What is a scleral lens?

- A gas permeable lens which vaults the cornea and lands on the sclera.

History

- 1508 – Leonardo da Vinci
- Late 19th century – Scleral lenses made from glass
- 20th century – Carl Zeiss experimented with plastic scleral lenses
- 1939 – Thier: Fitting of polymethyl methacrylate (PMMA)
- 1983 – Ezekiel first to use gas permeable materials

Indications

- Corneal ectasia
  - Primary ectasia – Keratoconus, pellucid marginal degeneration
  - Secondary ectasia – Post-refractive surgery ectasia
- Corneal scarring
- Aphasia
- Corneal degenerations or dystrophies

Indications

- Ocular surface protection
- Dry eye disease
- Exposure keratitis
- Sjogren's syndrome
- Stevens-Johnson Syndrome
- Graft vs. Host Disease
- Ocular exudative pemphigoid
- Recurrent corneal erosion

Financial Disclosures

- STAPLE Program Speaker
- Soft Toric and Presbyopic Lens Education Speaker
- Gas Permeable Lens Institute (GPLI) Speaker
- Visionary Optics Speaker
- NIH/NEI R01EY019105 (RAA and JDM) Funding
Indications

- Eyelid conditions
  - Incomplete lid closure
  - Eyelid coloboma
  - Enophthalmos
  - Ectropion
  - Lid retraction surgery
  - Trichiasis
  - Entropion

- Vision Improvement
  - Myopia
  - Hyperopia
  - Corneal astigmatism
  - Presbyopia

- Cosmetics/Sports
  - Hand-painted scleral lenses
  - Amniotic date
  - Albinism

- Does not induce corneal warpage (curvature change)
  - Great for “healing” warped corneas
  - Orthokeratology
  - Warped GP lens
  - PMMA lens wear

Classification

<table>
<thead>
<tr>
<th>Description</th>
<th>Bearing Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corneal</td>
<td>Lens rests on cornea</td>
</tr>
<tr>
<td>Corneo-scleral</td>
<td>Lens rests in part on</td>
</tr>
<tr>
<td>Scleral</td>
<td>cornea and in part on</td>
</tr>
<tr>
<td>Mini-scleral</td>
<td>sclera</td>
</tr>
<tr>
<td>Large scleral</td>
<td>Lens diameter &gt; 6 mm than HVID</td>
</tr>
</tbody>
</table>

Patient expectations

- Scleral lenses are comfortable
- Little to no movement
- Lens will not pop out
- Protection from environment
- Vision equal or improved to corneal gas permeable lenses
  - Larger optic zone
  - Minimal movement
  - Does not have image bounce

- Lens fit to the scleral
- No interaction with sensitive corneal nerves
- Edge tucked underneath upper lids
  - Provides improved comfort
Challenges

- Handling
  - Insertion and removal more difficult
  - Apprehension with new lens/technique
  - Dexterity (Parkinson's/tremors)
  - Eyelid apertures
- Fitting
  - Learn to fit different part of eye
  - Increased chair time initially
- Expense
  - Fitting and materials more expensive
  - Increase in medically necessary claims
    - Target for insurance companies (AUDITS!)
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Scleral Lens Layout

- Optic Zone
  - Provides optical correction
  - Aspheric or spherical optics
  - Comptonically vaults cornea and limbus
- Transition Zone
  - Consists of mid-periphery/intermediate/limbal zone
  - Gives the lens sagittal height
  - Reverse geometry profile

Scleral Lens Layout

- Scleral Zone
  - Aligns with the bulbar conjunctiva
  - Usually two or more PCs
  - Distributes pressure evenly over conjunctiva

Corneal GPs vs. Sclerals

<table>
<thead>
<tr>
<th></th>
<th>Corneal GPs</th>
<th>Scleral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial comfort</td>
<td>Poor</td>
<td>Very comfortable</td>
</tr>
<tr>
<td>Visual acuity</td>
<td>≥</td>
<td>≥</td>
</tr>
<tr>
<td>Corneal astigmatism</td>
<td>Limited</td>
<td>No limit</td>
</tr>
<tr>
<td>Corneal Staining</td>
<td>Possible</td>
<td>No corneal staining</td>
</tr>
<tr>
<td>Patient Handling</td>
<td>Easier</td>
<td>More difficult</td>
</tr>
<tr>
<td>Designs</td>
<td>Front toric / Bitoric</td>
<td>Toric Periphery</td>
</tr>
</tbody>
</table>

KEY POINT: IMPROVED COMFORT WITH SCLERALS
Hybrids vs. Sclerals

<table>
<thead>
<tr>
<th></th>
<th>Hybrids</th>
<th>Piggyback</th>
<th>Sclerals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial comfort</td>
<td>=</td>
<td>=</td>
<td>=</td>
</tr>
<tr>
<td>Long-term comfort</td>
<td>=</td>
<td>=</td>
<td>Could be an issue</td>
</tr>
<tr>
<td>Visual acuity</td>
<td>For regular corneas only</td>
<td>Limited by high corneal irregularity</td>
<td>More parameters available</td>
</tr>
<tr>
<td>Patient handling</td>
<td>Varies patient to patient</td>
<td>High</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Cost</td>
<td>Typically more costly than a corneal GP</td>
<td>Higher (lenses/solutions)</td>
<td>Lower</td>
</tr>
<tr>
<td>Clinical application</td>
<td>Limited to normal cornea</td>
<td>Limited to KC &amp; Post Refractive</td>
<td>Fully customizable</td>
</tr>
</tbody>
</table>

**KEY POINT:** HYBRIDS DO NOT PROVIDE TEAR RESERVOIR

Piggyback vs. Sclerals

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<tr>
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<th>Sclerals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial comfort</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Long-term comfort</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Visual acuity</td>
<td>GP can decenter</td>
<td>Stable, better VA</td>
</tr>
<tr>
<td>Patient handling</td>
<td>Cumbersome</td>
<td>Special techniques</td>
</tr>
<tr>
<td>Cost</td>
<td>Higher (lenses/solutions)</td>
<td>Lower</td>
</tr>
<tr>
<td>Convenience</td>
<td>Less</td>
<td>More</td>
</tr>
</tbody>
</table>

**KEY POINT:** PIGGYBACK LESS CONVENIENT

2 sets of lenses/solutions

Scleral anatomy

- Extraocular muscles
- Largest diameter = 24 mm
  - Medial rectus
  - Lateral rectus
  - Superior rectus
  - Inferior rectus

Corneoscleral Profile

- Daniel Meier
- Proposed five transition zones
  1. Gradual transition/convex
  2. Gradual transition/tangential
  3. Marked transition convex
  4. Marked transition tangential
  5. Convex cornea/concave sclera

Scleral Shape

- Nasal portion usually flatter
- Larger temporal angle
- Sclera non-symmetrical
- Incorporate toricity for lenses larger than 15.0 mm
- Cause scleral lenses to decenter inferior/temporal

The areas of least scleral depth (nasal and superior) are where the scleral lens will “land” first. The lens will search for its resting point of equilibrium and move in the direction of greatest depth, the areas of least mechanical resistance.
Average Conjunctival Curve at 15mm

Average Conjunctival Curve at 20mm

Average

Photo: M. Lipson OD

Almost symmetric

Limbal Angle
10.0 - 15.0 mm

Scleral Angle
15.0 - 20.0 mm

Highly asymmetric

Selecting a fitting set

• Select the appropriate fitting set
• Considerations:
  • Overall diameter
  • Prolate vs. oblate cornea topography
  • Laboratory warranty/exchange policy
  • Direct vs. indirect control

Fitting a Scleral Lens

• 1. Check Overall Diameter
• 2. Evaluate Central Clearance
• 3. Evaluate Limbal Clearance
• 4. Evaluate Landing Profile
• 5. Over-refract and order
Fitting a Scleral Lens

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Step 1. Check Overall Diameter

- HVID – corneal diameter
- Ocular health
- Type of cornea/ocular surface
- Endothelial cell layer status
- Potential troubleshooting issues
- Handling
- Risk/benefits ratio

Sagittal Depth: Diameter vs BC

- Understanding sagittal depth (Sag)
- With same diameter:
  - Steeper BC = higher sag value
- With same BC:
  - Larger diameter = higher sag value

Large Diameter Lens Characteristics

- Cover the cornea and a large portion of the conjunctiva
- Better option to restore ocular surface and to treat severe dry eyes
- 90%: May need Toric Peripheral Curves (Visser, OVS 2013)
- Spherical peripheral curves may exhibit:
  - Lens decentration/misalignment
  - Discomfort/localized edema
  - More debris in the reservoir
- Application issues – Require larger opening

Clinical Indications: Mini-Sclerals

- Low to moderate corneal irregularity
- Keratoconus, dystrophies, etc.
- Post-surgical (RK, PKP, Intacs, LASIK, PRK, LASEK)
- For post-graft evaluate endothelial cell count before considering scleral lenses
- High refractive errors - including presbyopia
- Sports
- Allergy control
Selecting the First Trial Lens

- Select trial lens #1 considering...
  - Sagittal height & overall corneal profile
  - Manufacturer's algorithm?
  - Avoid spending too much time choosing.

What's the easiest method of choosing trial #1? …

Fitting a Scleral Lens

- 1. Check Overall Diameter
- 2. Evaluate Central Clearance
- 3. Evaluate Limbal Clearance
- 4. Evaluate Landing Profile
- 5. Over-refract and order

Step 2. Evaluate Central Clearance

- Evaluate overall corneal chamber appearance
- Setup: Diffuse beam, low mag, medium illumination
- Then: Observe centration, areas of bearing, tear lens appearance, look for bubbles

Images courtesy of Chris Gilmartin

Application Bubble

- Evaluate central clearance
- Setup: Optic section, med mag, high illum, off axis
- Then: Compare lens thickness (black) to tear lens thickness (green) and estimate the central clearance in microns.
How much do scleral lenses settle?

A Comparison of the Short-Term Settling of Three Scleral Lens Designs

How much do scleral lenses settle?

What’s the ideal clearance?

Lens materials

- High and ultra-high Dk materials are important
- Center thickness increases towards periphery
- Dk/t decreases as lens thickness increases
- Examples:
  - Boston XO, Boston XO2
  - Optimum Extra, Optimum Extreme, Tyro-97
  - HDS 100

Scleral lens clearance

Acceptable clearance: Too little clearance:
How to maximize oxygen permeability

- Select maximum Dk for gas permeable material
- Decrease tear clearance behind lens
- Decrease center thickness of lens

What’s the ideal clearance?

- Ideal clearance:
  - Low: 50-100 µm
  - Moderate: 100-250 µm
  - High: 250-400 µm

Fitting a Scleral Lens

- 1. Check Overall Diameter
- 2. Evaluate Central Clearance
- 3. Evaluate Limbal Clearance
- 4. Evaluate Landing Profile
- 5. Over-refract and order

Step 3. Evaluate the limbal clearance

- Then evaluate the rest of the corneal chamber.
- Setup: Optic section (same settings as before)
- Then: Sweep limbus to limbus noting tear lens thickness. Tear lens should appear when the optic section is beyond (outside) the limbus and should gradually increase in thickness toward the central cornea.

*Adequate limbal clearance is critical for an acceptable fit and good tear exchange!*
Fitting a Scleral Lens

- 1. Check Overall Diameter
- 2. Evaluate Central Clearance
- 3. Evaluate Limbal Clearance
- 4. Evaluate Landing Profile
- 5. Over-refract and order

Step 4. Evaluate Landing Profile

- Evaluate the conjunctival (scleral) fit
- Setup: Diffuse beam, low to med mag, med illumination.
- Then: Observe the bulbar conjunctival vessels. Look for areas of blanching => inappropriate scleral curve alignment. Blanching usually (not always) indicates a PC is too tight. Ideal alignment is indicated when vessels course unobstructed under the scleral curves.
- Always observe the peripheral fit from outside the slit lamp as well.

Over-refraction

- Perform over-refraction (OR)
- Expect close to spherical OR
- If OR yields significant cylinder => think flexure
- Do over-keratometry or over-topography
- Don’t forget about potential “internal” astigmatism
Design & Order Lens

- You'll often need to modify the fit of the best trial lens
- Don't be afraid to use your friendly fitting consultant!
- Remember some designs allow for more direct control
- Ask about warranty details before ordering

Cleaning, Disinfection & Filling Solutions

Application – Solutions

- Non-preserved saline solution
- Unisol4 – No longer available
- Addipak – 0.9% Sodium Chloride inhalation solution
- Purelens
- LacriPure
- ScleralFil
- Avoid aerosol saline

Other solutions

- Additional options for deposit buildup
- Examples:
  - Optimax Extra Strength Cleaner (ESC)
  - Progent (Menicon)
Management of common scleral lens complications

Insertion bubbles
- Small vs. large bubbles
- Inadequate lens insertion
- Poor fit (especially periphery)
- Switch to more viscous filling solution

Application Bubble

Fogging
- Particular buildup in fluid reservoir
- Bilateral, asymmetric appearance
- Occurs mid to late in the day
- More common with:
  - Atopy
  - Ocular surface disease
  - Post-surgical cornea
- May improve over first month

Image courtesy of Maria Walker
Fogging

- May be caused by excessive central/limbal clearance
- Debris characteristics:
  - Mucus – small, white, fluffy
  - Atopic – diluted milk appearance
  - Oil droplet – oil over water

Excessive central clearance

- Troubleshoot: Decrease clearance

Images courtesy of Maria Walker

Excessive limbal clearance

- Troubleshoot: Decrease limbal clearance

Images courtesy of Maria Walker

Keratitis

- Microbial keratitis
- Infiltrates
- Not as common
- Long-term lens wear in healthy corneas unknown
- Increased risk extended wear

Hypoxia/Edema

- Satter's veil
- Endothelial cell count < 1,000 cells/mm²
- Lens design:
  - High-Dk material (150-170 range)
  - Reduced lens thickness (250 µm)
  - Minimal lens clearance (200 µm)

Lens adhesion

- Following prolonged wear time
- Discomfort
- Flexure
- Low central clearance/steep landing zone
Tight Lens Syndrome

- Comfortable initially
- Painful after 4-6 hours
- Difficult to remove lens
- Conjunctival hyperemia/chemosis
- Flatten peripheral curves
- Reduce central clearance

Wettability

- Initial non-wetting
- Plasma treatment
- Add extra strength clearance
- Hydrogen peroxide
- Progent
- Lens material

Bulbar Hyperemia

- Landing zone profile does not align to conjunctiva
- Lens lands on cornea and/or limbus
- Mechanical stress
- Toxic reaction
- After removal

Conjunctival Blanching

- Pressure on conjunctiva
- Sectoral or circumcorneal
- May need to increase landing zone surface area

Conjunctival Prolapse

- Aka conjunctival chalasis
- Loose conjunctiva drawn underneath lens
  - Negative pressure
  - Neovascularization under prolapse
  - Adjust limbal clearance

Corneal staining

- Mechanical
- Toxic reaction
- Epithelial bogging
Epithelial “Bogging”

Conjunctival elevations

- Pinguecula
- Pterygium
- Trabeculectomy (bleb)
- Notch
- Microvault
- Precision Lift
- Change diameter

Scleral elevations

Calculating the Notch
Surface Non-Wetting/Debris

- Hand contact lens coating
- Great for dry eye patients
- Increases wettability
- Minimizes deposit build-up

Is an OCT required for scleral lens fitting?
- No!
Mapping the Sclera

- sMap3D (Visionary Optics)
- Eye Surface Profiler (Eaglet Eye)

Toric scleral lenses

- Back surface toric provides better fit and comfort
- Available design options:
  - Front surface toric
  - Back surface toric
  - Bitoric
  - Quadrant specific

Range

- By combining several topographic measurements at different gaze directions we are able to obtain an accurate map of the entire scleral surface including the area under the eyelids.
Simulated NaFl Pattern

Scleral Toricity

WTR
Oblique
ATR

Mapping the Sclera

Scleral topography

Lens diameter

Diameter: 16.0 vs. 18.0 mm?
Scleral Toricity

Images courtesy of Patrick Caroline

Toric Scleral Design

Spherical 9.5 mm Optical Zone

Lowest Scleral Meridian

Highest Scleral Meridian

Images courtesy of Maria Walker

Toric Scleral Design
Custom molding

- Special polymer used to create casting of cornea/conjunctiva
- Mold is digitalized
- Custom scleral lens created based off mold
- Example:
  - EyePrintPro (EyePrint Prosthetics)

RESOURCES AND PROGRAMS

GP Case Grand Rounds Troubleshooting Guide

- Online Guide of 52 Case Studies
  - Spherical
  - Toric
  - Multifocal
  - Irregular Cornea
  - Corneal Reshaping

Answers
Practitioner's Questions
Societies to Join in 2017!

Benefits:
- Education
- Networking
- Doctor Resources
- Patient Resources

THANK YOU!

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