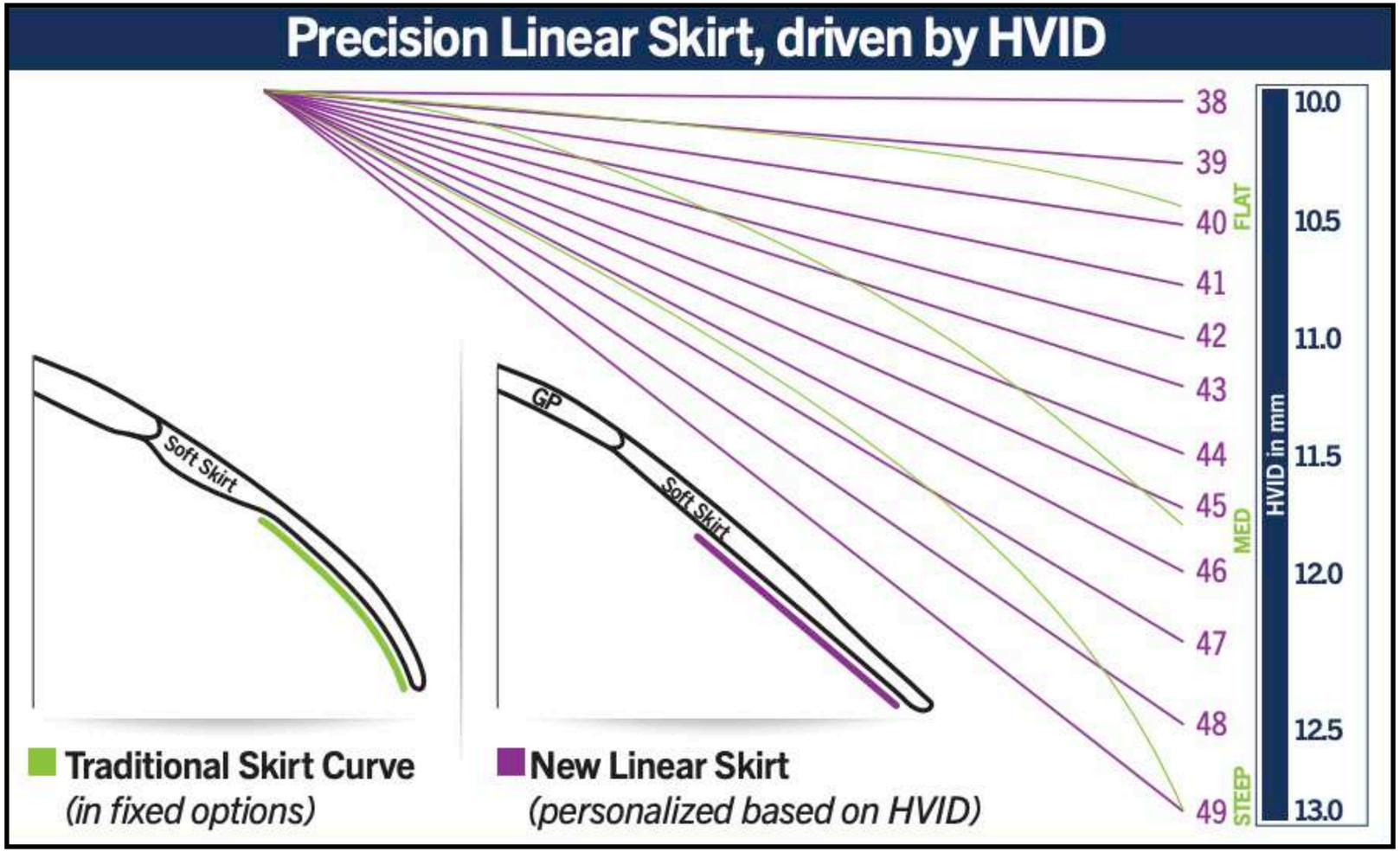
The road to Middle Earth

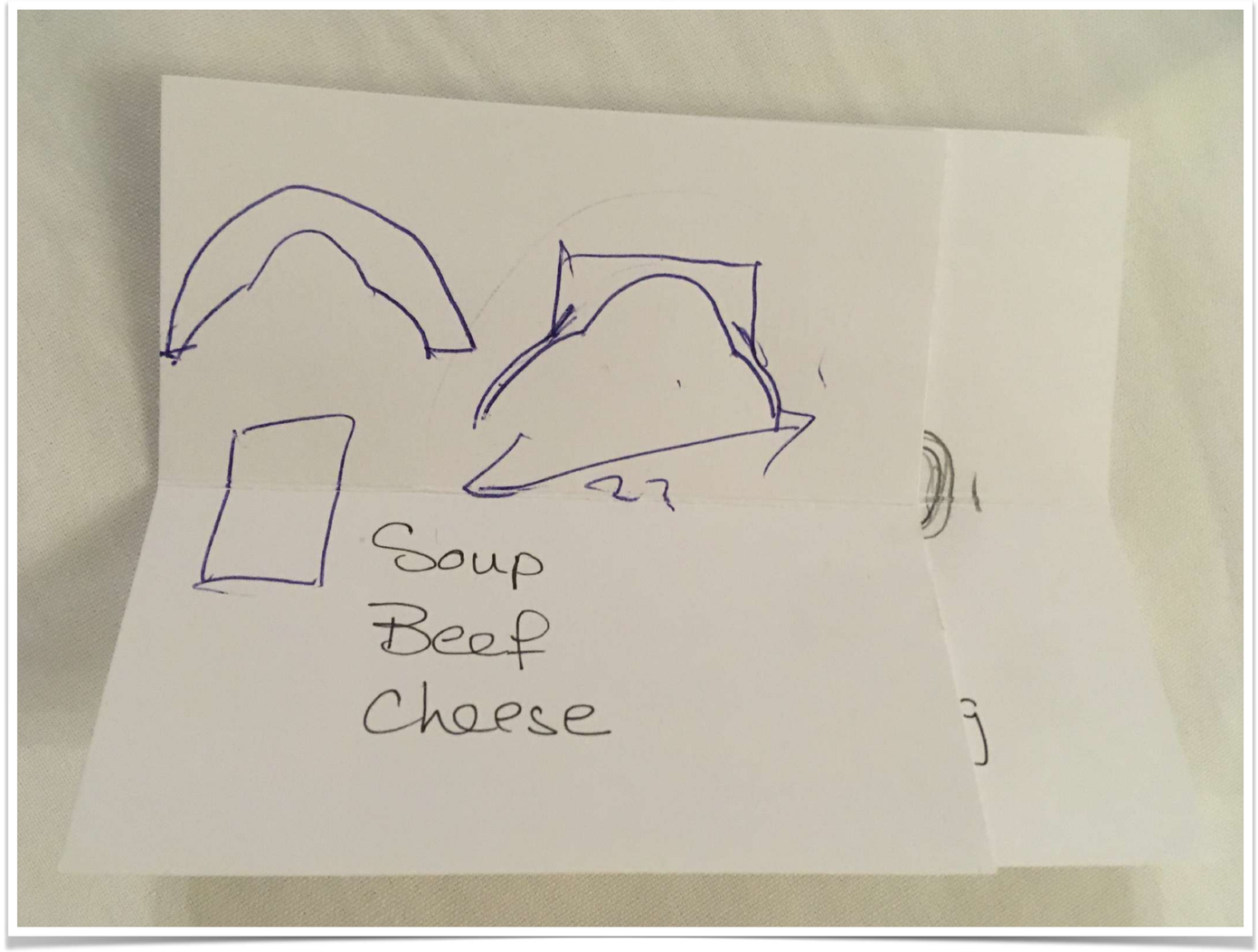
Apologies to J. R. R. Tolkien

- New designs include high Dk materials - both RGP and skirts
- Covalent bonding of skirt to RGP reduces separation & tearing
- Excellent for cases where RGP centration is a challenge
- Good choice for occupational or recreational environments where wind, dust, debris, or strenuous physical activity are factors



- Current skirt designs are linear rather than curved
- HVID is used as metric in skirt design
- This straight design more closely matches the tangent angles of the sclera
- The result is better centration and comfort





Ken’s choices

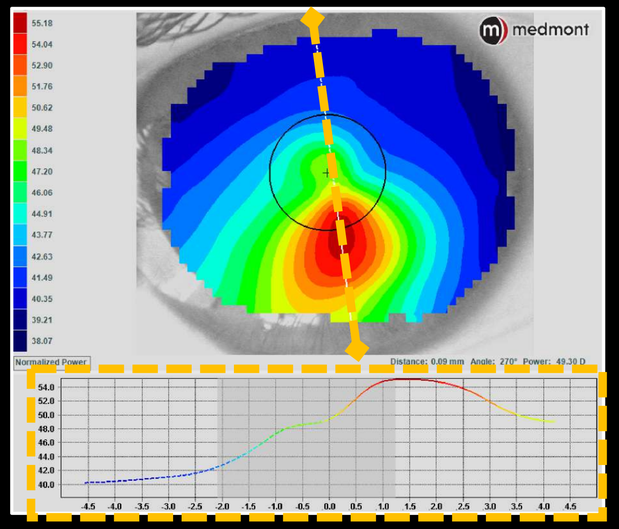
Always thinking about sclerals

When to pick a scleral lens vs. corneal RGP?

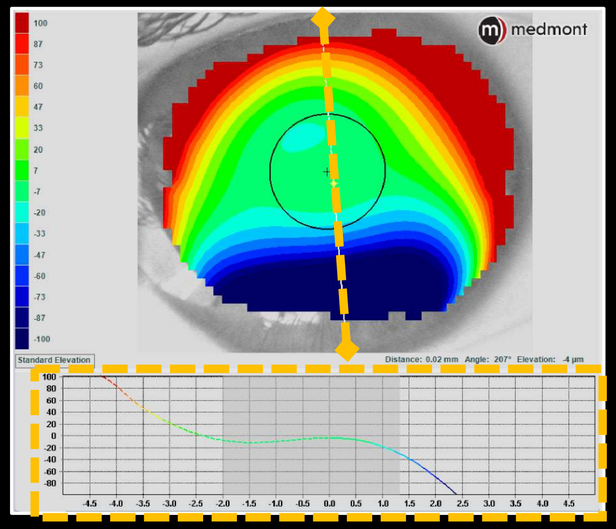
- 2015 - Randy Kojima & Pat Caroline evaluated corneal elevation
  - Measured elevation difference in the meridian of greatest curvature
  - If the elevation difference is less than ~ 350 μm, corneal lenses may be considered
- 2023 - Subsequent studies confirm 350 μm threshhold (Kojima)
  - Elevation differences between 200-400 μm may go either way (Kojima)

  - (Note: Randy Kojima's topography series on YouTube - highly recommended)

The Irregular Meridian



Axial Map



Elevation Map

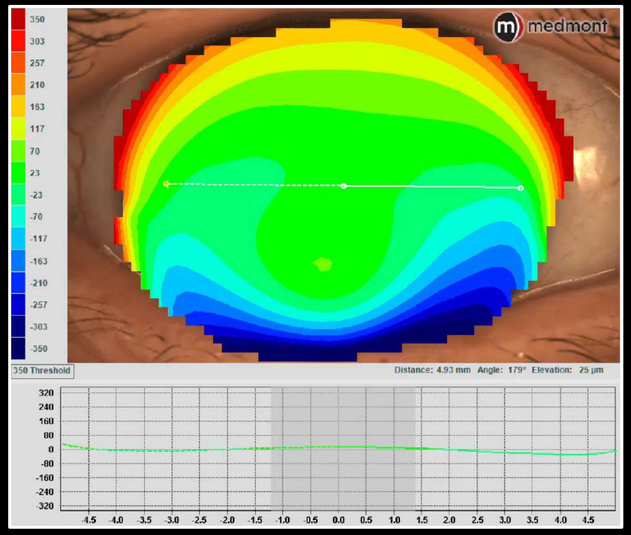
Axial maps = curvature change

Elevation maps - measurements of high/low points

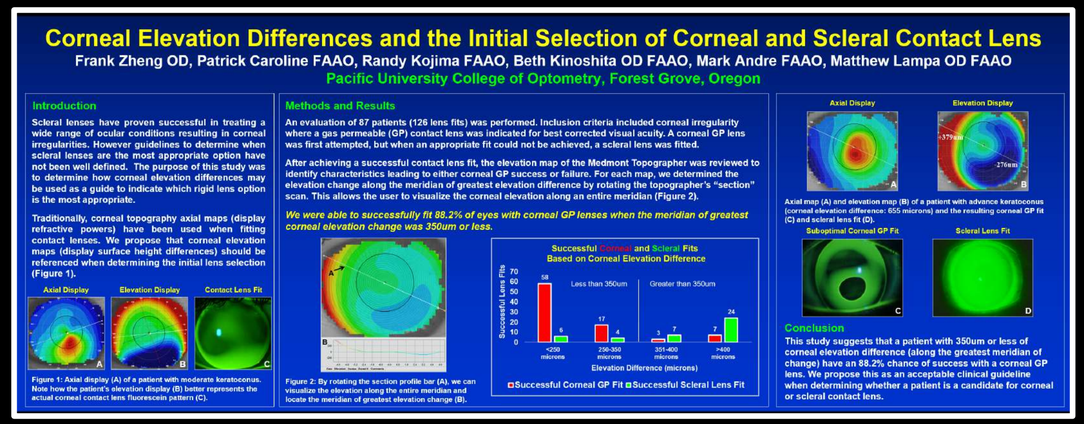
(Courtesy - Kojima, Caroline)

Novel software calculation

- **Algorithm searches**
  - **Employing the elevation map**
  - **Across a 8mm chord**
  - **360° degrees (axis?)**
  - **Highest elevation differential (microns)**



Elevation Differential Threshold 350 microns



Corneal Elevation Differences and the Initial Selection of Corneal and Scleral Contact Lens

Frank Zheng OD, Patrick Caroline FAAO, Randy Kojima FAAO, Beth Kinoshita OD FAAO, Mark Andre FAAO, Matthew Lampa OD FAAO
Pacific University College of Optometry, Forest Grove, Oregon

Introduction

Scleral lenses have proven successful in treating a wide range of ocular conditions resulting in corneal irregularities. However guidelines to determine when scleral lenses are the most appropriate option have not been well defined. The purpose of this study was to determine how corneal elevation differences may be used as a guide to indicate which rigid lens option is the most appropriate.

Traditionally, corneal topography axial maps (display refractive powers) have been used when fitting contact lenses. We propose that corneal elevation maps (display surface height differences) should be referenced when determining the initial lens selection (Figure 1).

Axial Display | Elevation Display | Contact Lens Fit

Figure 1: Axial display (A) of a patient with moderate keratoconus. Note how the patient's elevation display (B) better represents the actual corneal contact lens fluorescein pattern (C).

Methods and Results

An evaluation of 87 patients (126 lens fits) was performed. Inclusion criteria included corneal irregularity where a gas permeable (GP) contact lens was indicated for best corrected visual acuity. A corneal GP lens was first attempted, but when an appropriate fit could not be achieved, a scleral lens was fitted.

After achieving a successful contact lens fit, the elevation map of the Medmont Topographer was reviewed to identify characteristics leading to either corneal GP success or failure. For each map, we determined the elevation change along the meridian of greatest elevation difference by rotating the topographer's "section" scan. This allows the user to visualize the corneal elevation along an entire meridian (Figure 2).

We were able to successfully fit 88.2% of eyes with corneal GP lenses when the meridian of greatest corneal elevation change was 350um or less.

Figure 2: By rotating the section profile bar (A), we can visualize the elevation along the entire meridian and locate the meridian of greatest elevation change (B).

Successful Corneal and Scleral Fits Based on Corneal Elevation Difference

Axial Display | Elevation Display

Axial map (A) and elevation map (B) of a patient with advance keratoconus (corneal elevation difference: 655 microns) and the resulting corneal GP fit (C) and scleral lens fit (D).

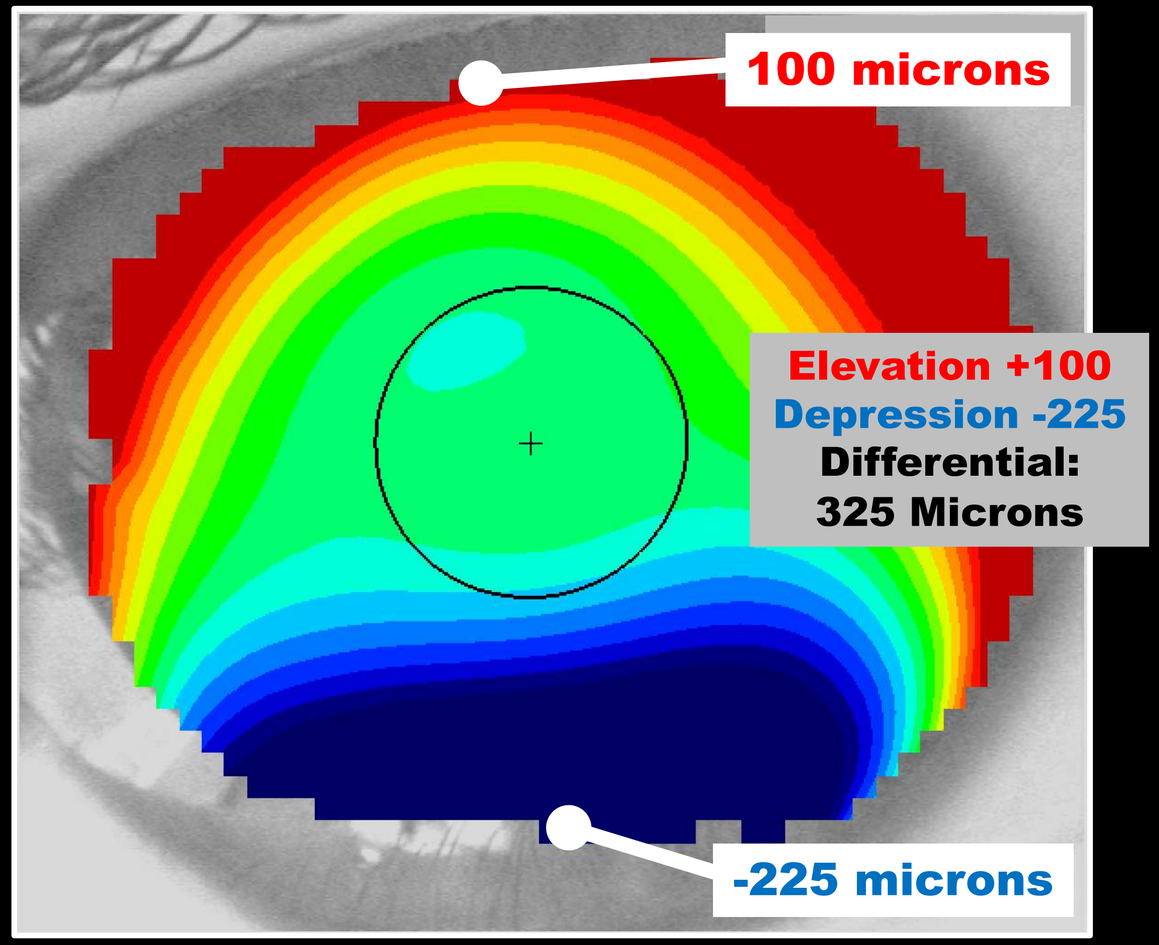
Suboptimal Corneal GP Fit | Scleral Lens Fit

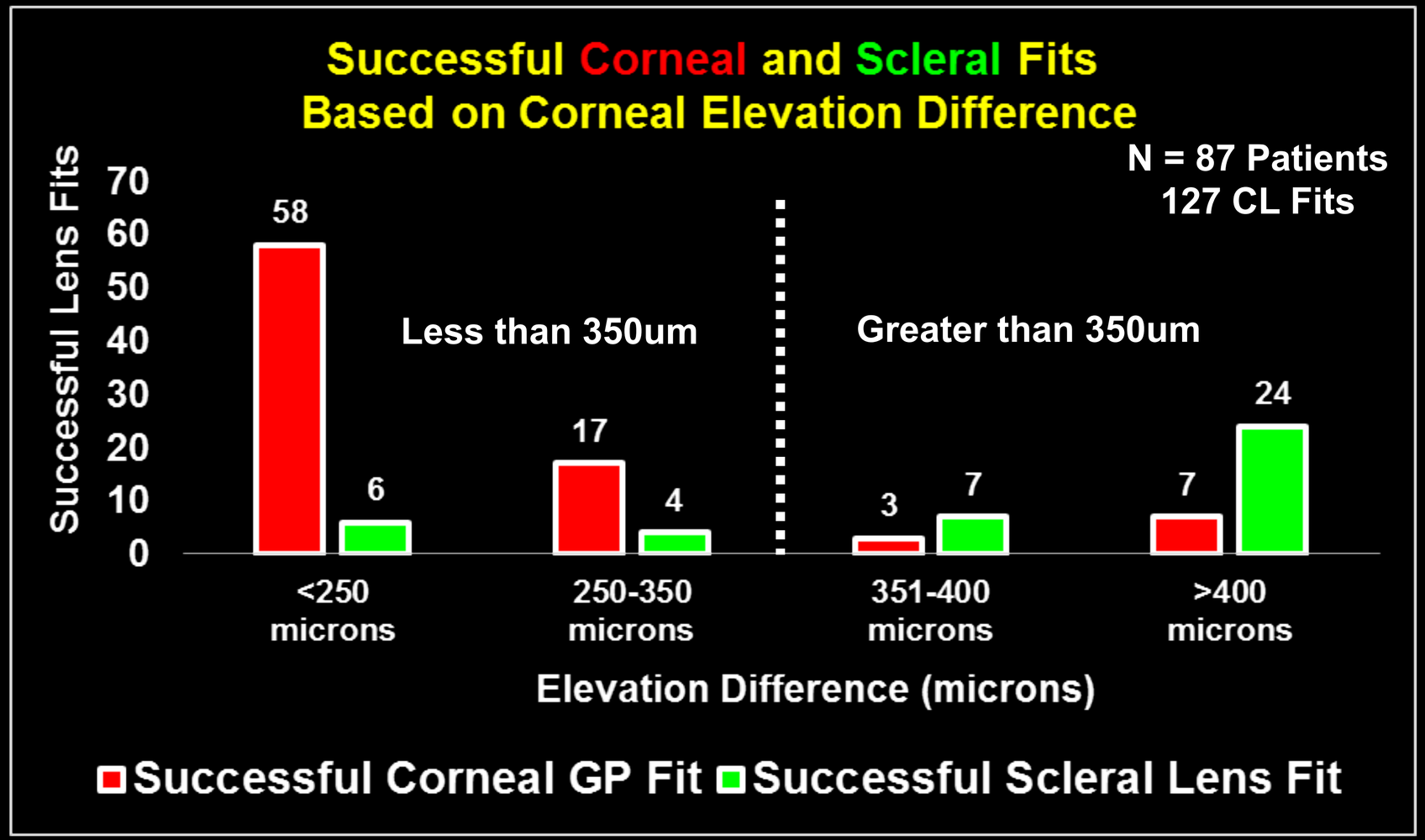
Conclusion

This study suggests that a patient with 350um or less of corneal elevation difference (along the greatest meridian of change) have an 88.2% chance of success with a corneal GP lens. We propose this as an acceptable clinical guideline when determining whether a patient is a candidate for corneal or scleral contact lens.

GSLS 2015

Pacific University Oregon





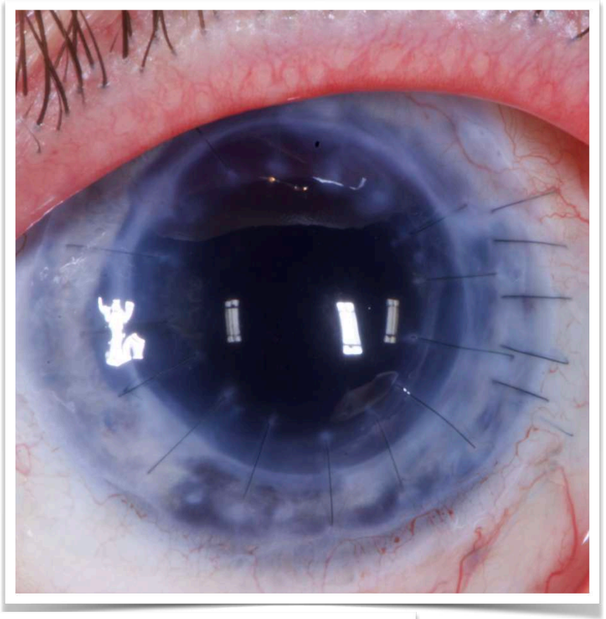
Patients with 350um or less of corneal elevation difference (along the greatest meridian of change) have an 88.2% chance of success with a corneal GP lens.

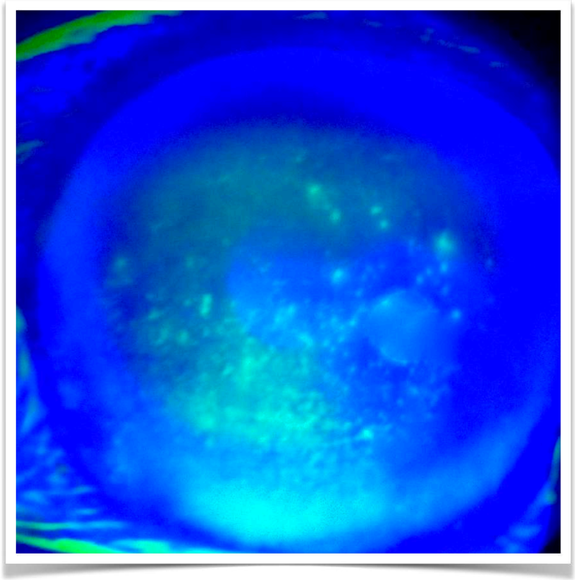
(Courtesy - Kojima; Caroline)

So? When is a scleral lens appropriate?

“To the cornea and beyond!” - Buzz Lightyear

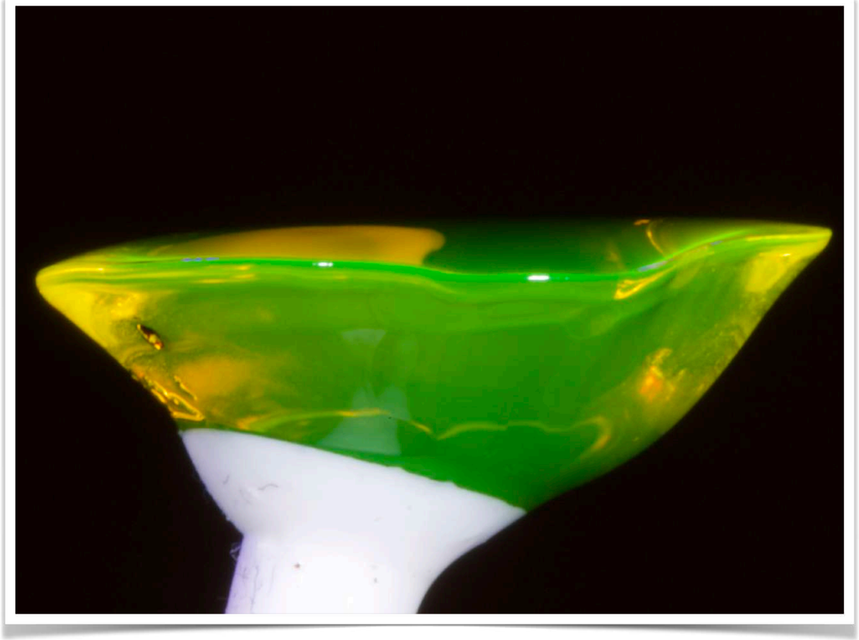
- Advanced keratoconus/pellucid marginal degeneration
- Post penetrating keratoplasty
- Post refractive surgery (RK; PRK; LASIK)
- Trauma
- Graft vs. host disease (GVHD)
- Dry eye disease; Ocular surface disease (DED; OSD)





Yay for sclerals!

- Comfortable
- Stable - minimal movement, if any
- Long wearing time - up to “all waking hours”
- Neutralize anterior corneal astigmatism
- Excellent for multifocals - stable; may decenter optics
- Landing zone (haptic) may be aligned to scleral shape



Scleral alignment

It's complicated (sometimes)

- Two-thirds of patients have a highly irregular scleral shape (DeNaeyer, et al - 2017)

Scleral Surface Patterns

Table 1 Scleral Surface Patterns Observed in 140 Scleral Lens Patients

Group	Pattern Description	N(%)
1	Spherical	8 (5.7%)
2	Toric-Regular	40 (28.6%)
3	Asymmetric High or Low Points	57 (40.7%)
4	Periodicity different from 180°	35 (25%)

65.7%

Journal of CONTACT LENS RESEARCH & SCIENCE

Original Research

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

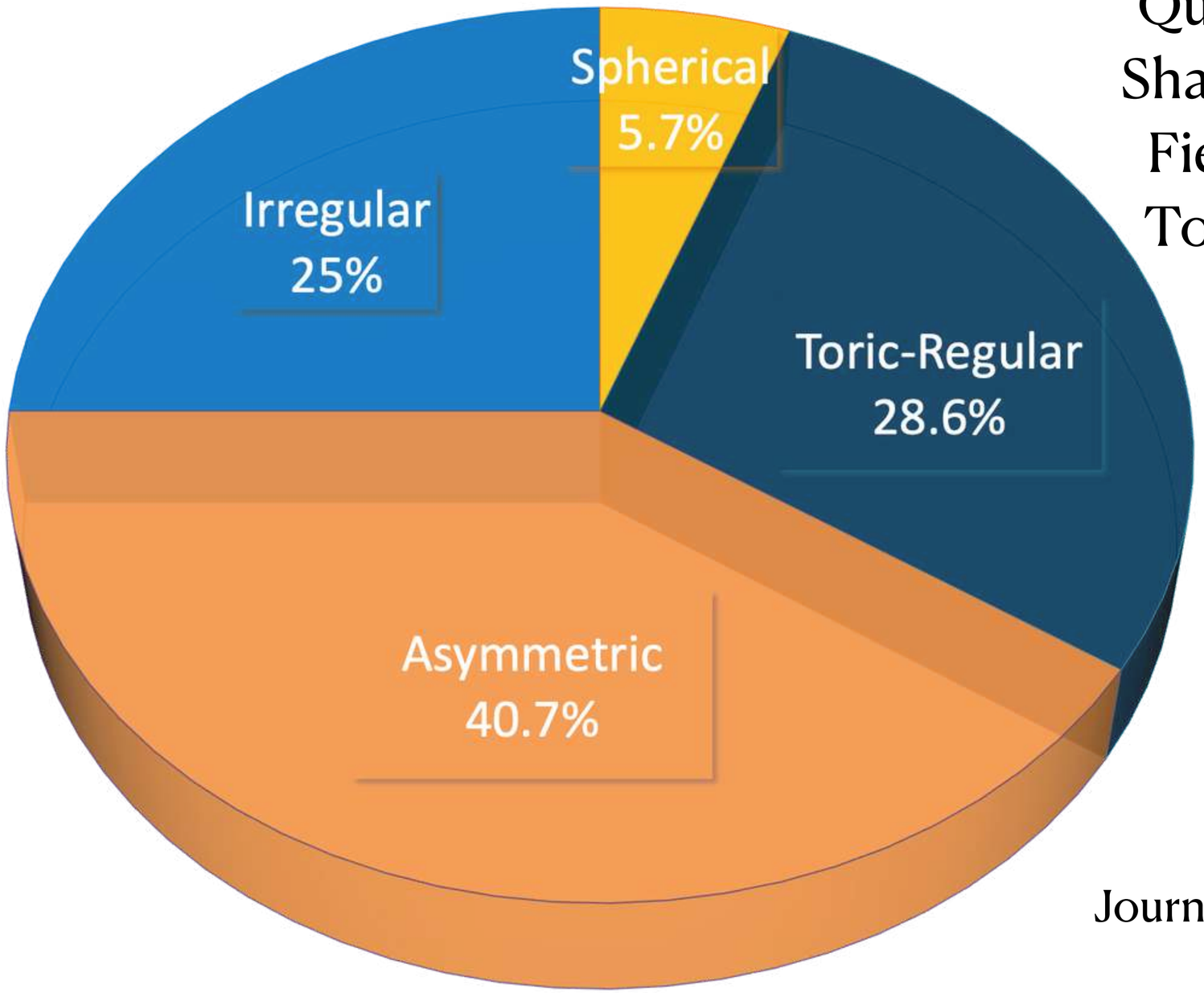
By Gregory DeNaeyer, OD[1], Donald R. Sanders, MD, PhD[2], Eef van der Worp, OD[3], Jason Jedlicka, OD[4], Langis Michaud, OD[5], Sheila Morrison, OD[6]

About the Authors

[1]Optometrist at Arena Eye Surgeons. [2]Director, Center for Clinical Research and President and CEO Visionary Optics LLC. [3]Adjunct Assistant Professor at Pacific University College of Optometry. [4]Clinical Associate Professor at the Indiana University School of Optometry. [5]Professor at University of Montreal School of Optometry. [6]Assistant Clinical Professor at University of Houston School of Optometry.

Corresponding Author: Donald Sanders: drsmd@drsmd.com.

Submitted: August 25, 2017. Accepted: November 5, 2017. Published:November 16, 2017.

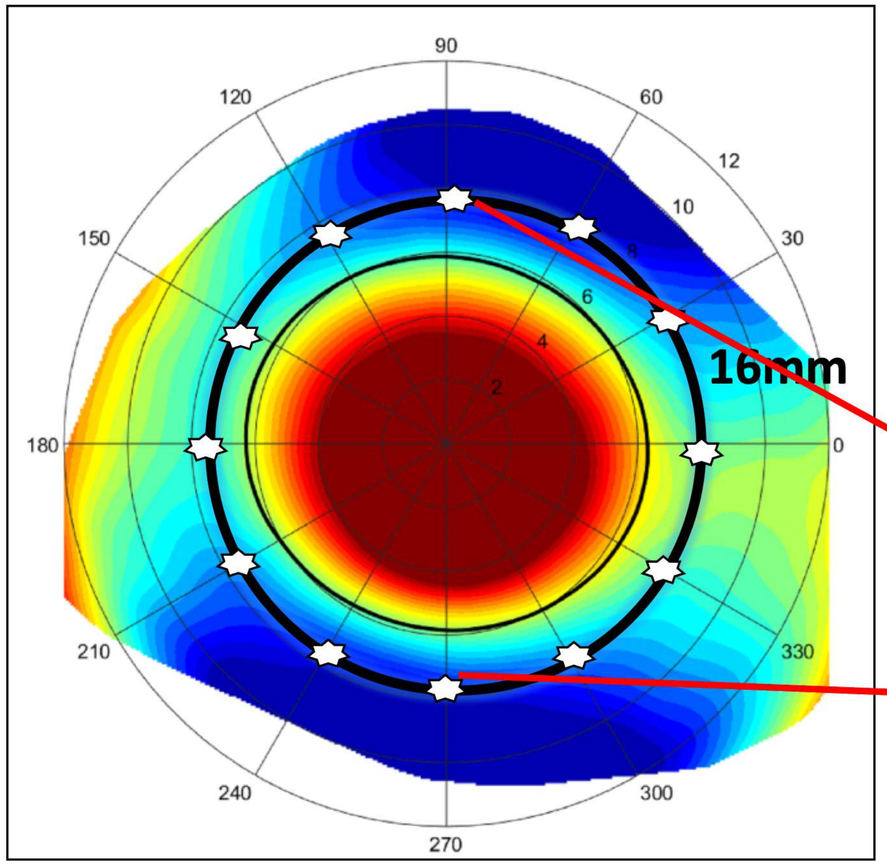


"Qualitative Assessment of Scleral Shape Patterns Using a New Wide Field Ocular Surface Evaluation Topographer: The SSSG Study"

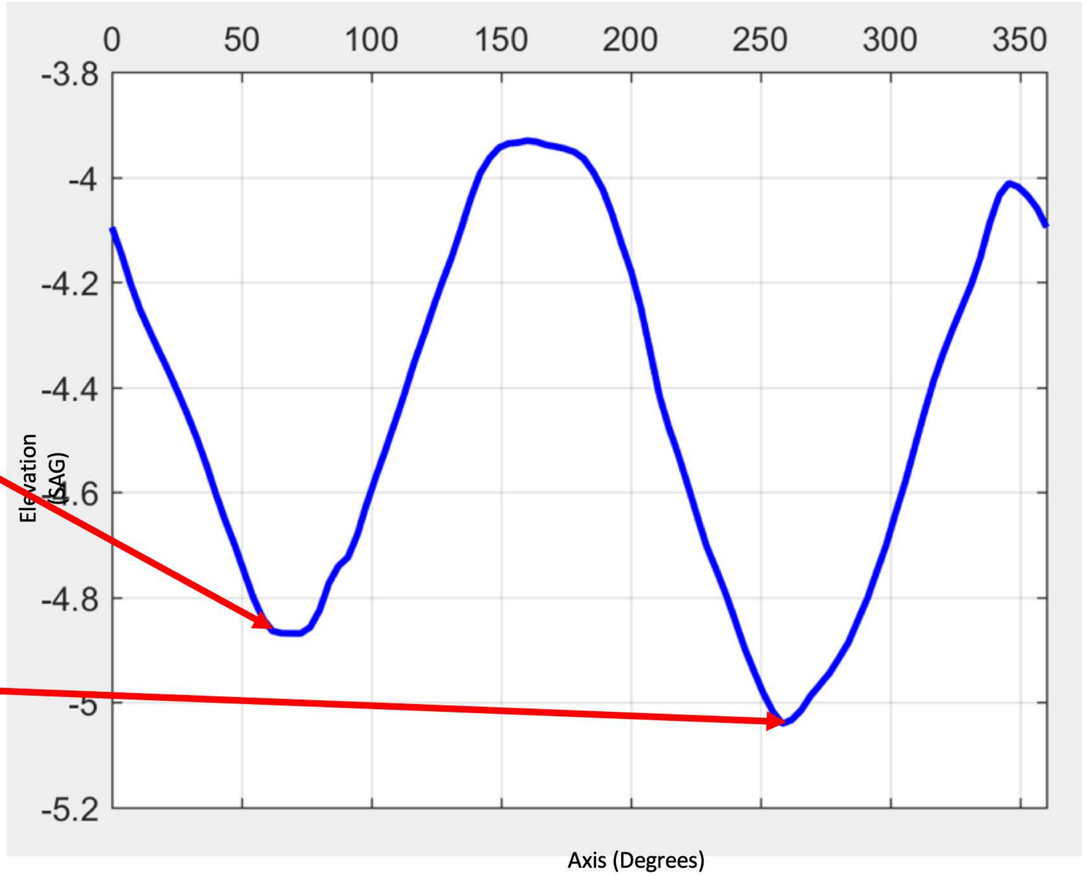
DeNaeyer, Sanders, van der Worp, Jedlicka, Michaud, Morrison

Journal of Contact Lens Research & Science
Nov 16, 2017

Scleral Elevation Map (Qualitative)



Scleral Shape Plot (Quantitative)



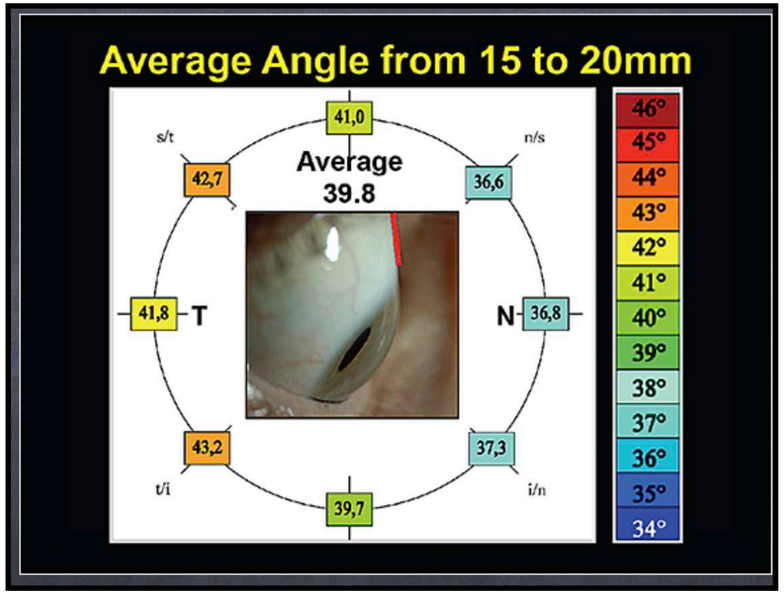
Asymmetric high-low points along same, with-the-rule meridian

(Courtesy of Greg DeNaeyer, et al)

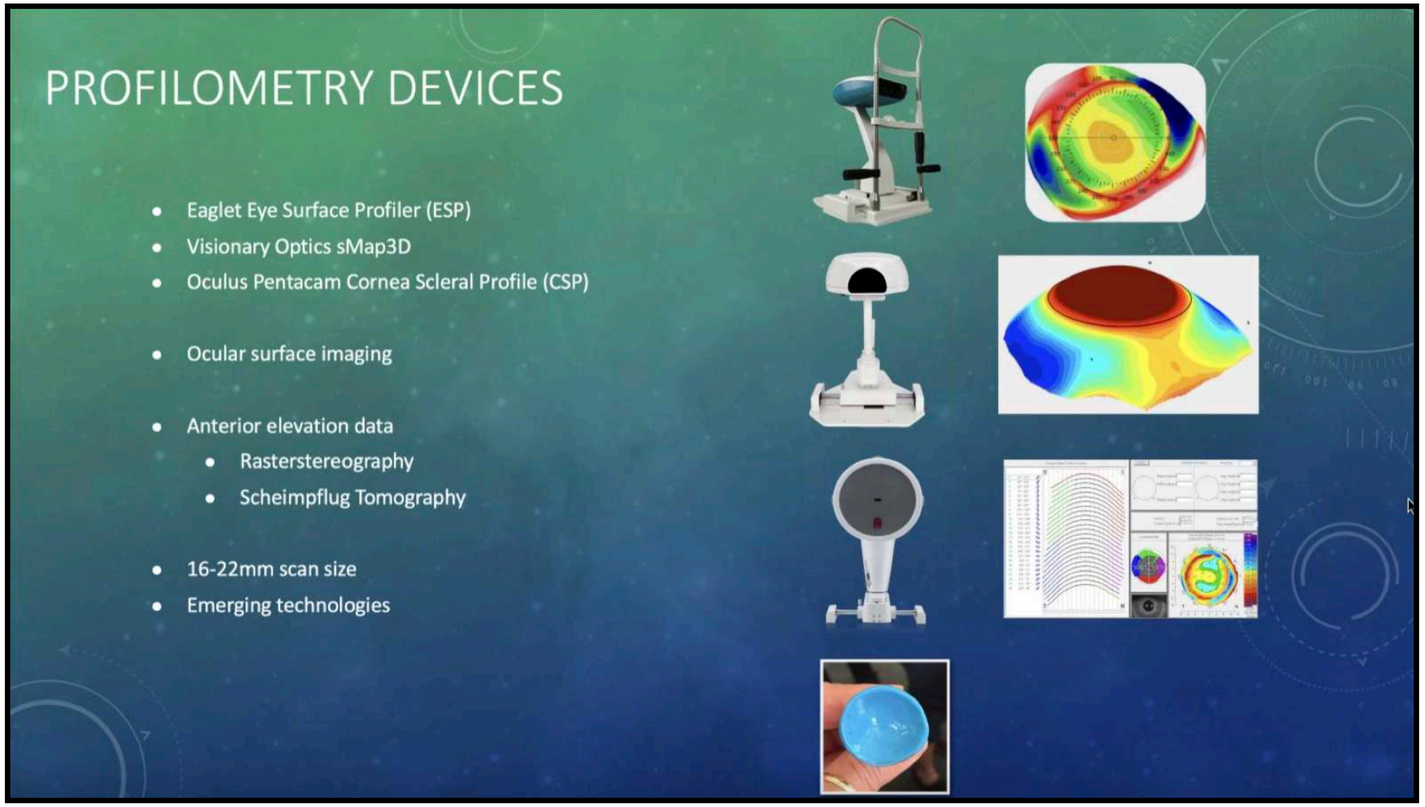
Seeing the unseen

“Enter profilometry”

- Many labs support direct importation of scanned information to assist in lens design

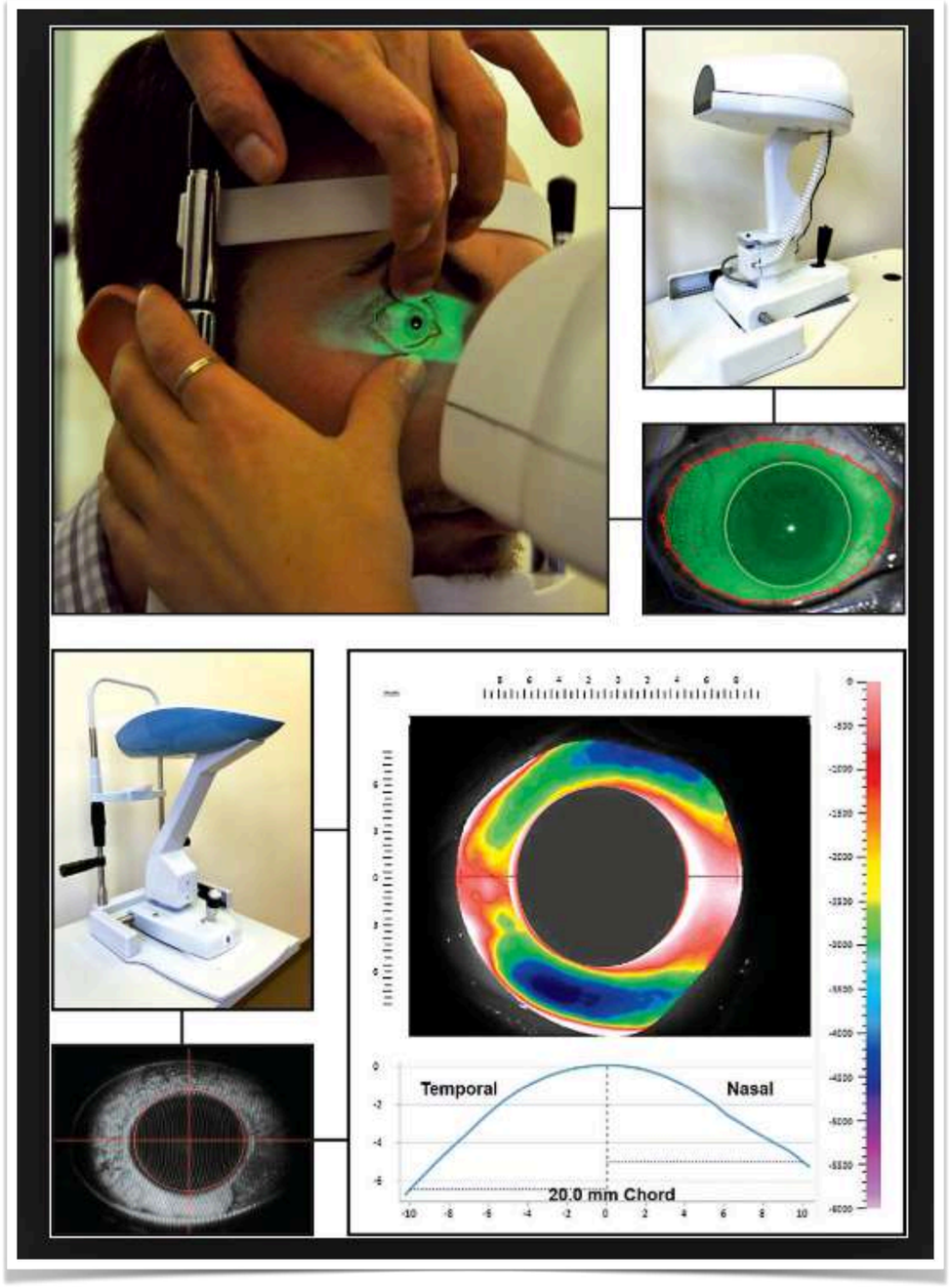


(Courtesy Kojima; Caroline; Andre)



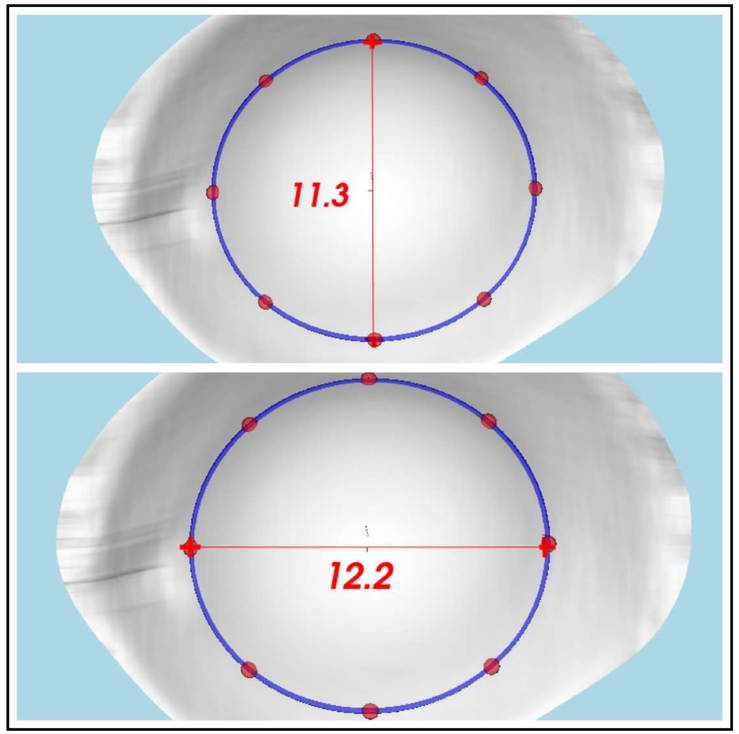
Tom's tips

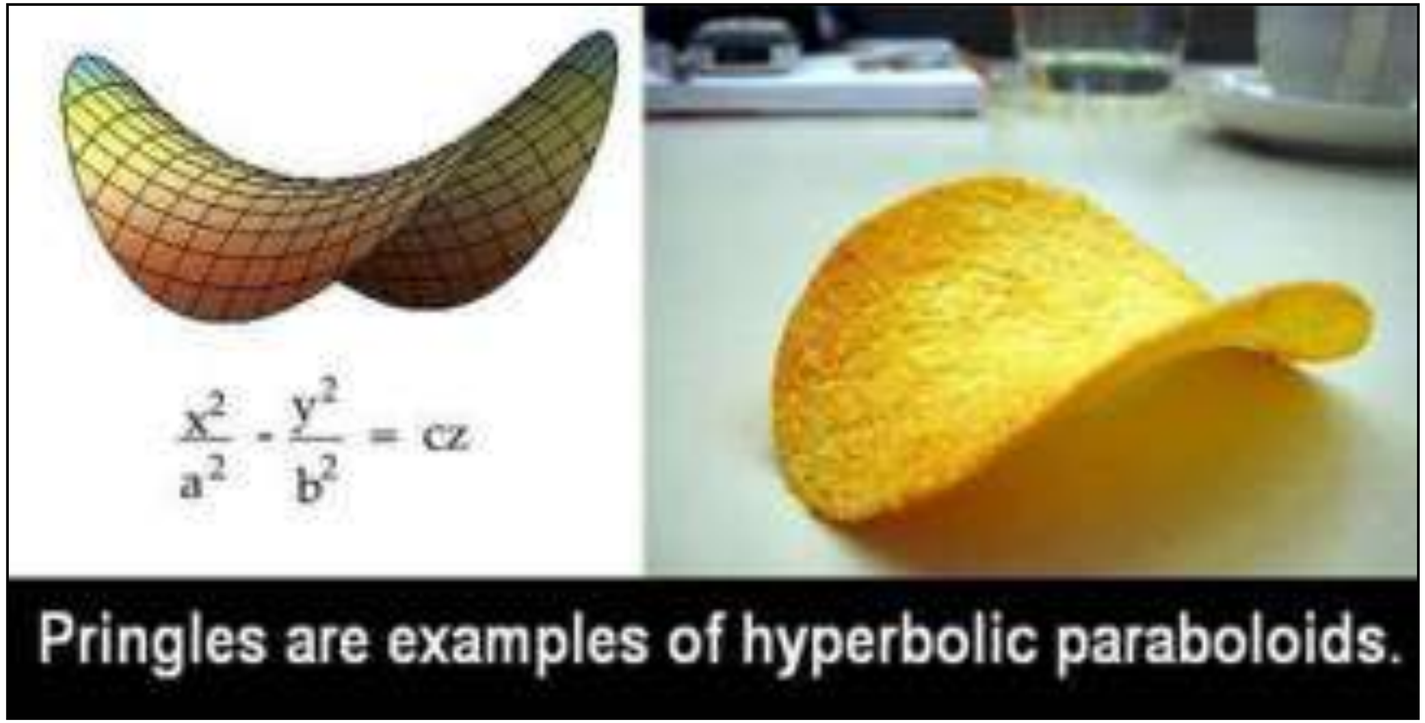
- Use two technicians
- Pre-align patient
- Room must be dark (for NaFl-based instruments)
- Select a "top tech" as the primary technician
- Practice, practice, practice



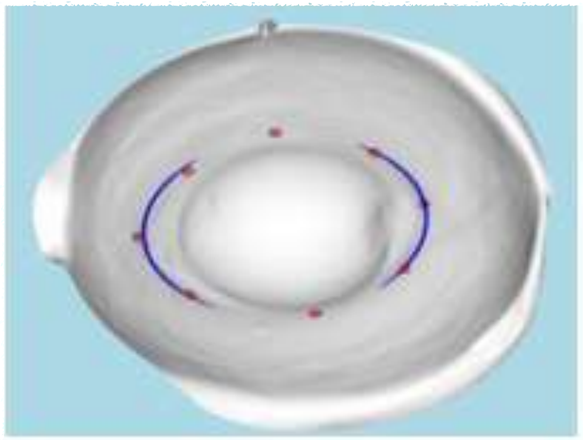
Scleral toricity starts at the limbus

- Detailed measurements (Fadel) and impression-molding studies (Sindt) have confirmed that the limbus is oval and a paraboloid.

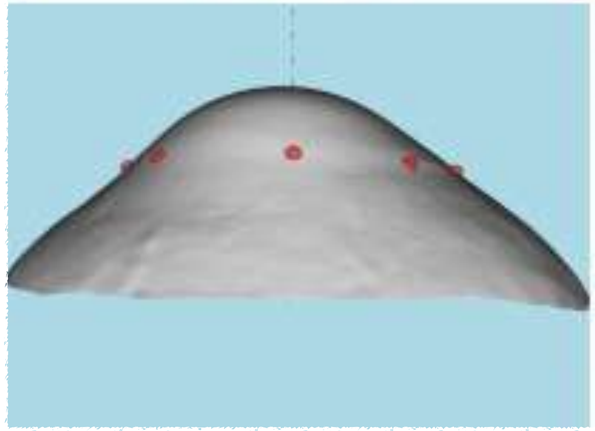


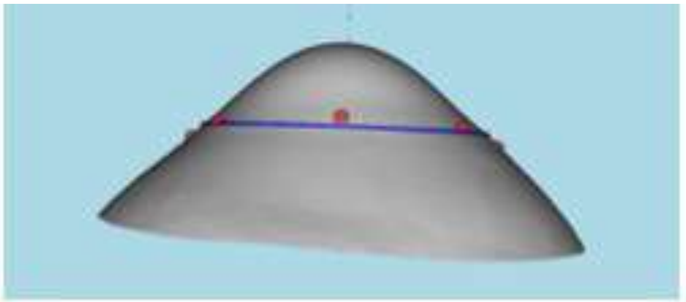


(Courtesy Christine Sindt)



Chord length is shorter & higher
in one meridian





This results in excessive clearance over the
limbus in that meridian

(Courtesy of Christine Sindt)

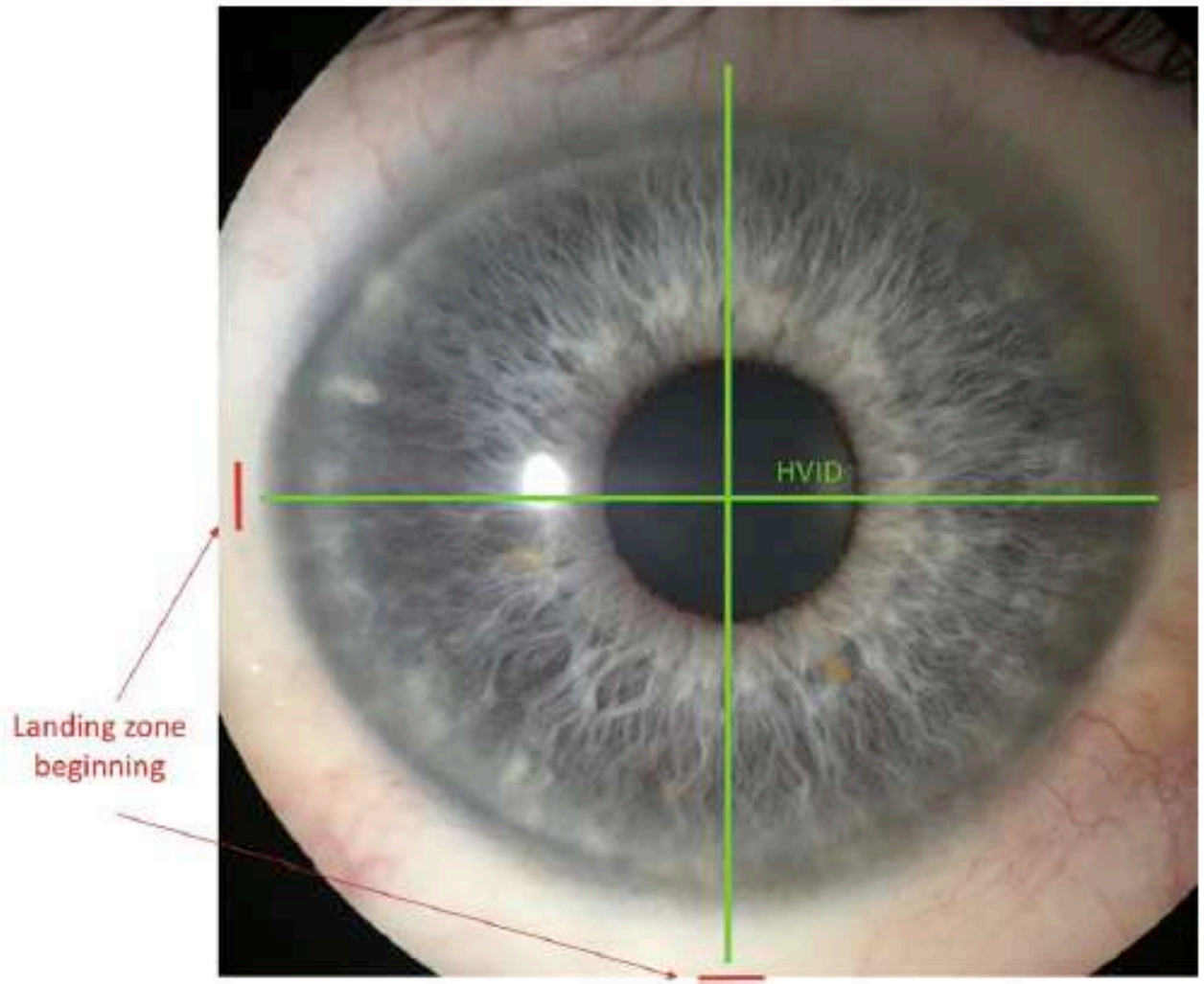


Fig. 3. Fitting a spherical scleral lens on a significantly oval limbus shape. Taking into consideration only the horizontal visible iris diameter (HVID), the landing zone starts near the limbus in the horizontal meridian and away from the limbus in the vertical meridian.

"The Influence of limbal & scleral shape on scleral lens design"

Fadel, D.

Contact Lens & Ant. Eye,

20 Feb. 2018, pp. 31-38

Contents lists available at ScienceDirect

Contact Lens and Anterior Eye

journal homepage: www.elsevier.com/locate/clae

Review article

The influence of limbal and scleral shape on scleral lens design

Daddi Fadel

Private practice, Italy

ARTICLE INFO

Keywords:
Scleral contact lenses
Anterior scleral profile
Limbus
HVID
VVID
Rotational symmetry
Rotational asymmetry
Landing zone
Scleral alignment
Corneoscleral topography
Sagittal height

ABSTRACT

Purpose: To summarize the research findings on the ocular surface profile, to provide a definition and a classification of the corneoscleral shape, and to offer guidelines in selecting scleral lens design.
Methods: The definition of rotational symmetry and rotational asymmetry was inquired and PubMed searches were conducted.
Results: The better understanding of the scleral contact lens comportment on the eye and the introduction of new diagnostic instruments to measure the anterior ocular surface have led to improve comprehension of corneoscleral contour formulating new scleral lens designs. The scleral lens landing zone is influenced by corneoscleral profile which may be rotationally symmetric and rotationally asymmetric. Corneal sagittal height, limbal shape, corneoscleral junction profile, corneal, limbal, and conjunctival angles, and scleral shape should be taken in consideration to prevent and manage fitting problems, such as air bubble formation, midday fogging, localized blanching, impingement, conjunctival prolapse, lens decentration, lens flexure, and to increase comfort, wearing time, overall satisfaction, and visual quality.
Conclusion: Corneoscleral shape may be considered rotationally symmetric including spherical, aspherical and toric profiles, and rotationally asymmetric including regular and irregular quadrants profiles. Each ocular surface contour requires a different landing zone design for an optimal fitting, vaulting properly over the cornea and limbus, and ideal alignment on the sclera. Further studies are still necessary to clarify many aspects of scleral lenses which are little known yet.

1. The background

Scleral shape has been widely described and measured for several years leading to clinical consequences on the fitting and design of scleral lenses in order to improve landing zone alignment with the sclera. In 1946, Feinbloom explained the first tangential fitting of Feincone Scleral contact lenses (ScCL) subdividing the lens into three sections: corneal, cone and temporal radius. The corneal section was to provide the refractive correction. The cone, or truncated conical section, available in 43, 46 and 49°, was to allow for lens bearing on the conjunctival tissue. The temporal radius was to reduce the interaction between the lens edge and the eyelid at the temporal side of the lens [1]. The purpose of such tangential fitting was to alleviate the pressure on the eye, to allow better tolerance and to increase wearing time [1,2]. In 1966, Marriott was the first to describe the ocular surface as asymmetrical. He found that the nasal sclera is flatter by using scleral shells taken from ocular impressions [3]. Later, in 1977, Bier and Lowther illustrated the issues that arise when fitting a spherical ScCL on toric scleras. The formation of air bubbles in the liquid reservoir behind the lens and the occurrence of sectorial blanching suggested the use of a spherical oval fitting or toroidal shell in eyes with high scleral toricity [4].

2. The technology

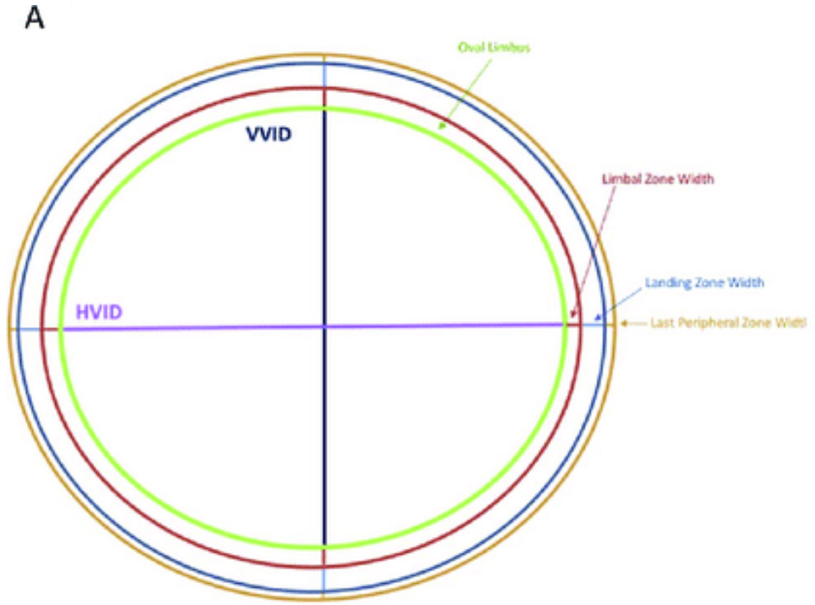
The introduction of new diagnostic instruments to measure the anterior surface shape, such as Scheimpflug Imaging, Projected Moiré Profilometry and Optical Coherence Tomography (OCT), confirmed the scleral shape intuited years ago. Several studies have reported the estimation and importance of the corneoscleral junction (CSJ) angle and profile [5–19]. Common findings were that the scleral toricity and asymmetry are more pronounced in the sclera than the limbus [5–19], and the limbal and scleral shape are more likely tangential rather than curved [5–11]. In radii, the nasal sclera was found to be flatter than the temporal [5–9,12,14,15–18] and in angles was smaller [5–10,13,16,19]. All of this data has led to the development of new ScCL designs with an improved fitting relationship.

3. Limbus and scleral shape affecting Sccl design

An optimal fitting consists of a proper vault over the cornea and limbus with a balanced distribution of lens pressure on the ocular

E-mail address: dfadel@tin.it.

https://doi.org/10.1016/j.clae.2018.02.003
Received 4 December 2017; Received in revised form 19 January 2018; Accepted 20 February 2018

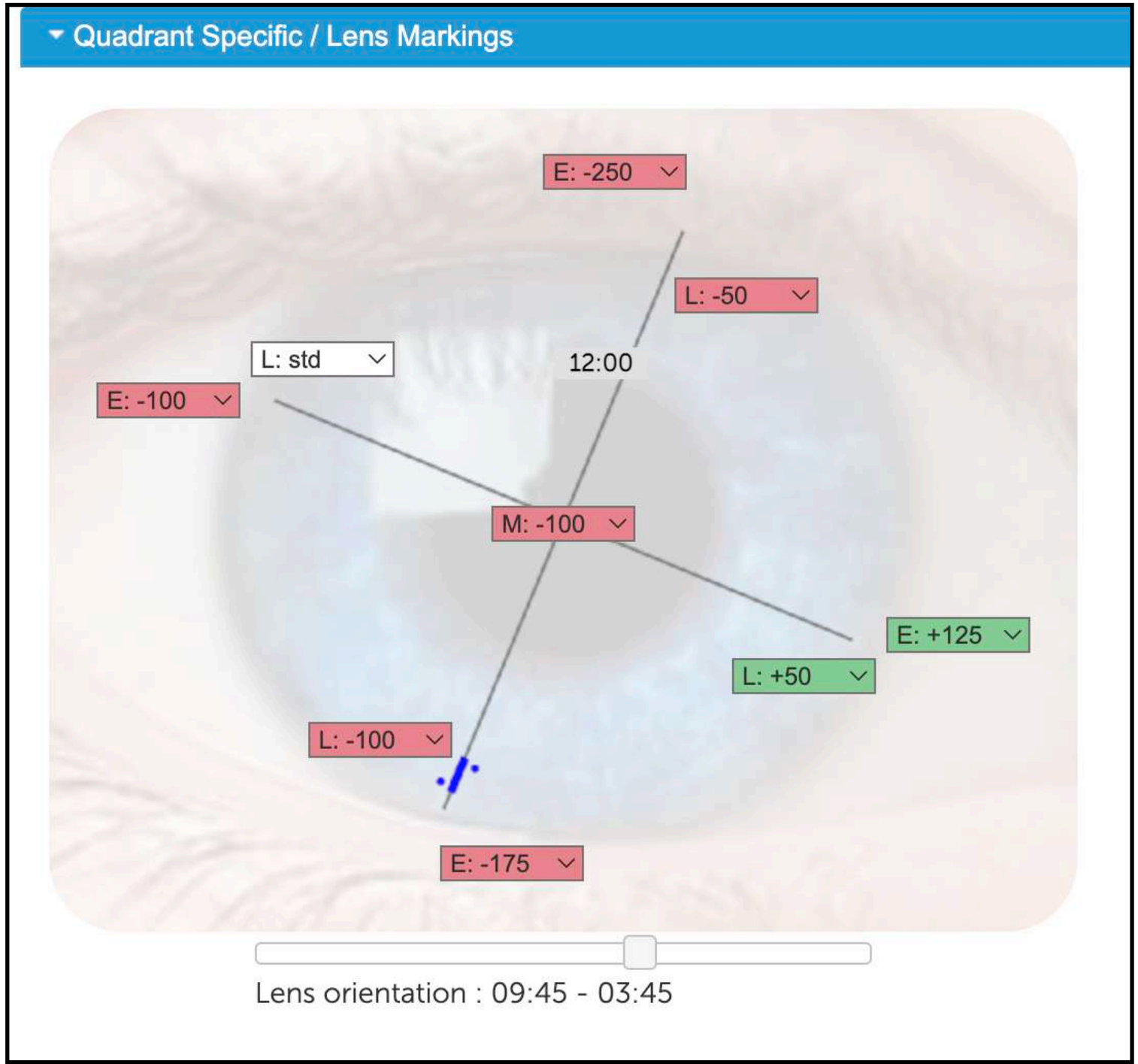


Elliptical scleral lens

HVID ≠ VVID
Peripheral zones all equidistant from corneal zone

Internal oval trend scleral lens

HVID ≠ VVID
Only corneal/limbal zones are oval
Landing zone width adjusts to compensate for oval shape of corneal/limbal zones

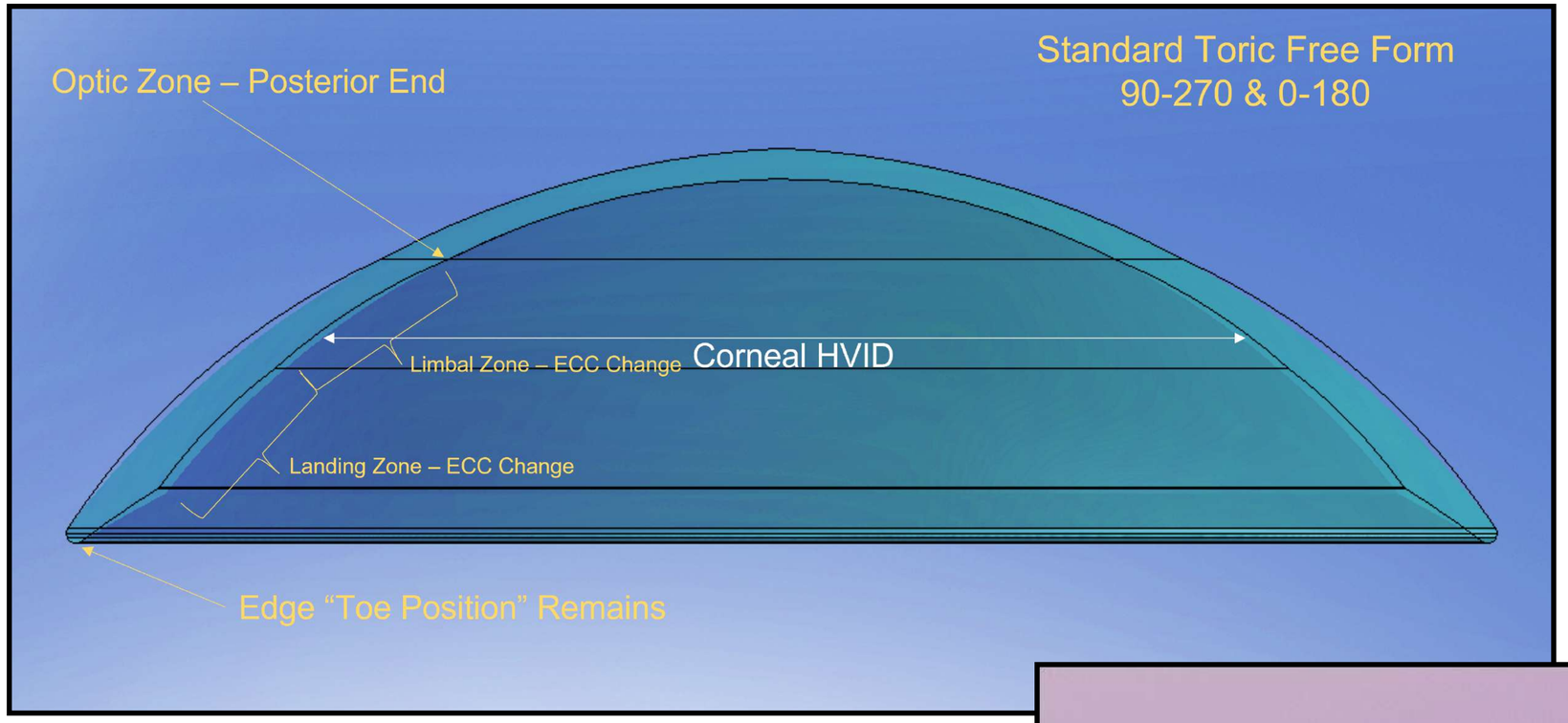


Quadrant-specific design

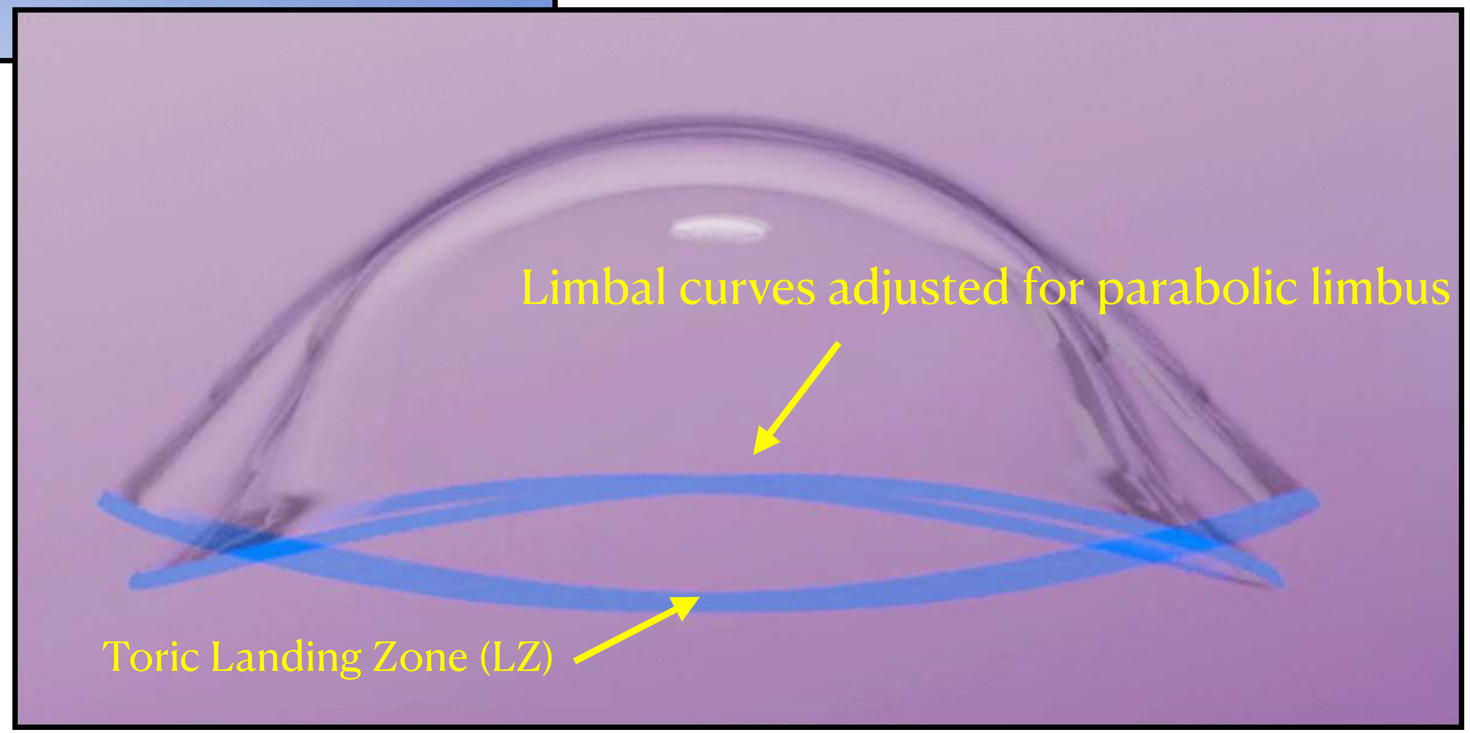
Practitioner specifies clearance in three zones:

1. Mid-periphery
2. Limbal zone
3. Landing zone

(Courtesy Justine Siergey)



(Courtesy Troy Miller)

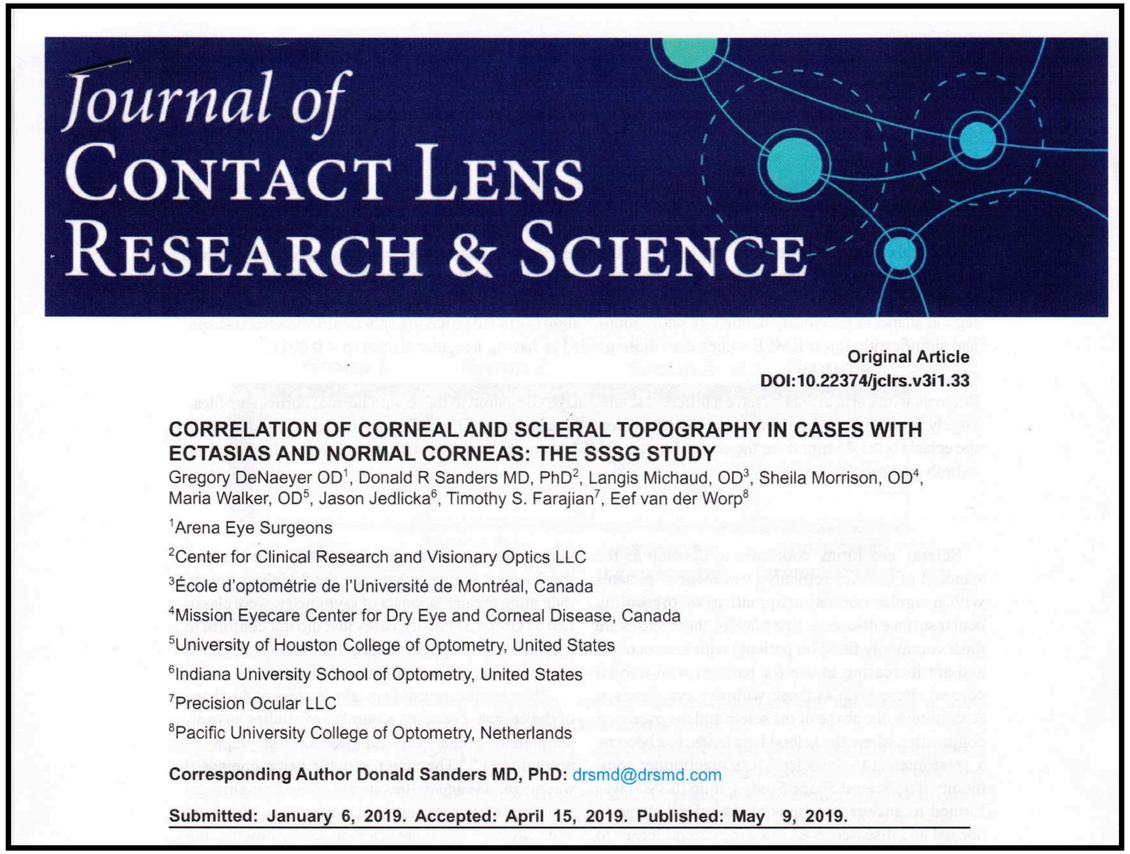


(Courtesy Jason Jedlicka)

“That’s great but I don’t have a profilometer”

Don’t despair

- DeNaeyer, et al, 2019
- Examined 115 prolate corneas (Group A)
- Examined 227 ectatic corneas (Group B)
- Group B -significantly greater proportion of irregular scleral shape vs. Group A
- Scleral shape was more likely to show quadrant-specific effect (difference in sagittal height along two meridians) when apex of ectasia was > 1.25 mm from corneal center



Journal of
CONTACT LENS
RESEARCH & SCIENCE

Original Article
DOI:10.22374/jclrs.v3i1.33

CORRELATION OF CORNEAL AND SCLERAL TOPOGRAPHY IN CASES WITH ECTASIAS AND NORMAL CORNEAS: THE SSSG STUDY

Gregory DeNaeyer OD[1], Donald R Sanders MD, PhD[2], Langis Michaud, OD[3], Sheila Morrison, OD[4], Maria Walker, OD[5], Jason Jedlicka[6], Timothy S. Farajian[7], Eef van der Worp[8]

[1]Arena Eye Surgeons
[2]Center for Clinical Research and Visionary Optics LLC
[3]École d’optométrie de l’Université de Montréal, Canada
[4]Mission Eyecare Center for Dry Eye and Corneal Disease, Canada
[5]University of Houston College of Optometry, United States
[6]Indiana University School of Optometry, United States
[7]Precision Ocular LLC
[8]Pacific University College of Optometry, Netherlands

Corresponding Author Donald Sanders MD, PhD: drsmd@drsmd.com

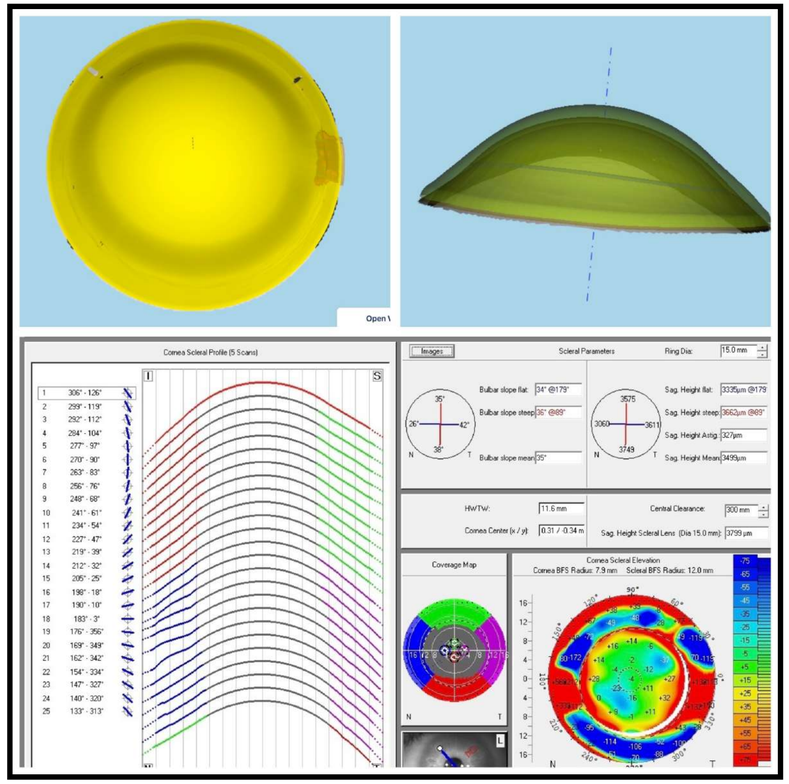
Submitted: January 6, 2019. Accepted: April 15, 2019. Published: May 9, 2019.

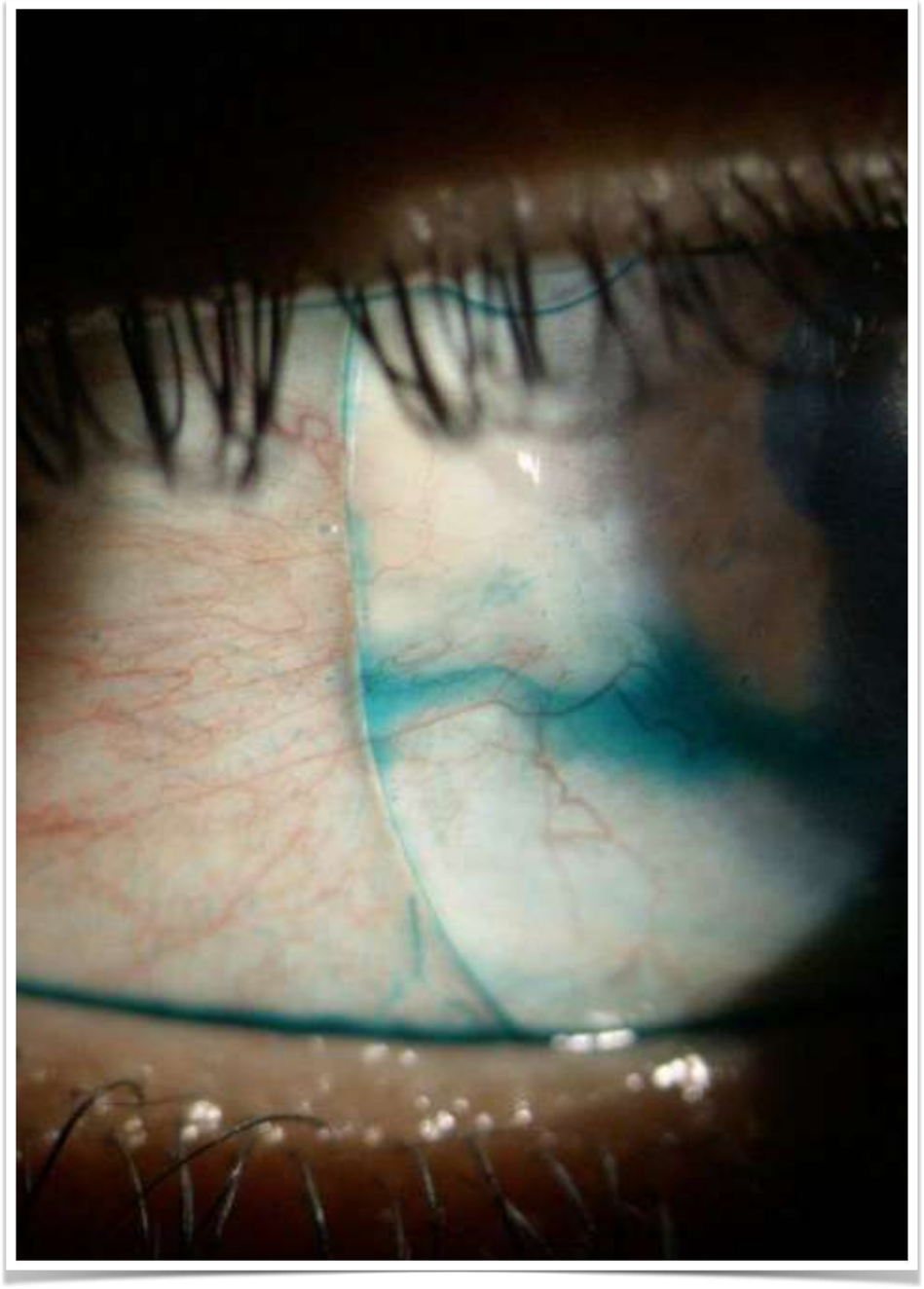
Toric landing zones? YES!

- When ordering toric peripheries specify at least 120-180 μm difference
- Many scleras average 120-300 μm (or more) variation between meridians
  (Fadel, Dec. 2017; Kinoshita, Morrison, Caroline, Kojima, Lampa, Jan. 2016)
- Larger lenses (15.2 mm or greater) are more likely to require toric PCs
- Some labs provide fitting sets with toricity built-in to the landing zone
- Practitioners may order toric PCs 80-95% of the time
  (personal communication)

This means.....

- The majority of scleral lens landing zones will be toric or quadrant-specific
- Severe ectasias may require impression-molding or “free-form” designs from profilometry





Lissamine green is a great tool for assessing haptic aligment

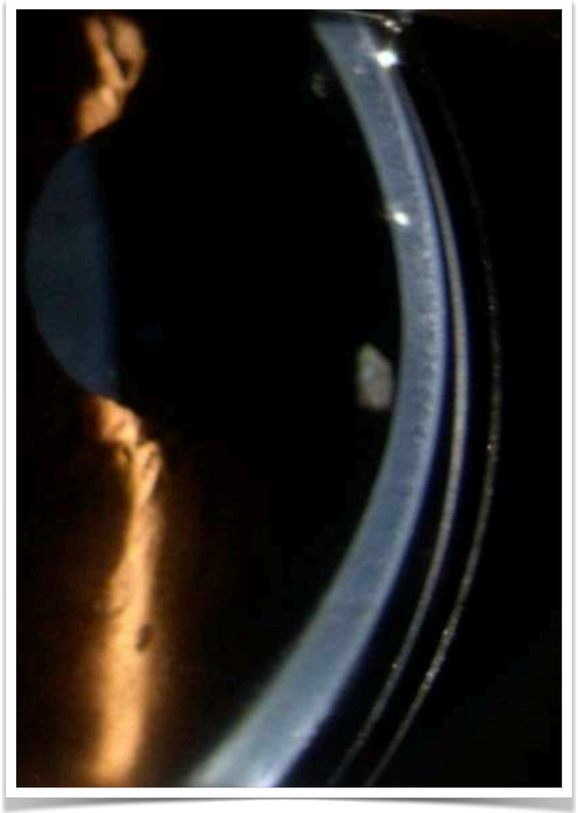
Uptake is very quick

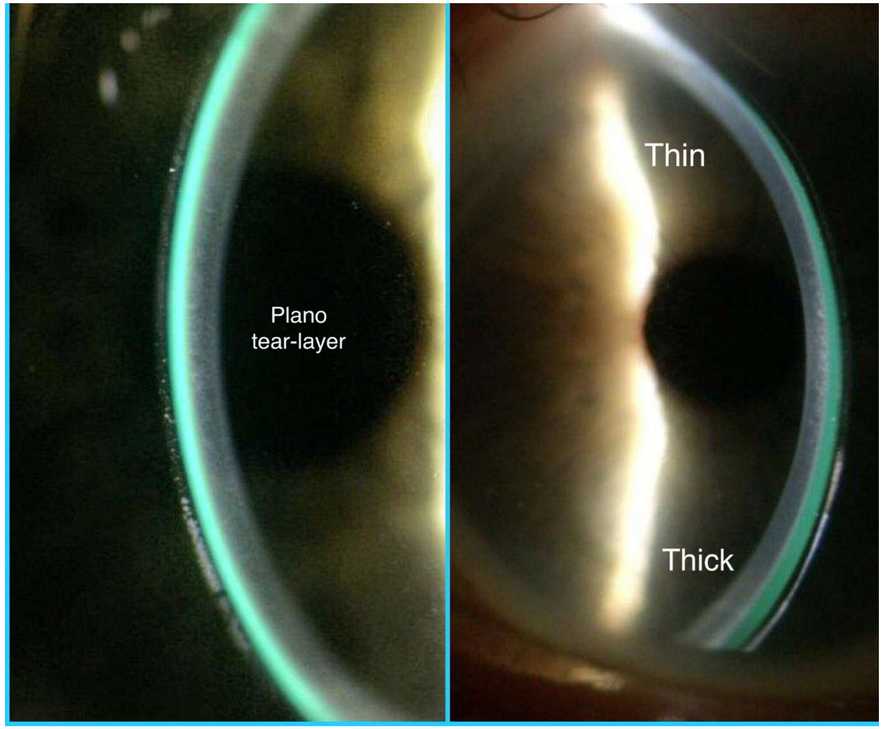
View in white light

What if the Rx calls for cylinder?

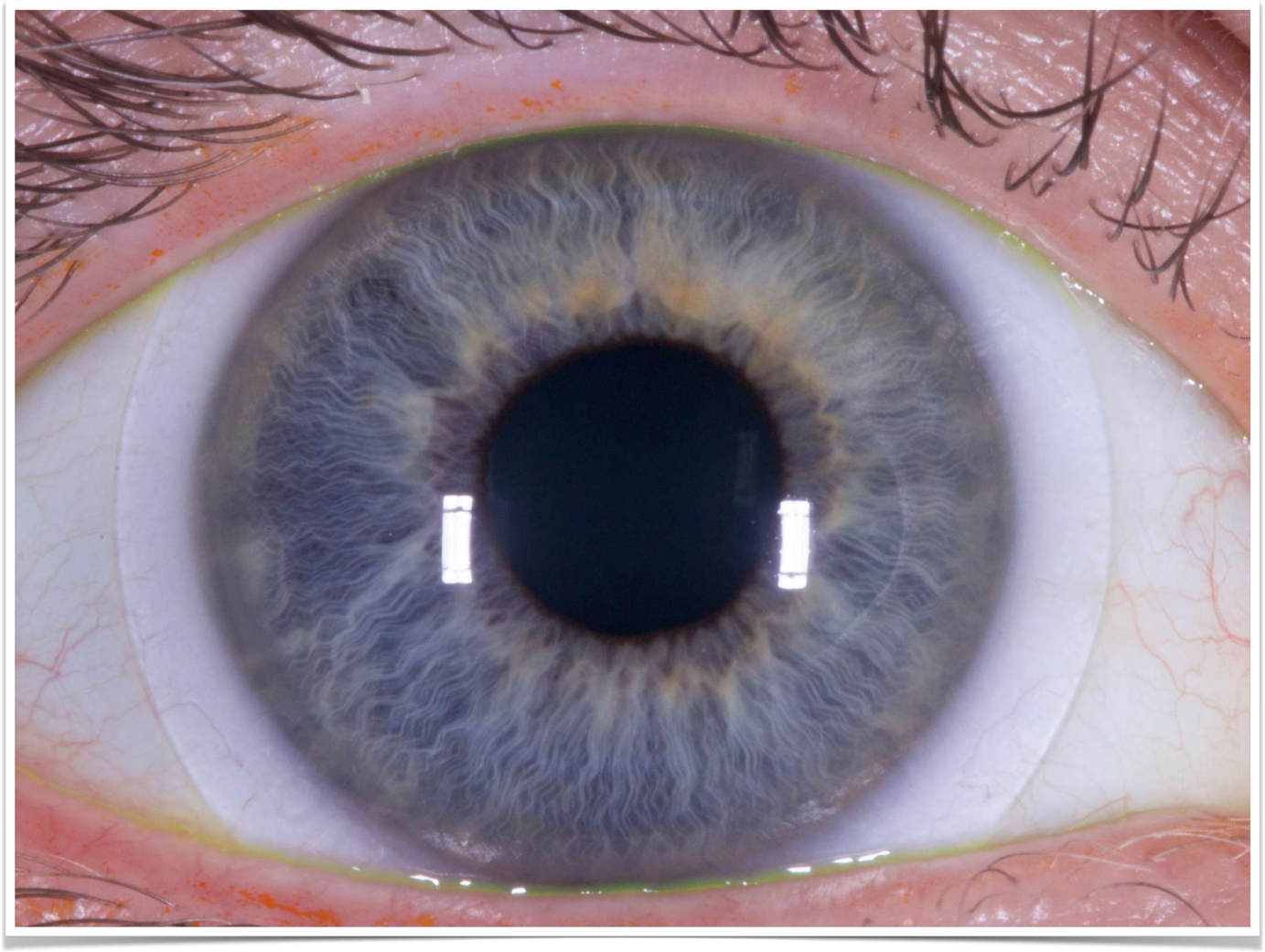
Stabilize and center the lens first

- Decentration may lead to induced cylinder in Rx
- Rule-of-thumb, order spherical-equivalent in first lens
- Once centration & rotational stability are achieved, add cylinder as needed





Centration is key

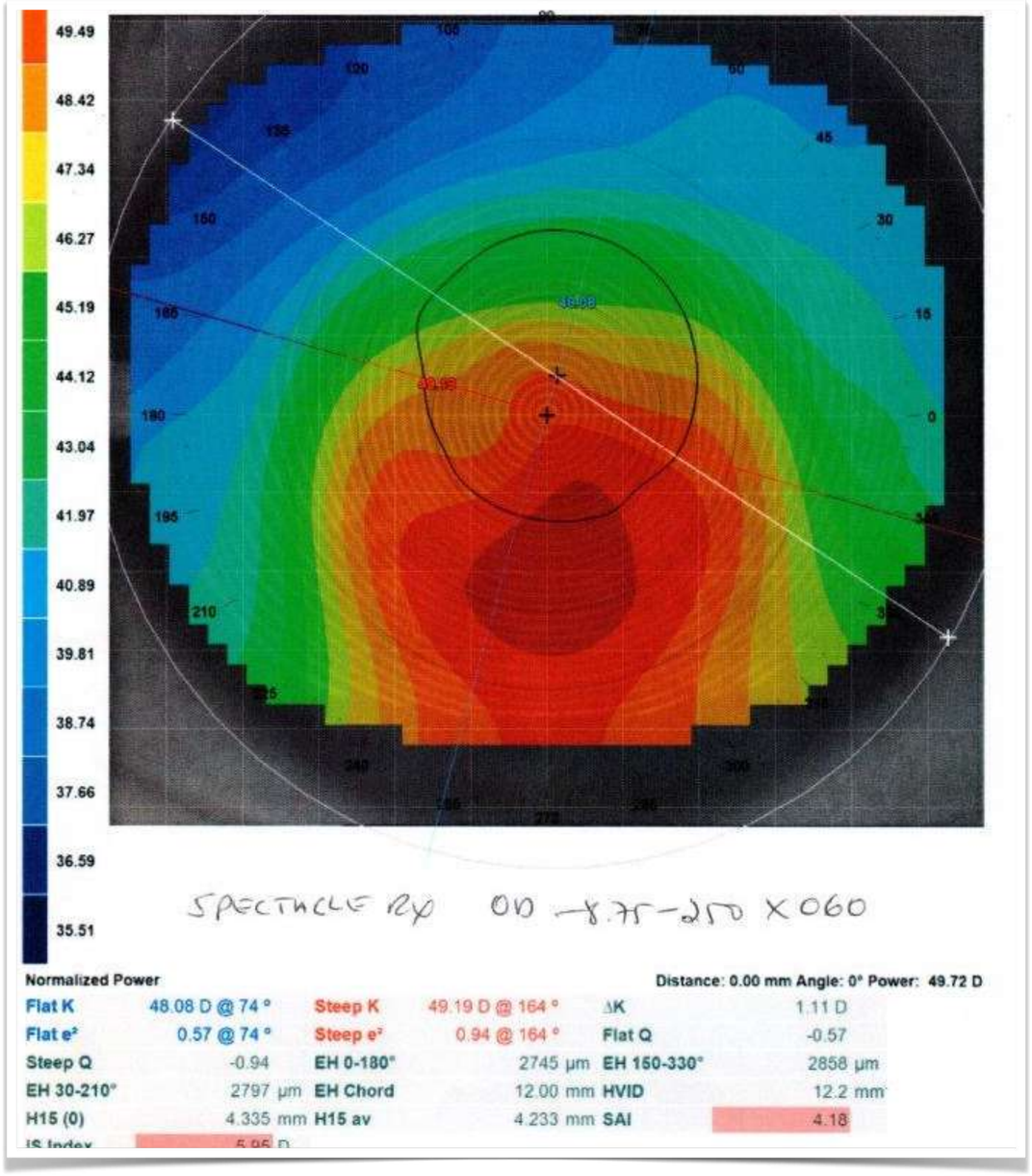


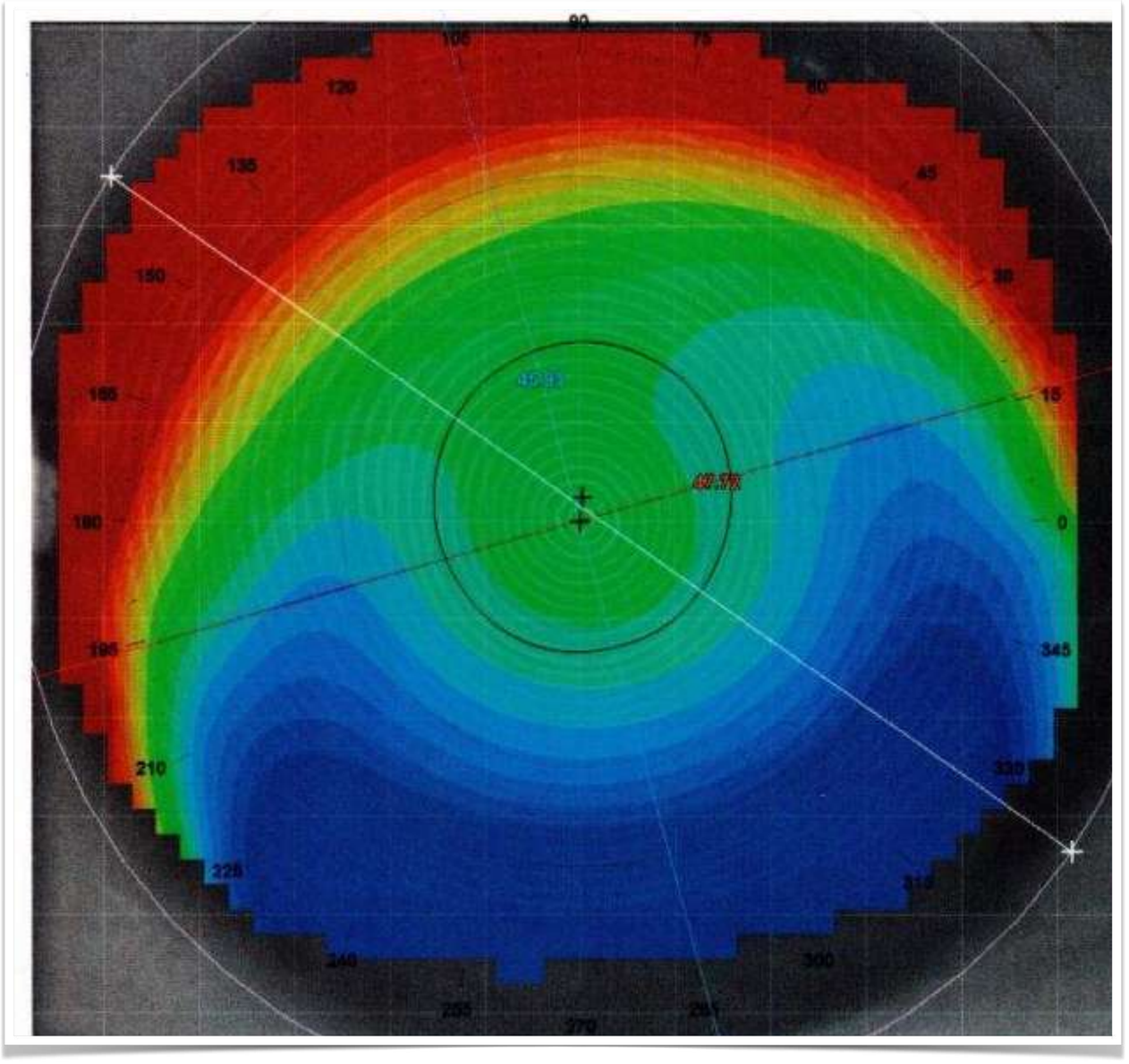
The case for a toric scleral lens

Dx: Keratoconus OD>>OS

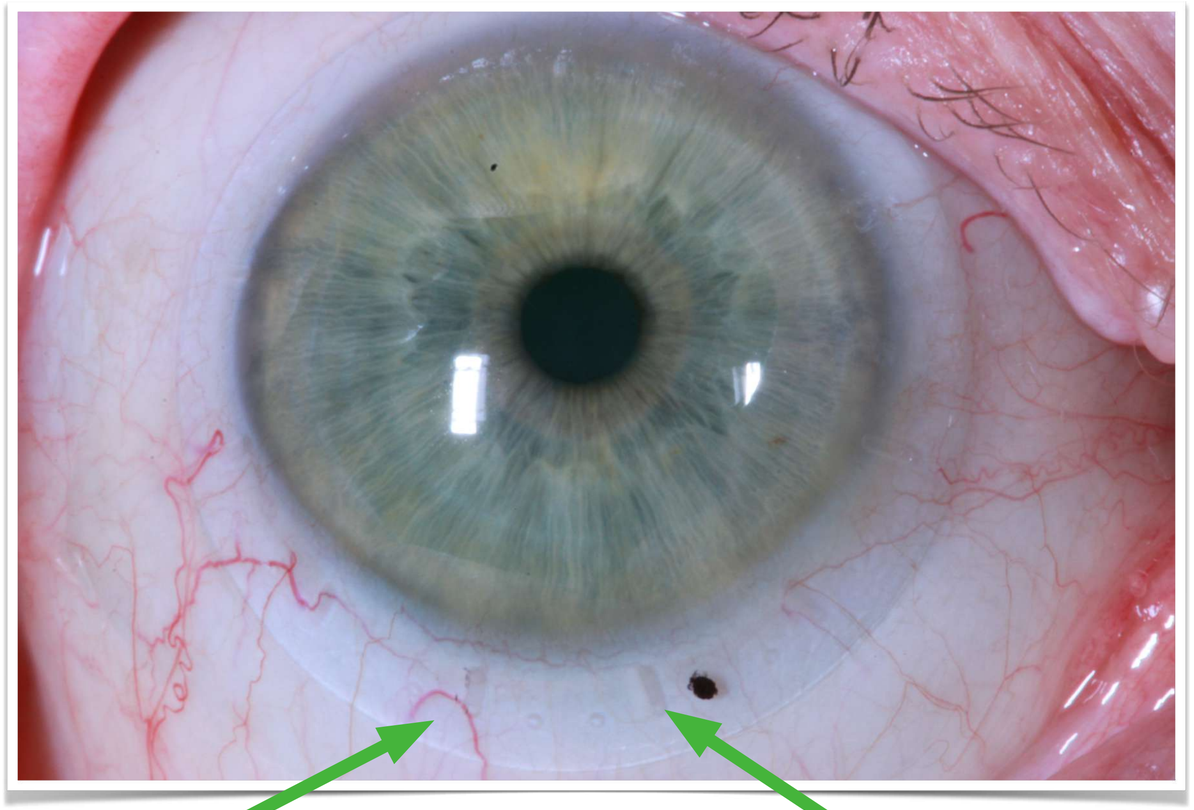
- 58 year-old Caucasian male
  - Hx - diabetes mellitus; hypercholesterolemia
  - Occupation - petroleum engineer
  - Hobbies - outdoorsman; hunting; fishing
  - Manifest refraction: OD —8.75-2.50 x 060; OS -2.00-3.50 x 100 BVA 20/20
  - Adult daughter also has KCN
  - Tried multiple lens designs - RGP; soft toric; hybrids

Before profilometry.....





Right eye

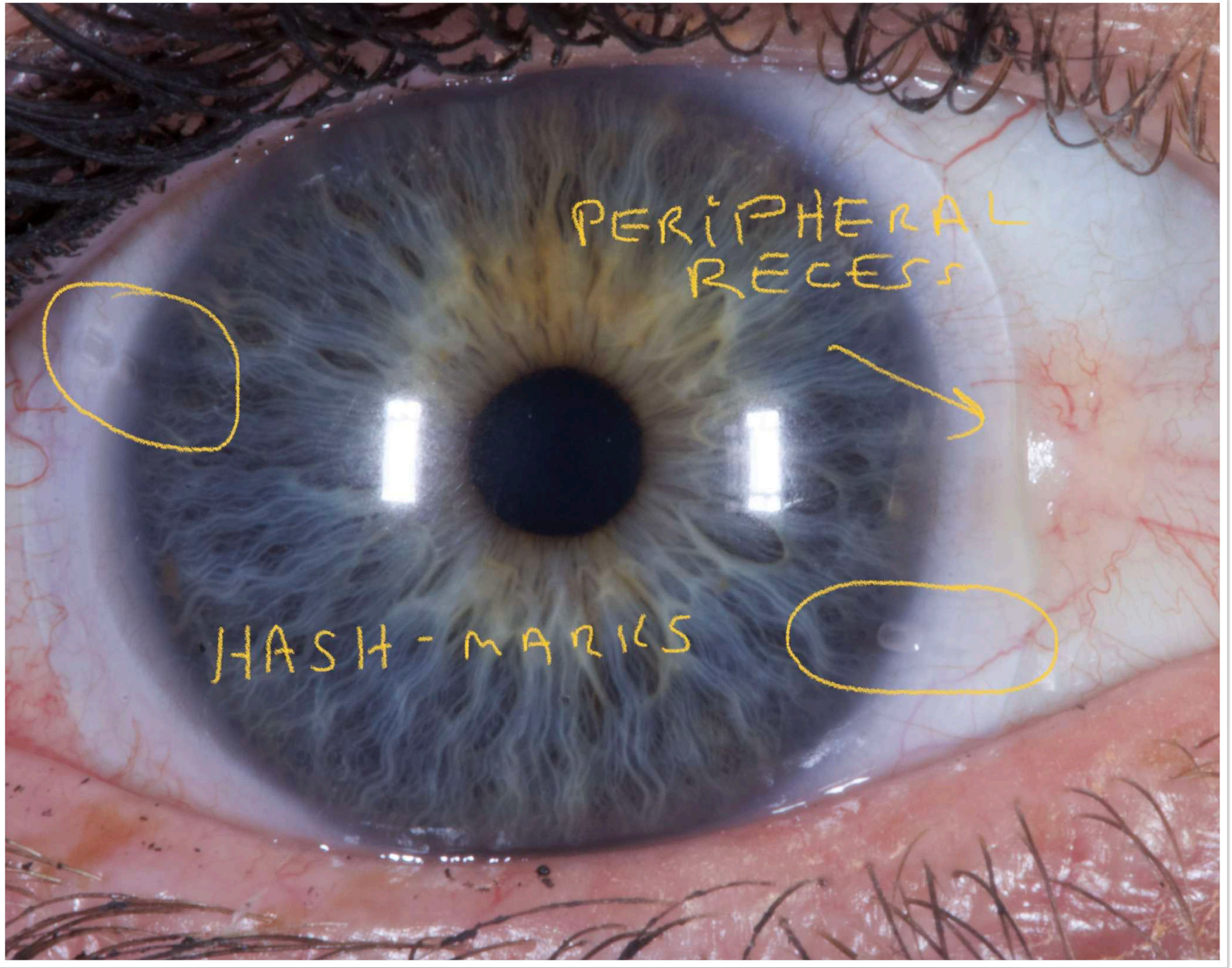


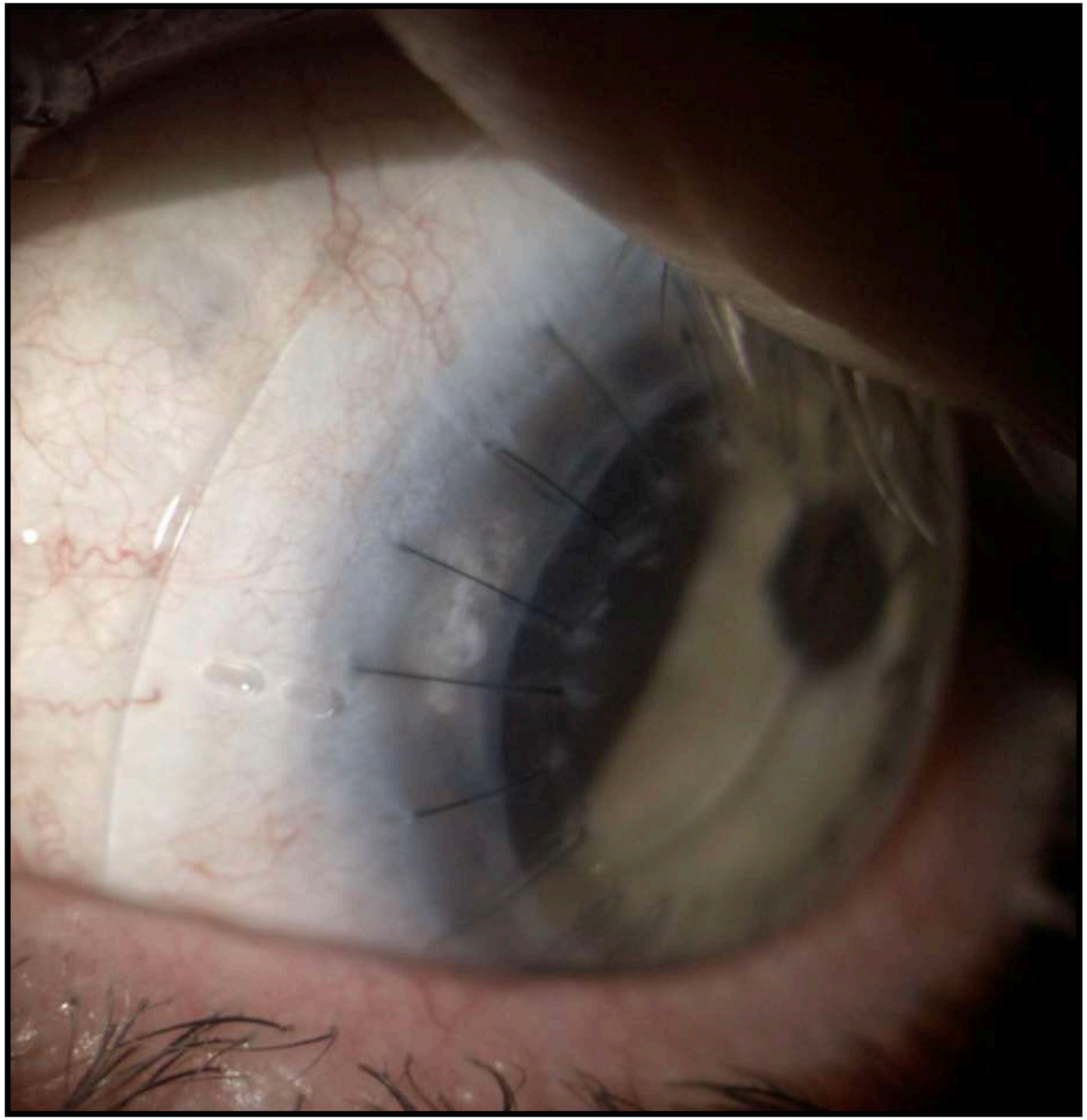
Note - hash marks

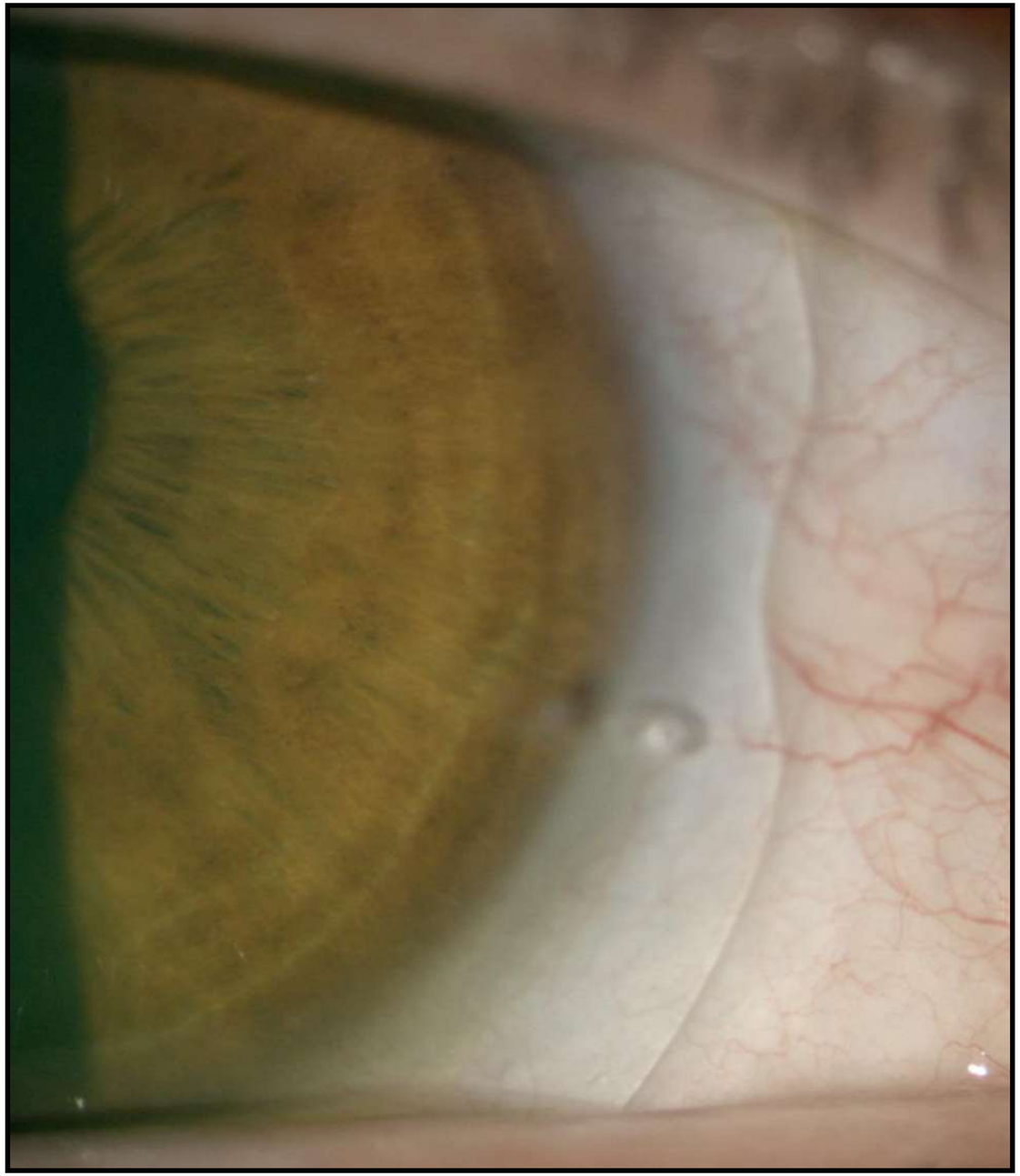
Small scleral lens: 7.40 BC/ Oblate 150 μm/14.9 OAD/
+0.75 -1.00 x 050
Limbus - XCL and toric (stabilizes cylinder)
Landing Zone (haptic) - spherical

[Note: oblate design (reverse curve) yields -6.00 diopters]

Stabilizing the Landing Zone (LZ)
w/ toric haptic & recess







REGISTRATION IS NOW OPEN!

International Congress of Scleral Contacts (ICSC) 2023

July 28-29, 2023

Fort Lauderdale Marriott Harbor Beach Resort

Thanks for listening

Tom Arnold
713-806-9160
tarnold@aegvision.com