Establishing a Solid Foundation: RGP Designs and Fitting

NCLE Level II - 2 hours

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Financial Disclosure Statement

Andrew Bruce . . .

- Has received honorariums from: VSP Optics
  Mitsui Chemicals
  Kaiser Permanente Vision Essentials
- Serves as a technical education advisor on CLSA Board of Directors
- Served on the Dispensing Optician Examination Committee for the Washington State Department of Health
- All relevant relationships have been mitigated
- Has NO financial interest in any product presented in this course

Outline/Objectives

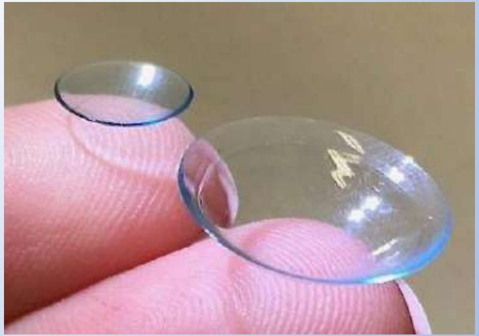
- Introduce the fundamentals of rigid contact lenses, and explore associated parameters and material characteristics
- Compare rigid fitting philosophies, and discuss the role of the keratometer and corneal topographer
- Discuss interpretation of K's for lens design selection
- Provide an overview of slit lamp biomicroscopy
- Present lens verification procedures
- Examine fluorescein patterns and present ways to improve the lens-cornea fitting relationship.

Introductory Topics

Evolution of Rigid Contact Lenses

- 1800 -1900s: First glass scleral designs
- 1934: PMMA replaced glass
- 1948: First corneal lens design
- 1978: First GP material for contacts.

Scleral vs. Corneal Designs



- 1st gen. scleral lenses: 18-20mm in diameter
- Corneal designs smaller than corneal diameter
- 9.2mm widely recognized as diameter of choice
- Which is better?

Benefits of a Scleral Design

- Mask corneal irregularities/injuries spread out over a large surface area of the cornea
- Mask corneal astigmatism
- Provide relief for patients with dry eye issues
- Excellent wearer comfort and easy adaptation.

Benefits of a Corneal Design

- Mask centrally located corneal irregularities
- Mask corneal astigmatism
- Facilitate a healthy corneal metabolism
- Easy handling.

Hybrid Design

- Economical - can run on gas or electricity!
- Rigid central area provides correction
- Soft carrier/skirt provides stability
- Improved comfort over traditional GP lens
- Can result in corneal neovascularization.

Piggy-Back Design

- GP fit over a soft lens
- Soft lens provides enhanced comfort and centration
- GP lens facilitates great vision
- Low “plus” SiHy recommended with high Dk GP.

Lens Materials

PMMA

Advantages

Excellent optical quality and wettability
Good deposit resistance
Good stability and durability
Relatively easy to manufacture
Can be cleaned, disinfected, modified

Disadvantages

Impermeable to oxygen and other gases (Dk = 0).

Rigid Gas Permeable Lens Materials (GP)

- GP materials are permeable to oxygen and other gases
- GPs reduce the potential corneal health risks associated with PMMA
- Currently, many GP materials available, some with very high permeability.

Cellulose Acetate Butyrate

- Late 70’s: first GP material
- Good wettability
- Good protein deposit resistance
- Affinity for lipid deposition
- Poor durability
- Low Dk (4 - 8).

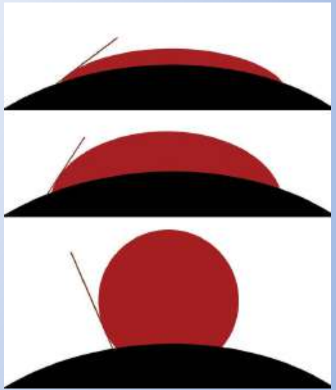
Silicone Acrylate

- Addition facilitated increased oxygen permeability by process of *diffusion*
- Higher Dk's than CAB became available
- Good dimensional stability with limited flexure
- Decreased optical quality over CAB and PMMA
- Inherently hydrophobic / poor wettability properties
- Prone to deposit accumulation.

Fluorosilicone Acrylate

- Added to minimize protein deposition, aid in oxygen transmission by process of *solubility*
- FSA gold standard of GP materials
- Facilitated very high Dk’s
- Proper combination of Si, Fl, and methacrylates for stability, improve wettability and deposit resistance
- Wettability issues still a daily struggle.

Surface Wettability



- Indicates how well tears spread across lens
- Determined by a material’s wetting angle
- With contacts, low wetting angle preferred
- Dry eye patients, especially, benefit from materials with good wettability properties.

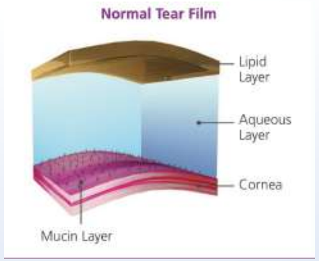
Surface Treatments

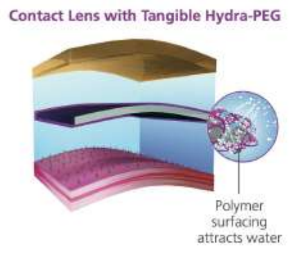
- Tear film deficiencies can cause anterior surface of contact lens to dry out, cloud over
- Lens surface can also accumulate deposits
- Lens material influences wettability and affinity for deposit accumulation
- Surface treatments can help prevent compromised acuities and wearer comfort.

Plasma Treatment

- Lens bombarded with high-energy radio waves in oxygen rich environment
- Surface molecules rearranged, become ionized
- Increases surface affinity to attract liquids
- Increases wettability and comfort, reduces fogging.

Tangible Hydra-PEG





- A 90% water polyethylene glycol (PEG) based polymer, permanently bonded to the contact lens surface
- Reportedly, the optically-clear coating encapsulates the contact lens with a mucin-like *hydrophilic* shell, separates it from ocular surface/tear film
- Further enhances wettability which improves tear breakup time, increases lubricity, reduces protein and lipid deposition.

Basic Terminology

Download "CL Terminology Handout: Expo West 2022" from *links* at . . .

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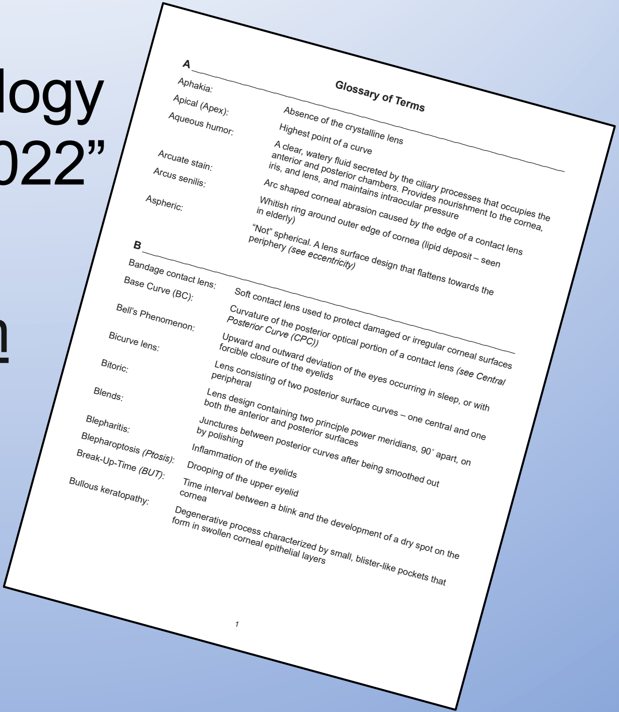
Glossary of Terms

A

Aphakia: Absence of the crystalline lens

Apical (Apex): Highest point of a curve

Aqueous humor: A clear, watery fluid secreted by the ciliary processes that occupies the anterior and posterior chambers. Provides nourishment to the cornea, iris, and lens, and maintains intraocular pressure

Arcuate stain: Arc shaped corneal abrasion caused by the edge of a contact lens

Arcus senilis: Whitish ring around outer edge of cornea (lipid deposit – seen in elderly)

Aspheric: "Not" spherical. A lens surface design that flattens towards the periphery *(see eccentricity)*

B

Bandage contact lens: Soft contact lens used to protect damaged or irregular corneal surfaces

Base Curve (BC): Curvature of the posterior optical portion of a contact lens *(see Central Posterior Curve (CPC))*

Bell's Phenomenon: Upward and outward deviation of the eyes occurring in sleep, or with forcible closure of the eyelids

Bicurve lens: Lens consisting of two posterior surface curves – one central and one peripheral

Bitoric: Lens design containing two principle power meridians, 90° apart, on both the anterior and posterior surfaces

Blends: Junctures between posterior curves after being smoothed out by polishing

Blepharitis: Inflammation of the eyelids

Blepharoptosis *(Ptosis)*: Drooping of the upper eyelid

Break-Up-Time *(BUT)*: Time interval between a blink and the development of a dry spot on the cornea

Bullous keratopathy: Degenerative process characterized by small, blister-like pockets that form in swollen corneal epithelial layers

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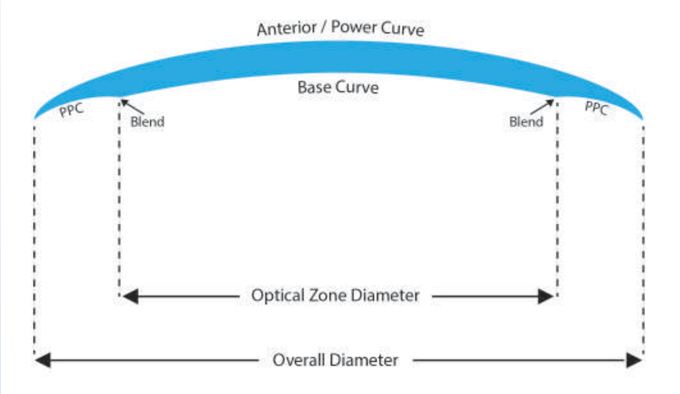
Optical Fundamentals of Rigid Lenses

Why Fit a Rigid Lens and Not a Soft?

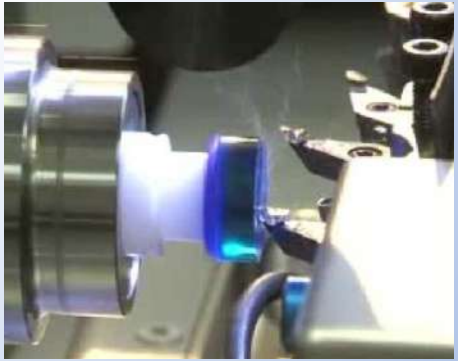
- Excellent optics
- Rigid properties mask corneal irregularities, provide a new primary refractive surface
- Lens refractive properties are combined with those provided by the lacrimal/tear lens
- Allow more precise management of an astigmatic cornea, neutralize corneal toricity
- Available in totally customizable parameters, a variety of materials, great precision.

Rigid Lens Parameters and Material Considerations

Base Curve (CPC)	Dk or Dk/t
Anterior / Power Curve	Color
Peripheral Curve (PPC)	Center Thickness
Overall Diameter (OAD/DIA)	Edge Design
Optical Zone Diameter (OZD)	Deposit Resistance
Material	Wetting Angle / Wettability

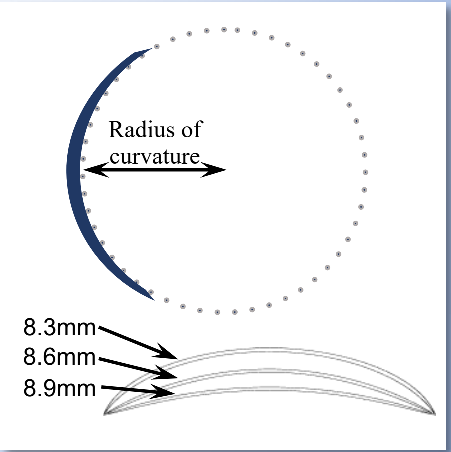


Rigid Lens Designs



Rigid Design	Calculated Residual Astigmatism	Corneal Toricity
Spherical	< 0.75	< 2.50
Front Surface Toric	> 1.00	< 1.00
Back Surface Toric	> 0.75 @ axis of k-toricity	> 1.50
SPE Bitoric	< 0.75	> 1.50
CPE Bitoric	> 0.75	> 1.50

Base Curve



- Posterior surface radius of curvature
- Based on corneal K's in diopters
- Fitting protocol: On K, FTK, STK
- Fitting philosophy influences BC selection.

Corneal Curvature Conversion

Surface Power Formula

$D = n-1 / r$

D = Corneal curvature in diopters
n = Refractive index of the tear film (1.3375)
r = Radius of curvature of cornea in mm
1= Refractive index of air

Ex: Convert K's of 44.50D to radius of curvature, in mm

Rearranging, $r = n-1 / D$

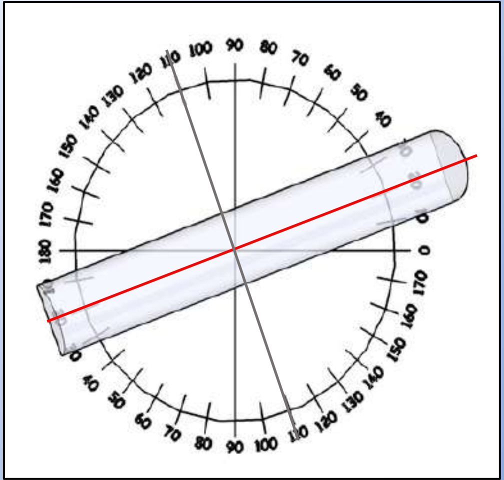
$$r = (1.3375-1) / 44.50$$

$$r = 0.00758 \text{ meters} = 7.58\text{mm}$$

To Simplify

- Radius of curvature in mm = 337.5 / curvature in diopters
- Curvature in diopters = 337.5 / Radius of curvature in mm.

Types of Astigmatism

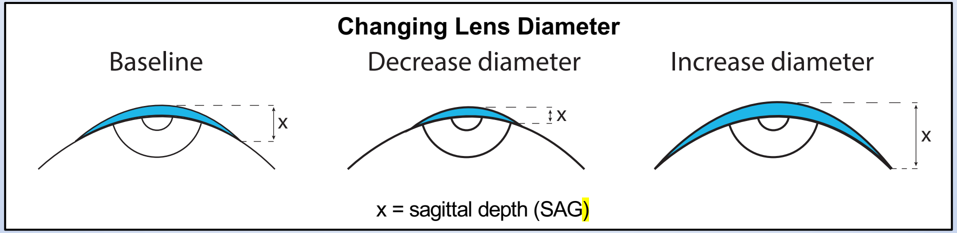


- Regular
- Irregular
- **WTR:** 001˚ to 030˚ & 150˚ to 180˚
- **ATR:** 060˚ to 120˚
- **Oblique:** 030˚ to 060˚ & 120˚ to 150˚

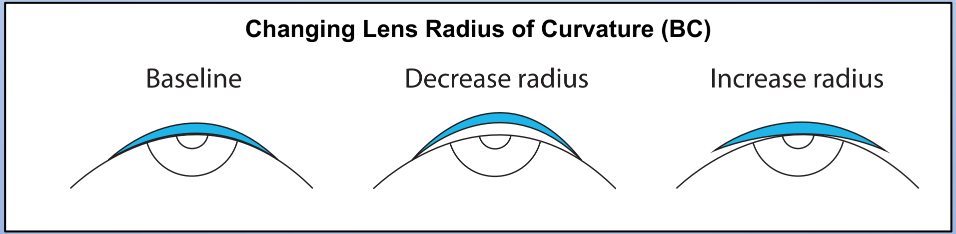
Lens Overall Diameter (OAD / DIA)

- OAD determined by HVID, lens type and design, and fitting philosophy
- Influences centration, stability, and overall fit.

Effects of Changing BC/OAD



- Influences sagittal depth (SAG)
- Increasing diameter tightens the fit
- Decreasing diameter loosens the fit



- Increasing radius of curvature loosens the fit
- Decreasing radius of curvature tightens the fit.

BC-DIA Relationships

Every 0.5mm diameter change requires 0.25D (0.05mm) change in base curve to maintain lens-cornea relationship

Corneal Cylinder	DIA: 8.5mm	DIA: 9.0mm	DIA: 9.5mm
PL to 0.50D	0.25D STK	On K	0.25D FTK
0.75 to 1.25D	0.50D STK	0.25D STK	On K
1.50 to 2.00D	0.75D STK	0.50D STK	0.25D STK
2.25 to 2.75D	1.00D STK	0.75D STK	0.50D STK
3.00 to 3.50D	1.25D STK	1.00D STK	0.75D STK

Mannis, MJ et al. Contact lenses in Ophthalmic Practice

GP Fitting

Importance of The Blink!

- Rigid lens has no water content
- Relies on blinking for ongoing spread of tears across lens surface
- Blinking also creates tear exchange behind lens to flush out debris, provide fresh tears
- Maintains healthy, hydrated cornea and lens.

Tear Break-Up Test

- Measures stability of tear film
- Important pre-fit assessment
  to determine suitability for lens wear
- Sodium Fluoride (NaFl) instilled, under diffuse illumination with cobalt filter, time for dark areas to form is recorded
- **Results:** < 10 seconds = borderline   < 5 seconds = abnormal.

Rigid Lens Fitting Approaches

- **Empirical:** Data based
  - Keratometry
  - Topography
- **Diagnostic:** Based on diagnostic lenses.

Rigid Lens Fitting Philosophies

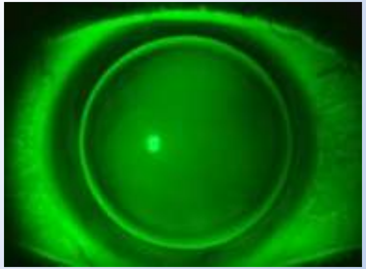
Apical clearance

- Designed to center on cornea, interpalpebral position
- Steep BC can result in flexure, unstable vision

Corneal alignment / Upper Lid Attachment

- Preferred approach
- Lens positions over superior cornea, influenced by upper lid
- Provides more stable vision, less flare, easier adaptation, reduced lid awareness, more natural blink rate, and less peripheral desiccation (drying).

Apical Clearance



Base curve: Steeper than flat K

Diameter: 8-9mm

Lens thickness: Thinnest possible without flexure.

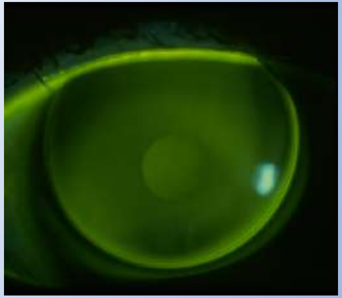
Corneal Cylinder	Base Curve
PL to 0.75D	0.25D STK
0.87 to 1.50D	0.50D STK
1.62 to 2.50D	0.75D STK
2.62 to 3.50D	1.00D STK
> 3.50D	Consider Toric BC

Contact Lens Manucal: CLSA

HVID	Lens Diameter
< 10.5mm	8.0mm
11.0mm – 11.5mm	8.5mm
> 12.0mm	9.0mm

Contact Lens Manucal: CLSA

Corneal Alignment or Lid Attachment



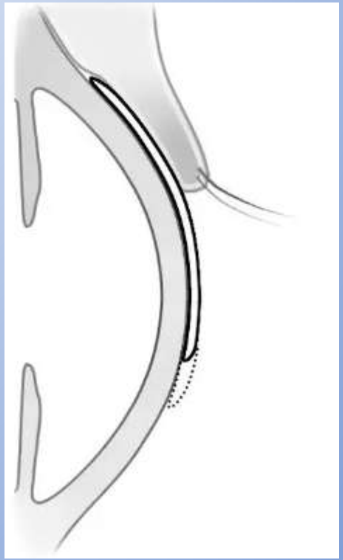
Base curve: 0.50D to 1.50D flatter than FTK

Diameter: 9.2 - 9.6mm (avg. 9.5mm)

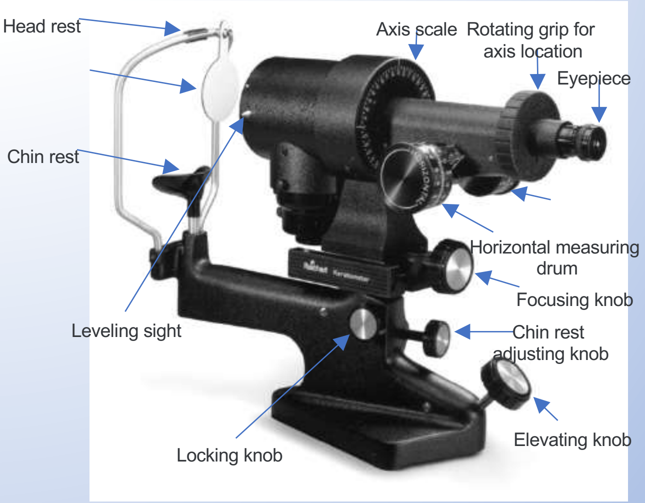
Lens thickness: minimum allowable for material.

Corneal Cylinder	Base Curve
PL to 0.75D	1.00D FTK
0.87 to 1.25D	0.75D FTK
1.37 to 1.75D	0.50D FTK
1.87 to 2.75D	0.25D FTK
2.37 to 2.75D	On K
2.87 to 3.50D	0.25 STK
> 3.50D	Consider Toric BC

HVID	Lens Diameter
< 10.5mm	9.2mm
11.0mm – 11.5mm	9.4mm
> 12.0mm	9.6mm

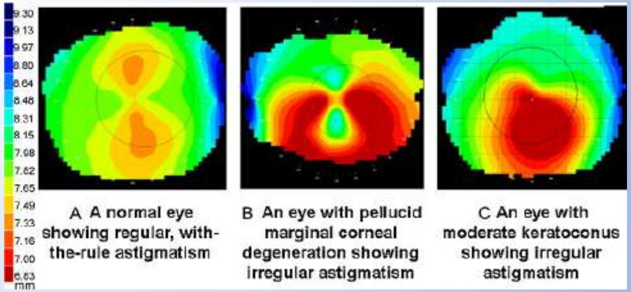


Keratometer



- Used to measure corneal curvature, central 3-4mm
- Range: 36.00D to 52.00D *(extendable)*
- Provides keratometry values (K's)
- Also used to evaluate tear film and soft lens fit.

Corneal Topographer



- Used to provide corneal "mapping"
- Broader coverage than a standard keratometer
- Provides detailed analysis of the overall corneal shape
- Very important when working with irregular corneas
- Vital for procedures such as ortho-k/refractive surgery.

Interpreting K's

Standard Notation
45.00 @ FTK / 46.00 @ STK
45.00 / 46.00 @ STK
(assumes axes 90 degrees apart)

- K's indicate corneal curvature in primary meridians
- Determines source of astigmatism: corneal/lenticular
- **Example Rx/K's:** -2.00 -2.50 x 090 44.00/46.50 @ 180
  - Refractive astigmatism = 2.50D
  - From K's, corneal astigmatism = 2.50D
  - All refractive astigmatism is corneal.

Base Curve and Diameter Selection

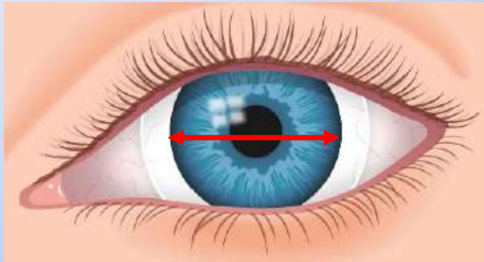
Base Curve Selection

- K’s indicate power meridians and source of astigmatism – corneal and/or lenticular
- K’s determine best suited lens type/design
- Fitting philosophy determines recommended BC range

Diameter Selection

- Influenced by HVID, lens type/design, fitting philosophy
- General starting point = HVID - 2.5mm.

Horizontal Visible Iris Diameter (HVID)



Classification:

Small	= 11mm
Medium	= 11.5mm
Large	= 12mm

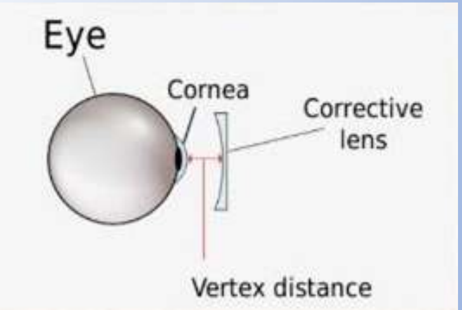
To measure: PD ruler

Graticule scale on slit lamp

Corneal topographer, AND ???

Soft lens of known diameter.

Vertex Distance and Effective Power



When and why is vertex distance important?

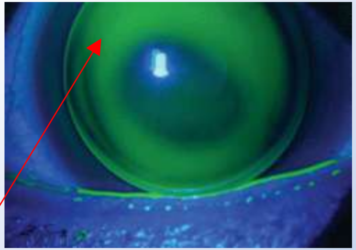
- Increase VD = increase in effective plus power
- Decrease VD = decrease in effective plus power
- Compensation recommended over +/- 4D

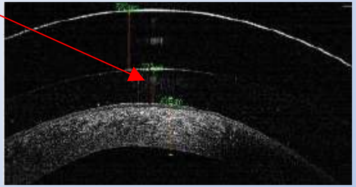
$$\text{Effective Power Formula} = \frac{\text{Original Power}}{1 + (\text{change in VD (m)} \times \text{Original Power})}$$

Determining Rigid Lens Powers

- Transpose to minus cylinder *(if necessary)*
- Compensate for changes in vertex power
- Determine astigmatism and its source
- Select design, based on magnitude/source of astigmatism
- Determine flattest meridian from K's
- Decide on initial BC selection, based on K's/philosophy
- Compensate for tear lens (SAM and FAP).

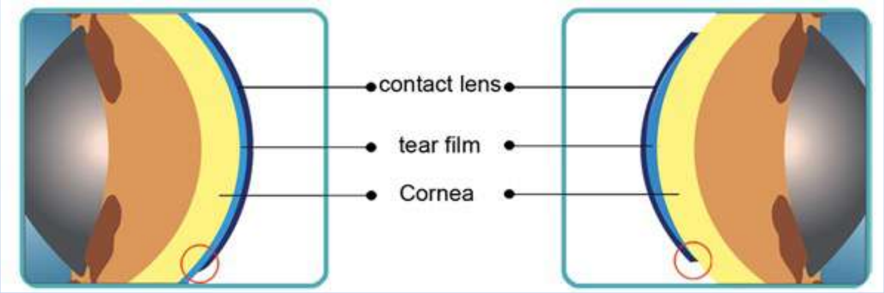
The Tear Lens





- A rigid contact lens “vaults” the corneal surface
- Creates a space filled with tears - the “tear lens”
- Combination of tear lens and rigid lens provide a crisp, clear refracting surface.

FAP: Flatter Add Plus
SAM: Steeper Add Minus



- Steeper BC = more central space / more tear lens
- Flatter BC = less central space / less tear lens
- Tear lens influences total refractive properties
- FAP/SAM used to compensate for changes.

Calculation Example

K readings: 44.00 / 45.00 @180
HVID: 11.5mm
Rx: -3.00 -1.00 x 180

- Type of astigmatism?
- Source(s) of refractive astigmatism?
- Determination . . .

For an *apical clearance fit* with 1.00D of corneal astigmatism:

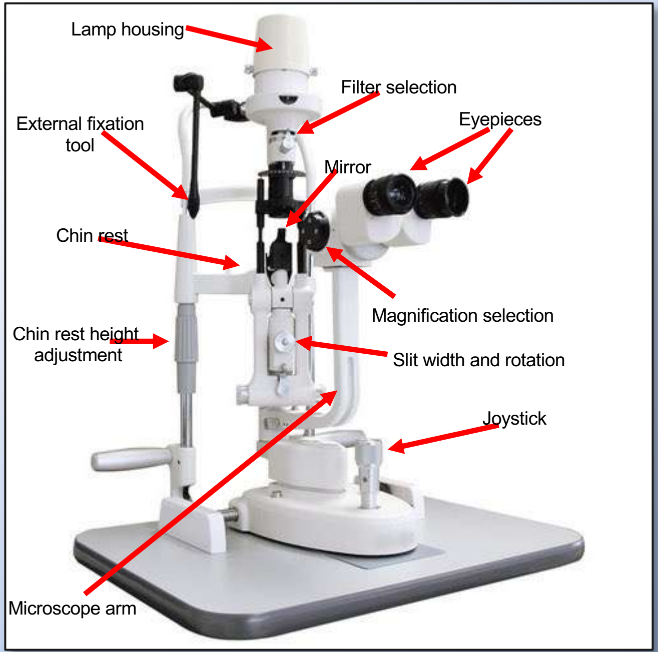
- Fit lens 0.50D STK
- Going steeper adds minus (SAM)

Lens BC and power? 44.50D **(7.58mm) / -3.50D**

Appropriate diameter: 8.5mm *or* 9.5mm? **8.5mm**

Slit Lamp Biomicroscopy

Slit Lamp Biomicroscope



- Permits magnified eye health examination, using various kinds of illumination

- Three main parts:
  - Illumination system (illumination arm)
  - Observation system (viewing arm)
  - Mechanical system (base).

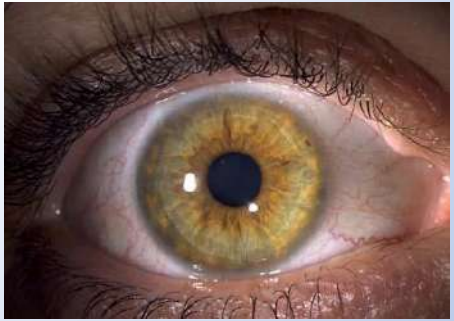
Viewing/Illumination Techniques

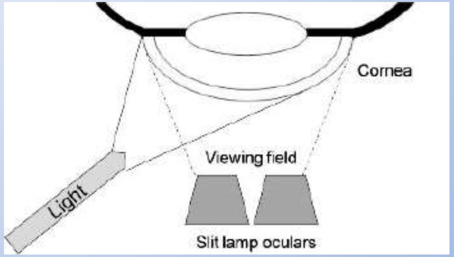
Direct: Viewing structures within the focused light
Indirect: Viewing structures not within the focused light

Illumination types vary with . . .

- Positioning
- Beam size, width, and shape
- Point of focus.

Diffuse

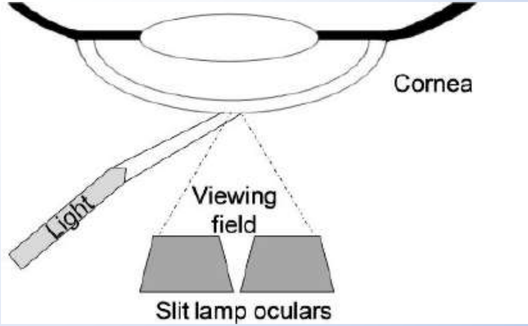




Courtesy of Craig Norman

- Broad uniform view
- Recommended 45˚angle between oculars and beam
- Slit width: wide open
- Low magnification
- Low beam intensity.

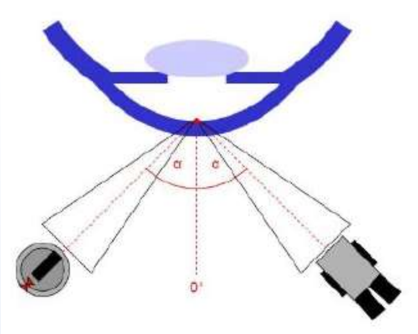
Direct Focal



Courtesy of Craig Norman

- Oculars viewing where beam focused
- Type varies with beam size:
  - **Optic section:** small, thin beam
  - **Parallelepiped:** larger/thicker, most common with contacts
- Magnification: med to high
- Beam intensity: med to high.

Specular Reflection



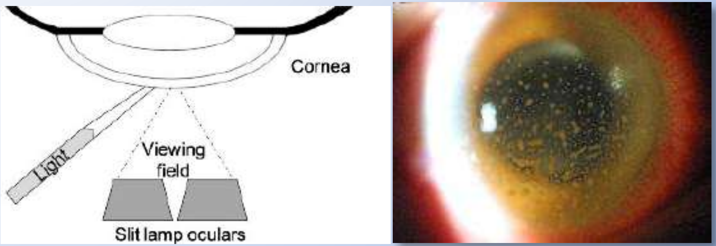
Courtesy of Zeiss

- Type of “Direct Focal”
- Used to evaluate tear film
- Beam and oculars set up so angle i = angle r
- Magnification = med to high
- Slit width: moderate
- Illumination: high.

Indirect and Retro

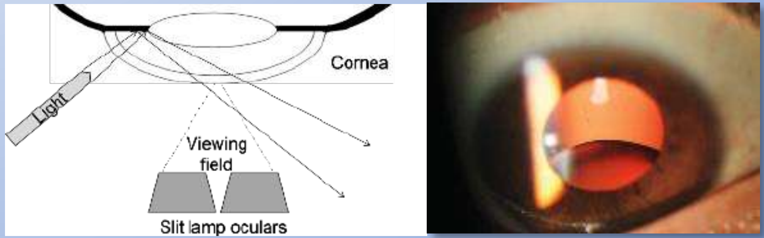
- Most common for clinical use to view foreign bodies, corneal infiltrates, neovascularization, corneal edema, etc.
  - Slit width: 2-3mm
  - Magnification: med to high
  - Illumination: high.

Indirect Illumination



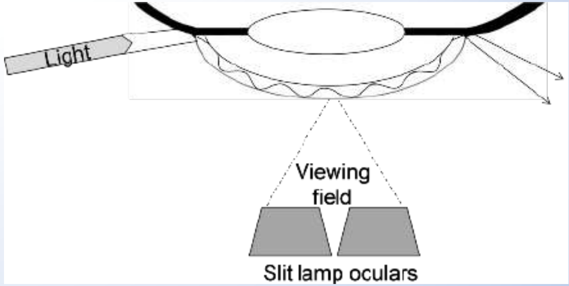
Courtesy of Craig Norman

Retro Illumination



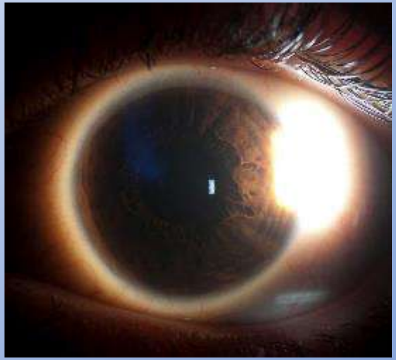
Courtesy of Craig Norman

Sclerotic Scatter



Courtesy of Craig Norman

- Form of "indirect"
- Used to detect central corneal edema
- Beam directed at a 90˚angle to limbus, scattered through cornea
- Viewed with naked eye
- Illumination: maximum
- Slit width: narrow.



Verification Procedures

Lensometry

INDUSTRY STANDARD: BACK VERTEX POWER
(CONVEX SIDE UP)

Lens Design	Lensometer Readings	Notation
Spherical	Spherical	Power Drum Reading
Back Surface Toric	2 Different Power Readings 90° apart No Prism	Drum Readings in Both Meridians No Axis
Front Surface Toric	2 Different Power Readings 90° apart Prism Present	Sphere Cylinder Axis (Same as Glasses)
Bitoric	2 Different Power Readings 90° apart No Prism	Drum Readings in Both Meridians No Axis

Radiuscope Interpretation

The Drysdale Principle
Measures the distance between lens surface and its center of curvature

- Single BC with no prism from lensometry = **Spherical**
- Single BC with prism from lensometry = **Front Surface Toric**
- If NO prism and 2 different meridians, convert BC readings to diopters and compare to lensometry:
    - If BC toricity x 1.5 = Refractive Cylinder: **Back Surface Toric**
    - If BC toricity = Refractive Cylinder: **SPE Bitoric**
    - If neither apply: **CPE Bitoric.**

Example
Back Surface Toric

- From lensometry: -4.00 / -5.50, no prism
- From radiuscope = 7.67mm / 7.50mm *(convert to diopters)*
- Using D = 337.5/r: BC = 44.00D / 45.00D

FINDINGS

- Refractive toricity = **1.5D** Surface toricity = **1D**

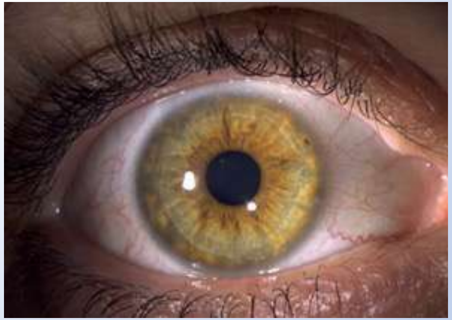
Surface toricity ≠ refractive toricity, so <u>NOT</u> a SPE bitoric

Surface toricity x 1.5 = 1.5 = refractive toricity

<u>Therefore, lens is a back surface toric.</u>

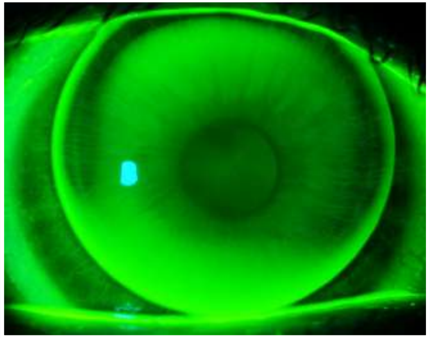
Fitting Evaluation and Follow Up Care

Gross Evaluation

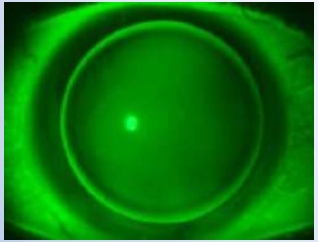


- Allow at least 15 mins for lenses to equilibrate
- Using diffuse illumination, evaluate centration/movement
- Document any misalignment
- Instill Sodium Fluorescein in tears, add cobalt blue filter
- Evaluate fluorescein pattern and fit
- Identifies how closely lens BC aligns corneal curvatures.

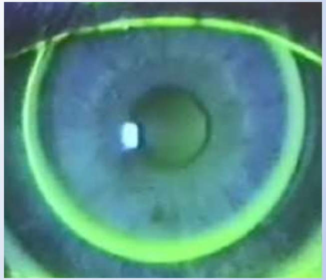
Fluorescein Evaluation



- Cobalt blue filter “excites” fluorescein in tears *(enhance with Wratten #12 yellow)*
- Becomes brilliant fluorescent green where tears present
- Variations in intensity of ”green” indicate how much space is between contact lens and cornea . . .
    - More-green = More space *(more tears)*
    - Less-green = Less space *(fewer tears)*
- *NOTE: even in absence of green glow, pre-corneal tears still present.*



What To Look For



General

- Uniform tear film, central clearance with touch in mid-periphery, adequate edge lift

Apical Clearance Fit

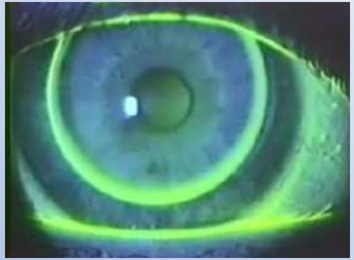
- Good central pooling, slightly less in transitional zone
- More intense fluorescein in periphery

Corneal Alignment/Lid Attachment Fit

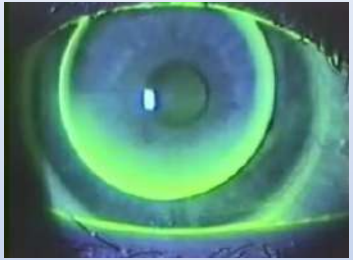
- Minimal central pooling, uniform tear film
- Adequate edge lift.

Fluorescein Patterns

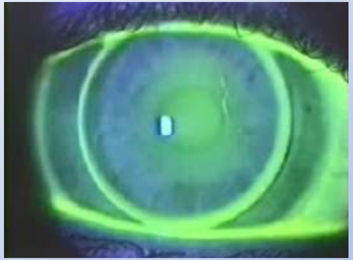
On K



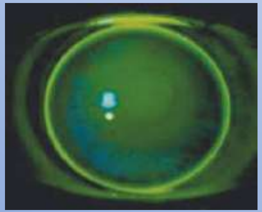
1D flatter than K



1D steeper than K

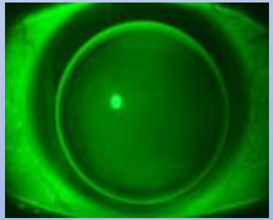


Spherical lens
spherical cornea

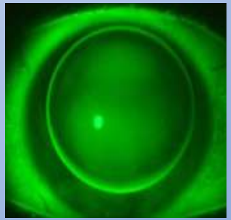


Spherical lens
WTR cornea

Inferior
decentered



Superior
decentered



Lens Centration and Movement

RULE OF THUMB
Lens will center over steepest curve, especially with irregular corneas

Apical Clearance Fit

- Should stabilize, centrally
- Remain relatively central during 4-6 sec blink
- Lens excursions approx. 1.5mm with blink

Corneal Alignment/Lid Attachment Fit

- Lens moves only with blink, lifts, and re-centers
- No drag or excessive “floating” around.

Correcting For Lens Decentration

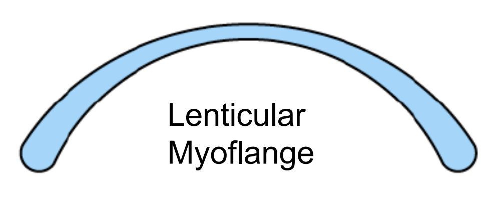
General Lateral Decentration

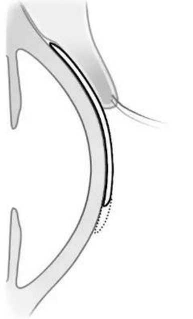
- Steepen BC
- Increase OAD or OZD
- Steepen peripheral curves
- Consider edge/center thickness
- Consider ATR astigmatism

Apical Clearance Fit

- *Superior decentration:* reduce OAD, steepen BC, change SG or RI
- *Inferior lens drop:* increase OAD, steepen BC if pattern indicates flat, flatten BC if pattern indicates steep, change SG or RI.

Correcting For Lens Decentration (cont.)





Corneal Alignment/Lid Attachment Fit

- *Superior decentration:* steepen BC, decrease OAD or OZD, flatten peripheral curves, change SG or RI
- *Inferior lens drop:* increase OAD or OZD, steepen BC if fluorescein indicates flat, flatten BC if indicates steep, change SG or RI
- Relies on interaction between upper lid and lens, consider . . .
  - Hyperflange lenticular or CN bevel recommended with high minus
  - Myoflange lenticular recommended with high plus.

Prepare Patient For Success

Provide Detailed Care/Maintenance Instructions

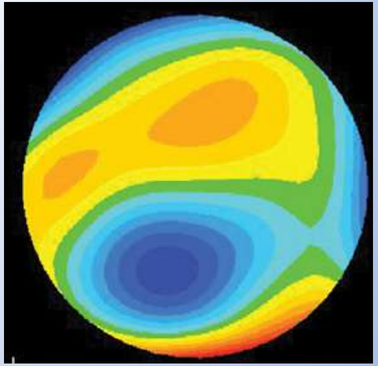
- Brand name solutions for cleaning, disinfection, rinsing
- Routine case replacement
- The “Dos and Don’ts” of contact lens wear

Recommended Follow-Up Protocol

- 1-3 months after finalized
- 6-12 month intervals after successful.

What's New and Exciting?

Free-form Contact Lenses



- Correct for high order aberrations (HOAs)
  - Currently, only available for scleral lenses
  - Aberrometer over manufacturer's diagnostic lens measures the HOAs
  - Software translates data, free-form lathe fabricates lens design, powers, and neutralizes HOAs
  - What does this mean for the patient?

To Take Away . . .

- Despite the popularity of soft lenses, don’t forget the benefits GPs can provide your patients
- Try not to be intimidated by the fitting and follow-up process
- Embrace every chance you get to work with GPs as an opportunity to expand your skill set and provide your patients with great vision.

Resources

GP Lens Institute: www.gpli.info

Valley Contax: www.valleycontax.com

Andrew S. Bruce

Thank You!

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