IN THE SCLERAL LENS WORLD: IT SEEMS THAT SMALLER IS BETTER

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PROFESSOR – U DE MONTREAL

DISCLOSURE

DR MICHAUD

- SPEAKER’S HONORARIUM FROM ALL MAJOR CONTACT LENS MANUFACTURERS

- RESEARCH GRANTS FROM BLANCHARD LABS, JOHNSON*JOHNSON VISION CARE AND COOPER VISION.

What are the Size Options?

<table>
<thead>
<tr>
<th>Lens Type</th>
<th>Description</th>
<th>Definition of Resting Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corneal</td>
<td></td>
<td>Less rests entirely on the cornea</td>
</tr>
<tr>
<td>Corneoscleral</td>
<td></td>
<td>Less rests partly on the cornea, partly on the sclera</td>
</tr>
<tr>
<td>Scleral</td>
<td>Medium Scleral</td>
<td>Lens is up to three times larger than 30 x 30</td>
</tr>
<tr>
<td></td>
<td>Large Scleral</td>
<td>Lens is more than three times larger than 30 x 30</td>
</tr>
</tbody>
</table>

- Made of High dK materials
  - Boston XO, XO2
  - Optimum Extra, Tym-97
  - HD800
### CONTACT LENS INDICATIONS

<table>
<thead>
<tr>
<th>Optical Correction</th>
<th>Ocular Protection</th>
<th>Ocular Comfort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keratoconus</td>
<td>Neurotrophic Keratitis</td>
<td>Pinguecula</td>
</tr>
<tr>
<td>Pellucid Marginal Degeneration</td>
<td>Ocular Surface Disease (Dry Eye)</td>
<td>Pterygium</td>
</tr>
<tr>
<td>Post LASIK Ectasia</td>
<td>Graft vs Host Disease</td>
<td>Scarring</td>
</tr>
<tr>
<td>Post Radial Keratometry</td>
<td>Steven Johnson Syndrome</td>
<td>Chemical Burns</td>
</tr>
<tr>
<td>Corneal Transplants</td>
<td>Ocular Cicatrical Pemphigoid</td>
<td>Chemical Burns</td>
</tr>
<tr>
<td>High Myopia / Hyperopia</td>
<td>Stem Cell Failure</td>
<td>Chemical Burns</td>
</tr>
<tr>
<td>Aphakia</td>
<td></td>
<td>Chemical Burns</td>
</tr>
</tbody>
</table>

### YOU DON'T HAVE TO SHOOT A MOSQUITO WITH A BAZOOKA

Use the lens with the lowest risk

### THE LEARNING CURVE

- Harder with very large lenses

- In average: 5-10 cases should be enough to become comfortable in fitting a particular design

- The harder learning curve is understanding the disease you are working with
### Sclerals vs. Corneal GPs

<table>
<thead>
<tr>
<th></th>
<th>SMALL RGPs</th>
<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 clarity</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Corneal astigmatism</td>
<td>No limit</td>
<td>Uncertain</td>
</tr>
<tr>
<td>Fitting/learning curve</td>
<td>Exceed</td>
<td>Larger</td>
</tr>
<tr>
<td>Handling</td>
<td>+/−</td>
<td>+/−</td>
</tr>
<tr>
<td>Design (toric)</td>
<td>Front/ bi-toric</td>
<td>Front</td>
</tr>
<tr>
<td>Design (MF)</td>
<td>Spherical</td>
<td>Lens is stable and centered</td>
</tr>
<tr>
<td>Cost</td>
<td>$</td>
<td>$$$</td>
</tr>
<tr>
<td>Complications/ inflammation</td>
<td>varied</td>
<td>++</td>
</tr>
</tbody>
</table>

### Sclerals vs Hybrids

<table>
<thead>
<tr>
<th></th>
<th>DURITE</th>
<th>Clear Kaye</th>
<th>Ultra Health</th>
<th>SCLERALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial comfort</td>
<td>-</td>
<td>No limit</td>
<td>No limit</td>
<td>-</td>
</tr>
<tr>
<td>Long term comfort</td>
<td>-</td>
<td>No limit</td>
<td>No limit</td>
<td>-</td>
</tr>
<tr>
<td>Visual clarity</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Corneal astigmatism (spherical lens)</td>
<td>No limit</td>
<td>-</td>
<td>Uncertain</td>
<td>-</td>
</tr>
<tr>
<td>Fitting/learning curve</td>
<td>No limit</td>
<td>No limit</td>
<td>No limit</td>
<td>-</td>
</tr>
<tr>
<td>Handling</td>
<td>Easier</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Clinical application</td>
<td>Limited to normal cornea</td>
<td>Limited to KC</td>
<td>KC &amp; post-refractive</td>
<td>Fully customizable</td>
</tr>
</tbody>
</table>

**Key Point:** Hybrids do not provide tear reservoir.

### What Determines the “Right” Diameter

- Vision?
- Oxygen?
- Disease State?
- Ocular Geometry?
- Physiological Response?
2018-05-27

SMALLER OR LARGER SCLERALS

- SMALLER SCLERAL LENSES
  - GO TO LENSES FOR MOST OF THE CURRENT REFRACTIVE ERROR PATIENTS
  - LESS INTIMIDATIVE
  - EASIER TO HANDLE
  - LESS TROUBLESHOOTING
  - REDUCED LEARNING CURVE
  - BETTER LONG-TERM OCULAR HEALTH – OXYGEN DELIVERY

- LARGER SCLERAL LENSES
  - LARGER CORNEAS
  - FRONT TORIC DESIGNS
  - SIGNS OF DES

HANDLING

- LESS APPREHENSION DUE TO LARGE DIAMETER

14.9 OAD 18.2 OAD

Similar to soft toric lens diameter

VISION
IRREGULAR CORNEAS
DISEASED EYES
INCLUDING DRY EYE SYNDROME
NORMAL CORNEAS
PATIENTS SYMPTOMATIC OF DISCOMFORT OR FLUCTUANT VISION
HIGH REFRACTIVE ERRORS
ASTIGMATISM (UP TO 3-3.5D WITH A SPHERICAL)
Presbyopia (especially with Astigmatism)
SPORTS
ALLERGY CONTROL

Known applications

CURRENT REFRACTIVE ERRORS

WHAT DOES IT NEED TO SWITCH PATIENTS FROM SOFT TO SCLERAL LENSES
IDENTIFYING A NEED
VISION
COMFORT
EDUCATE THE PATIENT ABOUT THE TECHNOLOGY
BENEFITS
LIMITS
HANDLING
COST
CONVENIENCE
HANDLING
CARE REGIMEN
RESULTS

• COMFORT IS FOUND SIMILAR WITH BOTH LENSES
  • NO MAJOR DIFFERENCE AT THE END OF THE DAY
  • PATIENTS WERE ASYMPOTOMATIC OF CLD

• 75% OF PATIENTS PREFERRED ONERIT LENSES FOR VISUAL ACUITY

• 55% REMAINED IN THAT MODALITY FOR THE FUTURE
  • HANDLING WAS AN ISSUE FOR 10-15% OF THE WEARERS (VS SOFT)

DOES SAGITTAL DEPTH AFFECT VISION?

SCLERAL LENSES FOR NORMAL CORNEA
ASSESS RISK/BENEFITS

VS
ETHICAL CONSIDERATIONS

- Ratio Risks / Benefits
  - Obvious for corneal ectasia or diseased eyes
  - Not so obvious for normal corneas vs limiting factors

- Potential limiting factors
  - Oxygen permeability
  - Corneal physiology
  - Conjunctival anatomy
  - Rate / nature of complications
  - Ease of fit / troubleshooting
  - Learning curve
  - Handling

OXYGEN AND DISEASE STATE

HOW MUCH OXYGEN IS REALLY GETTING TO THE CORNEA?
Theoretical Oxygen Delivery

- **A theoretical approach**
  - Considering available materials
    - DK of 100 to 170
  - Various lens thicknesses
    - 250-500 um
    - Post-lens tear thickness
    - 100-400 um

**PREDICTED OUTCOME:**

THEORETICAL MODEL VALIDATED

- Jaynes et al; Weissman et al
- Calculations to determine the ideal fit to prevent corneal hypoxia effect
- Larger diameter lens higher risk than smaller lens

Modeling Corneal Oxygen with Scleral Gas Permeable Lens Wear

**ABSTRACT**

Purpose: The main goal of this current work is to use an updated calculation paradigm, and updated boundary conditions, to provide theoretical guidelines to assist the clinician in selecting the appropriate gas permeable GP contact lens wearing patient, irrespective of oxygen supply.

Methods: Our model uses a scalable value of corneal oxygen consumption developed through Menard equations that describes negative oxygen tension within the cornea under oxygen starve at the administration of a gas permeable GP contact lens wearing eyes, and to describe oxygen tensions and flux profiles for various boundary conditions through the lens, rim, and cornea. The use assesses optical, thermal, and metabolic parameters in the model. Tear occlusion with GP lenses is a considered restriction in the model.

Results: The model of corneal oxygen consumption demonstrates that a 10 mm diameter GP contact lens should produce some levels of corneal hypoxia under open eye conditions. The corneal oxygen consumption is reduced by approximately 30% with a 10 mm diameter GP contact lens.

Conclusions: The model suggests that clinicians would need to prescribe smaller GP lenses to ensure sustained higher oxygen permeability, research and evaluate the without excessive corneal compromise.
IN Vivo Study

- AIM: TO EVALUATE RELATIVE PO2 AT THE CORNEAL SURFACE UNDER SCLERAL RIGID GAS PERMEABLE LENSES OF DIFFERENT CLEARANCES.

- RELATIVE PO2 AT CORNEAL SURFACE EXPECTED FROM THESE DK/T WERE ESTIMATED AS FOLLOWS:
  - A NON-LINEAR REGRESSION ON THE DATA OF BENJAMIN AND HILL*, RELATING EOP TO CONTACT LENS DK/T, THE EQUATION FORCED THROUGH THE ORIGIN WAS:
    \[ EOP (\%) = -19.6 \times \exp (-0.029 \times DK/T) + 19.8 \] (R² = 0.97)
  - CALCULATED VALUES OF DK/T WERE INPUT INTO THIS EQUATION.
  - AS FOR REFERENCE: MINIMAL LEVEL OF PO2 TO AVOID HYPOXIA: 9.9%

- RESULTS
  - CURRENT LARGE DIAMETER LENS WEAR IS ASSOCIATED WITH 2-3% EDEMA
    - NOT COMPARABLE TO PHYSIOLOGICAL EDEMA
  - REDUCED CLEARANCE OVER OTHER AREAS OF THE CORNEA
  - NO HYPOXIC STRESS OVER THE LIMBUS: NO NEOVASCULARIZATION SEEN
  - COULD BE TRANSIENT: IF CLEARANCE IS REDUCED < 200 UM OVER LENS WEAR
  - CLINICAL IMPACTS:
    - UNKNOWN ON THE LONG TERM
    - OTHER MECHANISMS CAN BE IN PLAY...
    - RAISE THE QUESTION ABOUT RISK/BENEFIT FOR NORMAL CORNEA PATIENTS

- MODEL REVISITED

**TABLE**

<table>
<thead>
<tr>
<th></th>
<th>Sl 200</th>
<th>Sl 400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average clearance (um)</td>
<td>208.7± 18.9</td>
<td>319.6 ± 31.2</td>
</tr>
<tr>
<td>Average with haptic (um)</td>
<td>234.6 ± 25.4</td>
<td>308.6 ± 27.9</td>
</tr>
<tr>
<td>Estimated DK (x 10^-11 cm²/sec)</td>
<td>18.7± 1.9</td>
<td>12.5± 0.7</td>
</tr>
<tr>
<td>Predicted pO2 (%)</td>
<td>8.3± 0.3</td>
<td>6.7± 0.2</td>
</tr>
<tr>
<td>Measured pO2 (%)</td>
<td>9.07± 0.86</td>
<td>6.19± 0.87</td>
</tr>
</tbody>
</table>

AVERAGE SCLERAL LENSES

- **Traditional CT**
  - Range: 0.3 mm (300 microns) to 0.6 mm (600 microns)
  - Industry concern of flexure under 0.3 mm
  - Average CT: 0.45 mm

- **Traditional Vaults**
  - Multiple fitting sets and lectures reviewed
    - Low Vault: 100 microns
    - High Vaults: 400 microns
    - Average: 300

- **Traditional Material**
  - Lagado Tyro 97 = DK 97
  - Boston XO = DK 100
  - Contamac Optimum Extra = DK 100
  - Average DK of 100

- **Traditional Haptics**
  - No blanching of conjunctival vasculature
  - Variable based on guide
    - Some state quadrant of blanching is acceptable

- **In Vivo Study - Berkeley**
  - Lens 350 um
  - Hypoxia stress to the cornea – peer-reviewed evidence
  - Happens when:
    - Lens thickness is over 250 um
    - Tear fluid layer (clearance) exceeds 200 um
  - Affects central cornea:
    - Swelling, pachymetry increases
  - Transient:
    - Hypoxia stress is reduced as the
      - Lens stabilized (fluid loss)
      - Not compensated by tear exchange or tear mixing

Kim, Tan, Li, Curr. Eye Res. 2015
IS THIS HAPPENING?

Scleral Lens-Induced Corneal Graft Edema
By Boris Severinsky, MOptom, Jerusalem, Israel

This is a photo of scleral lens-induced corneal graft edema in an eye with 12.00 diopter residual post-keratoplasty astigmatism.

PHYSIOLOGICAL STRESS WITH SCLERAL LENSES
DIFFERENTIAL DIAGNOSIS

• LIMBAL MICRO-BULLAE
  • LIMBAL TOUCH
  • HIGH CONVEX
  • NON OPTIMAL DK MATERIAL (<1.50)
  • TOO MUCH CLEARANCE

SCLERAL LENS AND ENDOTHELIAL CELLS

“ENDOTHELIAL CELL COUNT OF LESS THAN 800 CELLS/MM² IS WHERE THE PROBLEMS MAY ARISE (SINDT 2010A) AND ENDOTHELIAL CELL COUNTS <1,000 CELLS/MM² SHOULD BE HANDLED WITH EXTRA CARE AND SHOULD NOT BE FITTED WITH SCLERAL LENSES TO AVOID EDEMA.”

EEF VAN DER WORP, 2015. A GUIDE TO SCLERAL LENS FITTING (2 ED)

EXHAUST OTHER OPTIONS FIRST:

A NEW FINDING: BLEBS !!!
OTHER CONTRIBUTING MECHANISMS?

• TEAR EXCHANGE
  • MINIMAL DURING LENS SETTLING
  • PAUGH, EYE & CONTACT LENS, MARCH 2018 - VOLUME 44 - ISSUE 2 - P 97–101
    • 0-30 MIN 0.57 (±0.6) %/MIN
    • 30-60 MIN 0.42 (±0.5) %/MIN
    • NON-CL WEAR 3.4 (±1.5) %/MIN
    • SI-HY CL (0-30) 6.09 (±2.8) %/MIN.
• TEAR MIXING (MENG-LIN, GSLS 2018)
  • NOT CONTRIBUTING A LOT
  • IMPROVED IF CLEARANCE IS REDUCED

TEAR EXCHANGE UNDER A SCLERAL LENS

• TEAR EXCHANGE IS NOT DEFINITIVELY KNOWN
• CORNEAL GP LENSES WEAR, 20% OF THE POST LENS TEAR VOLUME IS EXCHANGED WITH EACH BLINK
• SOFT CONTACT LENSES, THE EXCHANGE IS LESS THAN 1%

CONCLUSIONS:
• MINIMAL TEAR EXCHANGE TAKES PLACE OVER 8 HOURS
• MOLECULAR ANALYSIS OF THE POST LENS FLUID WILL BE NEEDED TO QUANTIFY TEAR EXCHANGE.

Conclusion

• HIGHER CLEARANCE IN SCLERAL LENSES MAY BE ASSOCIATED WITH CHRONIC EDEMATOUS RESPONSE FROM THE CENTRAL CORNEA
• THIS RAISES THE IMPORTANCE OF EVALUATING THE RISK/BENEFITS RATIO BEFORE FITTING PATIENTS, ESPECIALLY IF THE CORNEA IS COMPROMISED
**IMPACT ON THE SELECTION OF THE LENSES**

- There are options to alleviate hypoxia:
  - To fit lenses with reduced thickness
  - To limit fluid uptake (to avoid hypoxia)
  - To regular scleral lens volume and individual cornea characteristics

Most probably feasible with smaller diameter scleral lenses OR
Customized larger scleral lenses

**Smaller lenses are still sclerals**

- Should vault over the limbus
- Should not be associated with compression nor physiological response
- In doubt, assess the patient at F/U—Fluorescein staining assessment needed.

**Limbus**

- Any scleral lens should vault over the limbus
- However, too much clearance is detrimental
  - Bullae
  - Distors in the reservoir

**Troubleshooting**

- Ask for Xtra limbal clearance
- Increase the diameter slightly
- In doubt: let the patient go, F/U 2 wks, stain

https://ferris.edu/HTMLS/colleges/michopt/vision-research-institute/pdfs-docs/Scleral-lens-fit-scales_v2.pdf
PHYSIOLOGICAL REACTIONS

TOO MUCH VAULT = SUCTION EFFECT

• Epithelial bogging or “Water-logged epithelium” occurs when cornea is in saline for 10-12 hours/day
  – Similar to skin wrinkling when put in water for extensive period of time
  – Electrolyte imbalance or altered homeostasis stimulates sympathetic nerve response

• In response: cells are swelling /Increase their surface
  – Slight adaptation, bogging reduction, can happen over weeks/months

• Troubleshooting
  – Artificial tears with electrolytes (SH)
  – Increase tear exchange (flatter pc’s) and oxygen delivery
  – Hypromellose agent – short term; cyclosporine – long term

Photo: M. Walker, OD
COMPRESSION FACTORS

• COULD THIS AFFECT UVEAL SCLERAL OUTFLOW?
• INCREASED INFLAMMATORY EVENTS
• TIGHT LENS SYNDROME

A STUDY

• 22 PATIENTS – CAUCASIAN - < 30 Y.O

• IOP BEFORE AND AFTER SCLERAL LENS WEAR
• 2 TYPES OF LENSES: 15.8 AND 18.0 MM
• 4 TO 5 HRS BETWEEN 2 MEASUREMENTS
• EXERCISE/ NUTRITION DURING STUDY TIME WAS CONTROLLED
• IOP EVALUATED TRANSDERMAL WITH DIATION TONOMETER

RÉSULTATS

ANTERIOR CHAMBER VARIATIONS

<table>
<thead>
<tr>
<th>Lens type</th>
<th>AC depth (mm)</th>
<th>AC volume (mm³)</th>
<th>IC angle (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSD 15.8mm</td>
<td>1.21</td>
<td>-1.21</td>
<td>-0.01</td>
</tr>
<tr>
<td>MSD 18.0mm</td>
<td>0.002</td>
<td>-2.84</td>
<td>-0.18</td>
</tr>
</tbody>
</table>
DISCUSSION

- MCMONNIES SUGGESTED THAT IOP MAY BE INCREASED WITH SCLERAL LENSES
- COMPRESSION OF THE EPISCLERAL VEINS AND COLLECTING CHANNELS
- VINCENT AND SCHORNACK DID NOT FIND A SIGNIFICANT AT Lens REMOVAL
- TOPOGRAPHIC TONOMETRY WERE JUST AT LENS REMOVAL
- NAU SUGGESTED THAT SMALLER DIAMETER LENSES MAY GENERATE HIGHER IMPACT
- IN THIS STUDY, IOP VARIED SIGNIFICANTLY, INDEPENDENTLY OF THE LENS DIAMETER

IF THIS IS CONFIRMED, THERE ARE SEVERAL CLINICAL IMPLICATIONS

- SHOULD WE STILL FIT:
  - GLAUCOMA SUSPECT ?
  - KERATOCONUS PATIENT ? (HIGHER INCIDENCE OF NORMAL PRESSURE GLAUCOMA)
  - THINNER CORNEAS ? (RISK FACTOR FOR GLAUCOMA)
- IS THERE A WAY TO LIMIT THIS SIDE-EFFECT?
RATE OF COMPLICATIONS

POSSIBLE COMPLICATIONS

SMALLER DIAMETER
- HANDLING
- IMPRINTS / INDENTATION
- TIGHT LENS SYNDROME
- PHYSIOLOGICAL RESPONSE

LARGER DIAMETER
- HANDLING
- POST-LENS CLOUDING
- LENS FITTING / CONJUNCTIVAL TIGHTNESS
- CONJUNCTIVAL EDEMA
- IMPRINTS / INDENTATION
- TIGHT LENS SYNDROME
- PHYSIOLOGICAL RESPONSE
- LENS DECENTRATION

DEBRIS IN THE RESERVOIR

MILKY APPEARANCE OF THE RESERVOIR
CAN BECOME CONTAMINATED IN A FEW MINUTES UP TO SEVERAL HOURS
DEPOSITS: LIPIDS AND MUCINS

ETIOLOGIES
- MECHANICAL IMPACT ON THE CONJUNCTIVA
- NATURAL CELL METABOLISM
- MIGRATE UNDER THE LENS, SUCTION FORCES

NOT HAPPENING WITH SMALLER DIAMETER LENSES

TROUBLESHOOTING
- REDUCE MECHANICAL IMPACT: FLATTER PC'S, SMALLER DIAMETER
- LOWER LIMBAL CLEARANCE
- OPTIMIZE MID-PERIPHERAL CLEARANCE
EXPLORING THE OCULAR SURFACE:
WHAT DO WE KNOW?

• CONJUNCTIVA IS A NON-ROTATIONAL ASYMMETRICAL SURFACE

• CAN BE HIGHLY TORIC – TORICITY INCREASES WITH CHORD
  • NO RELATIONSHIP BETWEEN CORNEAL AND CONJUNCTIVAL TORICITY

• HIGHLY VARIABLE
  • QUADRANT BY QUADRANT (N ≠ T; S ≠ I)
  • OD VS OS
  • PATIENT PER PATIENT

• LESS VARIABLE WITH AGEING
  • SCLERAL LENS RADIUS BECOMES STEEPER
  • SCLEROS-CORNEAL ANGLE INCREASES WITH AGE

Average Conjunctival Curve
@ 15-20 mm

QUALITATIVE ASSESSMENT OF SCLERAL SHAPE

• THE SCLERAL SHAPE STUDY GROUP
  • GREGORY DENUZER
  • DONALD SANDERS
  • EEF VAN DER WORP
  • JASON JEDLICKA
  • LANGIS MICHAUD
  • SHEILA MORRISON

Objective: Examine new findings of conjunctival/scleral shape and to propose a new classification system for scleral shape.
METHODS:
RETROSPECTIVE
152 EYES
PROSPECTIVE
SCLERAL LENS
PATIENTS

Elevation Maps
Blue=Increased sagittal height
Red=Less sagittal height
SCLERAL SHAPE

- Scleral shape patterns were reviewed in all cases and classified according to recurring characteristics.

- 4 groups
  - Group 1: Spherical
  - Group 2: Toric-regular
  - Group 3: Asymmetric high or low points
  - Group 4: Toric-periodicity different from 180°

### Table 1: Scleral Surface Patterns

<table>
<thead>
<tr>
<th>Group</th>
<th>Pattern Description</th>
<th>N</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Spherical</td>
<td>8</td>
<td>5.7%</td>
</tr>
<tr>
<td>2</td>
<td>Toric-regular</td>
<td>40</td>
<td>28.6%</td>
</tr>
<tr>
<td>3</td>
<td>Asymmetric high or low points</td>
<td>57</td>
<td>40.7%</td>
</tr>
<tr>
<td>4</td>
<td>Periodicity different from 180°</td>
<td>35</td>
<td>25%</td>
</tr>
</tbody>
</table>

65.7% of patterns observed in 140 scleral lens patients.

CONCLUSIONS

- 4 primary categories of scleral shape
- Measurement of the scleral allows for more efficient and accurate determination of lens design.
- Results suggest that the majority of eyes may benefit from custom back surface haptics beyond a toric design.
CONJUNCTIVAL PROLAPSE

- Conjunctival tissue folds over the cornea
- Considered benign
- Inferior quadrant mostly
- If conjunctiva is flatter and less elevated
- Suction forces
- Not happening with smaller sclerals

Troubleshooting
- Smaller diameter lenses
- Lower limbal clearance
- Revisit mid-peripheral clearance

CONJUNCTIVAL TORICITY VS CORNEAL TORICITY

- Not related
- May be different among different populations
- Keratoconus vs normal cornea
- We cannot predict from the cornea, what the conjunctiva will look like.

CORNEAL GEOMETRY

- Courtesy C. Sindt
LIMBAL GEOMETRY

Different transition profiles from cornea to sclera:

1. Gradual / convex (8-23%)
2. Gradual / tangential (42-56%)
3. Marked / convex (24-28%)
4. Marked / tangential (2.5-7%)
5. Concave / convex (0-0.5%)

HYPERBOLIC PARABOLOID

CONCLUSION

Important features to consider:
- Curves
- Angles
- Height differences
- In every opposite quadrants
- We need a 3D modelization
- Find a quadrant specific approach
IMPACT ON THE LENS DESIGN

• WE NEED TO CONSIDER CONJUNCTIVAL TORICITY FOR EVERY LENS OF 15.5 MM DIAMETER OR LARGER

• TORICITY IS NOT SYMMETRICAL, NOT PREDICTABLE BASED ON THE CORNEAL TOPOGRAPHY. WE MUST ASSESS CONJUNCTIVAL TORICITY ACCURATELY.

• CUSTOMIZED- QUADRANT SPECIFIC – PERIPHERAL CURVES SHOULD BE CONSIDERED
  • POTENTIAL IMPACT ON TEAR EXCHANGE
  • IMPROVED COMFORT AND CENTRATION
  • LESS IMPORTANT IF SMALLER LENSES ARE USED

INDUCED RESIDUAL ASTIGMATISM

• LENS DECENTRATION
  • SIZE (>16 MM) / MASS OF THE LENS
  • NON UNIFORM TEAR FLUID LAYER
  • VISUAL AXIS NOT MATCHING OPTICAL AXIS
    • REDUCED VA
    • HALOES AND GLARE
    • SUPERO-NASAL BEARING
    • PHYSIOLOGICAL COMPLICATIONS

THE MOST PROBABLE CAUSE

• PRESENCE OF HOA: COMAS
  • 4TH ORDER
    • COMA IS AN ABERRATION WHICH CAUSES RAYS FROM AN OFF-AXIS POINT OF LIGHT IN THE OBJECT PLANE TO CREATE A TRAILING "COMET-LIKE" BLUR DIRECTED AWAY FROM THE OPTIC AXIS (FOR POSITIVE COMA).
    • GENERATES HALOES AND GLARE
    • SIMILAR TO ASTIGMATISM
    • ESPECIALLY IN KC AND IF THE LENS IS DECENTRED
    • PARTLY CORRECTED WITH FRONT-TORIC LENSES
TROUBLESHOOTING

- LENTICULAR ASTIGMATISM/
  - DESIGN A FRONT TORIC LENS
  - REDUCE LENS SIZE/MASS
- DECENTRED LENS
  - IF PROBLEM PERSISTS, EX TORIC PERIPHERAL CURVES (200 UM FLATTER HORIZONTAL, STANDARD VERTICAL)
- NON-UNIFORM TEAR FILM PROFILE (IRRREGULAR CORNEA)
  - INCREASED OPTIC ZONE
  - USE DLATE DESIGN (COMPLICATION NEEDED)
- HOA
  - REDUCED CENTRAL CLEARANCE
  - FRONT TORIC DESIGNS
- LENS IS TOO THIN (?)
  - INCREASED LENS THICKNESS (DO NOT EXCEED 300 UM)

LET'S TAKE A LOOK AT LENS « FLEXURE »

- PROSPECTIVE STUDY - PRELIMINARY RESULTS
- LENS FITTED WITH SMAP 3D – TORIC PC’S AS NEEDED
- VARIATION OF LENS THICKNESSES AND CLEARANCE

- DEMOGRAPHICS: F (70%) M (30%); 23 Y.O.; NON SCLERAL LENS WEARERS, WASHOUT 72000

<table>
<thead>
<tr>
<th>Parameter</th>
<th>LENS A and C (OD)</th>
<th>LENS B and D (OS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refraction sphere</td>
<td>-1.88 ± 1.09</td>
<td>-1.72 ± 1.70</td>
</tr>
<tr>
<td>Refraction CYL</td>
<td>-0.45 ± 0.29</td>
<td>-0.64 ± 0.31</td>
</tr>
<tr>
<td>Spherical @ distance (baseline)</td>
<td>-0.16 ± 0.09</td>
<td>-0.11 ± 0.09</td>
</tr>
<tr>
<td>Flat K</td>
<td>-0.60 ± 1.09</td>
<td>-0.37 ± 1.50</td>
</tr>
</tbody>
</table>

TARGETTED VS MEASURED LENS PARAMETERS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>LENS A</th>
<th>LENS B</th>
<th>LENS C</th>
<th>LENS D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
</tr>
<tr>
<td>Clearance</td>
<td>0.2 ± 0.1</td>
<td>0.2 ± 0.1</td>
<td>0.2 ± 0.1</td>
<td>0.2 ± 0.1</td>
</tr>
<tr>
<td>Power</td>
<td>plano</td>
<td>plano</td>
<td>plano</td>
<td>plano</td>
</tr>
</tbody>
</table>
### INDUCTED ASTIGMATISM

<table>
<thead>
<tr>
<th></th>
<th>LENS A</th>
<th>LENS B</th>
<th>LENS C</th>
<th>LENS D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thick</td>
<td>High clear</td>
<td>Thick</td>
<td>High clear</td>
</tr>
<tr>
<td>Sphere</td>
<td>-0.60</td>
<td>-0.98</td>
<td>-0.125</td>
<td>-0.191</td>
</tr>
<tr>
<td>CyL</td>
<td>0.03</td>
<td>-0.32</td>
<td>-0.35</td>
<td>-0.34</td>
</tr>
<tr>
<td>Axis</td>
<td>90.1</td>
<td>102.2</td>
<td>67.1</td>
<td>91.2</td>
</tr>
<tr>
<td>Over K</td>
<td>0.04</td>
<td>-0.69</td>
<td>-0.20</td>
<td>-0.14</td>
</tr>
<tr>
<td>Vx (OE)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

### CONCLUSION: HOW BIG SHOULD A BIG LENS BE?

- KNOW THE LENS DESIGN YOU ARE WORKING WITH
- WHAT COMPLICATIONS TO EXPECT
- HOW TO HANDLE
- HOW TO MODIFY
- UNDERSTAND THE DISEASE YOU ARE FITTING
- RECOMMENDATION: OWN BOTH A LARGE SCLERAL AND A MINI SCLERAL SET. ONE SIZE DOES NOT FIT ALL!

### SUMMARY: Potential Complications

<table>
<thead>
<tr>
<th></th>
<th>SMALL SCERAL</th>
<th>LARGE SCERAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astigmatism</td>
<td>Visual</td>
<td>Visual</td>
</tr>
<tr>
<td>Corneal distortion</td>
<td>Graft</td>
<td>Graft</td>
</tr>
<tr>
<td>Corneal/ limbal</td>
<td>Small, deep, banding zone</td>
<td>High, centred; if not enough elevation, lift</td>
</tr>
<tr>
<td>Corneal/ limbal</td>
<td>High, anterior</td>
<td>High, regular, toric, peripheral arc</td>
</tr>
<tr>
<td>Probable /Paraconjunctiva</td>
<td>Can be an issue</td>
<td>Need, micro-stitch, elevation, specific technology</td>
</tr>
<tr>
<td>Tight lens syndrome</td>
<td>None</td>
<td>Occurs with excessive vault</td>
</tr>
<tr>
<td>Hypotony</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Hypotony</td>
<td>Small, if fitted with lower clearance and induced less blinks.</td>
<td></td>
</tr>
</tbody>
</table>

If astigmatism remains $> 300$ arc
### SUMMARY: Potential Complications

<table>
<thead>
<tr>
<th></th>
<th>SMALL SCLERAL</th>
<th>LARGE SCLERAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution related toxicity</td>
<td>Some reactions if preservative products are used to fill in the bowl</td>
<td></td>
</tr>
<tr>
<td>Lens decentration</td>
<td>Rarely an issue if diameter &lt; 13.5 mm</td>
<td>Frequent if toric peripheries not prescribed</td>
</tr>
<tr>
<td>Residual astigmatism</td>
<td>Rarely happening</td>
<td>May occur</td>
</tr>
<tr>
<td>Epithelial bogging/epi edema</td>
<td>Rarely happening</td>
<td>Considered benign phenomenon</td>
</tr>
<tr>
<td>Deposits/Build-up on the surface</td>
<td>Rarely happening</td>
<td>More reservoir debris with increased reservoir or increased limbal clearance Surface wetting issue may occur</td>
</tr>
<tr>
<td>Bubbles</td>
<td>May occur: leave in reservoir or sucked in from the edge</td>
<td></td>
</tr>
<tr>
<td>Handling</td>
<td>Everyone learns to handle what they are given</td>
<td></td>
</tr>
</tbody>
</table>