Keratoconus Contact Lens Management

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Disclosures
• Clark Chang (cchang@vision-institute.com)
  • Allergan, Inc.
  • Oasis Medical, Inc.
  • Synergeyes, Inc.
• Greg DeNaeyer
  • Visionary Optics (Europa Scleral Lens™)
  • B+L
  • Aciont
  • Alcon

Objectives
• Keratoconus- defined
• Ectasia- defined
• Classifications
  • Keratoconus
    • Forme Fruste
    • Post-surgical ectasia
  • Keratoglobus
  • PMD

Objectives
• Treatment Options
• Contact Lens Management
  • Soft
  • Corneal GP
  • Hybrid/Piggyback
  • Scleral
  • Presbyopia/Wavefront

Keratoconus (KC)
• Incidence
• Risk Factors
  • Genetic
    • Hormonal
    • Enzymatic dysregulation
  • Environmental
    • Eye rubbing
    • Trauma
    • Oxidative stress

Keratoconus (KC)
• Diagnosis
  • Topography
  • Pachymetry <500
  • Tomography
  • Aberrometry
  • Optical Signs
  • Slit lamp Signs
Keratoconus (KC)

- External
- Munson’s sign
- Slit lamp
  - Vogt's Striae
  - Fleischer’s Ring
  - Apical Thinning
  - Apical Scar
  - Apical Nodule
  - Hydrops

Keratoconus (KC)

- Corneal Hydrops
- Break(s) at Decemet’s allows aqueous infusion into stroma
- Monitor until resolution, ~3Mth
- Scarring process may flatten corneal curvature

Keratoconus (KC)

- Nipple
- Oval

Spectrum phenotypic expression

Keratoglobus

- Keratoglobus
  - Global
  - 75-90% of area involved
  - Typically congenital and rarely acquired

Pellucid Marginal Degeneration

- PMD
  - Topography
  - Slit Lamp
    - Peripheral apex above inferior thinning
    - Clear tissue typically intervening apex and limbus
Post-surgical ectasia
- Refractive surgery
- Relatively rare
- LASIK or PRK
- Management

Medical Management
- Corneal Crosslinking
- Riboflavin (photosensitizing agent)
- UV exposure results in free radical formation
- Age
- Diabetes

Surgical Management


**DESIGN:** To evaluate the long-term results of corneal collagen cross-linking (CXL) in patients with progressive keratoconus (40 eyes, 32 KC) patients.

**MAIN OUTCOME MEASURES:** BCVA, UCVA, MRSE, max-K, mean-K, CCT, and anterior and posterior elevation at the apex (baseline; 1, 3, 6 months after CXL; 1, 2, 4, and 5 years later).

**RESULTS:** The mean-K, max-K, UCVA, and astigmatism showed no change over time during these 5 years. After the first year, BCVA, MRSE, and OCT showed no change and stabilized, whereas elevation readings continued to decrease up to 5 years after CXL.

**CONCLUSIONS:** Treatment of progressive keratoconus with CXL can stop disease progression, without raising any concern for safety, and can eliminate the need for keratoplasty.

Surgical Management

**Intracorneal Ring Segments (ICRS)**
- Intacs®
- FDA- HDE 2004
- Improve biomechanical support and VA

Surgical Management

- Despite CL material/design advancements
  - 12-26% KC patients seek surgical Tx
  - PKP most common
- Alternative keratorefractive Treatment Options
  - Ablative, Incisional, Thermal, Additive
  - Lewinger S et al4, BCVA unchanged splntacs®, but mean UCVA improved from 20/200 to 20/50 (N=58 eyes)
  - 72.2% reported significant VA improvement

Surgical Management

- Corneal Transplant
  - 20% KC patients
  - > 7000 KC in US (2012)
  - Penetrating Keratoplasty- PKP
  - Deep Anterior Lamellar Keratoplasty- DALK

Contact Lens (CL) Management

- Corneal Crosslinking
  - Will crosslinking decrease severity to the point that we need GPs less often?
  - Influences to surgical management options?

CL Management

- Higher order aberrations (HOAs)
  - "Masking"
  - Residual
    - Contact Lens
    - Posterior cornea

CL Management

- Lower order aberrations
  - Myopia
  - Hyperopia
  - Astigmatism

CL Management

- Patient Education
  - Specialty contact lenses
    - Why
    - Vision
    - Cost
  - Two contact lenses
  - Glasses over contact lenses for BCVA
CL Management

- Goals
  - Vision
  - Comfort
  - Short/Long Term Health

CL Management

- Specialty Soft
- Gas Permeable
  - Corneal
  - Scleral
  - Piggyback
  - Hybrid

CL Management

<table>
<thead>
<tr>
<th>K Irregularity</th>
<th>Contact Lens Device Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade I Irregularity</td>
<td>Specialty Soft Lens Design (potential fitting and/or VA compromises) Corneal-Scleral Lens Mini-Scleral, or hybrid lens</td>
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<tr>
<td>Grade II Irregularity</td>
<td>Specialty Soft Lens or Corneal GP Design Corneal-Scleral Lens Mini-Scleral, or hybrid lens</td>
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<td>Grade III Irregularity</td>
<td>Corneal-Scleral Lens (potential fitting difficulties) Mini-Scleral or hybrid Lens Full-Scleral Lens</td>
</tr>
<tr>
<td>Grade IV Irregularity</td>
<td>Mini-Scleral or hybrid Lens (potential fitting difficulty) Full-Scleral Lens</td>
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CL Management - Specialty Soft

- Yamazaki (2006)
  - 66 KC/80 eyes
  - Mild to advanced KC
  - 91% achieved visual acuity better than 20/40 with a specialty KC soft lens design
- Corneal Transplant
  - Scar
  - Comfort

Soft Lenses for KC

- Soft Lenses
  - Standard designs
    - Forme Fruste KC
    - Spectacle Responses
    - Unable to accommodate HOAs induced by moderate to severe KC
- Soft Specialty Lenses
  - Lathe cut
    - Extended BC/Power ranges
    - Increased center thickness
    - Large OZ to enhance draping
    - Adjustable secondary curve(s)
  - Hydrogel vs SiHy
  - Wavefront-Guided correction
**Soft Specialty KC Lenses**

- **Base Curve**
  - As steep as 4.1mm

- **Rx Range**
  - SPH: Up to ± 30D
  - Cyl: Up to -15.00 D

- **Center Thickness**
  - 0.3mm to 0.6mm
  - Fixed or Variable

**Soft Specialty KC Lenses**

- **Enhanced thickness**
  - Masks mild-moderate degree of corneal irregularity

- **Corneal draping mechanism available**

**Soft Specialty KC Lenses**

- **Secondary Curves**: Independently adjustable
  - Geometry customizations
  - Alignment with disproportional eccentricity
    - Essential to lens performances in KC (De Brabander et al., 2003)

- **Lenticularization**
  - Improves comfort & Oxygen delivery

**Soft Specialty KC Lenses**

- **Topography without CL**
  - BSCVA = 20/40

- **Topography over a 0.48mm thick soft KC CL**
  - BCVA = 20/25

**Soft Specialty KC Lenses**

- **Wavefront guided soft lenses**
  - Marsack et al. refit patient into wavefront guided soft lenses
  - VA improved 1.5 lines
  - HOA reduced 50%

- **Hurdles**
  - Translation/Rotation
  - Neural Adaptation
Soft Specialty KC Lenses

- Material selection
- Hydrogel
  - Maximize Oxygen
  - Lens Movement
  - Lenticularization
- SiHy
  - Monitor
  - CLPC
  - CIE

Soft Specialty KC Lenses

- Empirical Fitting
- Diagnostic Fitting
  - Lens fitting set
  - Manufacturers guidelines

Soft Specialty KC Lenses

- Initial BC selection
  - Follow design specific formulary
  - Flatter than you think
  - Sagittal depth
  - 1st diagnostic lens will be your guide.

Soft Specialty KC Lenses

Dynamic Assessment

- Centration
- Comfort
- Movement
  - 1mm movement
- Rotation
  - Prism ballast
  - Double slab off
- Vision
  - No fluctuation with blinking.

Case Example - LM

- 34 YO female KC
  - MR
    - OD -2.50 – 5.75 x 090 20/40
    - OS -2.50 – 0.50 x 097 20/20
  - OD
    - Previous scleral lens
  - OS
    - Oasys 8.4 -3.00
Case Example - LM

- Specialty soft fit OD
- Diagnostic Lens
  - Dia: 15.0mm
  - BC: 8.5/8.3
  - Power +2.50 -5.75 X 090
  - OR -0.50 +1.50 X 014
- Excessive Movement
  - 8.5/8.0

Case Example LM

- During dispense
  - NaFl Video
  - NaFl Video
  - 15.0mm
  - 8.5/8.0
  - +0.62 -4.50 X 085 20/30
  - OR +1.00
  - Fit Evaluation
- Final
  - +1.62 -4.50 X 085 20/25

Soft Specialty KC Lenses – Take Home

- Many new designs available
- Wide range of Sph and Cyl Rx available
- Fitting requirements differ from regular soft
- For some KC patients, specialty soft lenses might be a first option
  - Typically Mild – Moderate KC
  - Alternative for those who failed GPs
  - Realistic expectations for outcome

GP Lenses for KC

- The firm nature of GP allows the underlying tear layer to seamless connect both refractive surfaces

Increasing corneal irregularity often requires an increase in diameter for a successful fit
Corneal GP Lenses

- Lens selection guided by
  - Disease severity
  - Cone location
  - Cone area
  - Elevation
  - Eccentricity
  - Ocular adnexa
  - Handling skill

- Advantages
  - Lens Handling
  - Application/Removal
  - Durability
  - Cost

- Disadvantages
  - Adaptation time
  - Dislodgement
  - FB entry
  - Non-compliance in replacement and care

- Trends in corneal GP
  - Larger Diameters
  - Weight distribution
  - Stability/Position
  - HOA Reduction
  - Aspheric Optics
    - Lens Weight
    - Posterior OZ alignment
    - Spherical Aberration
  - Asymmetrical PCs
    - Stability/Position
    - Comfort

- Consultation or Empirical fitting
- Diagnostic fitting Recommended!!
  - Initial BC selection
    - Fitting guide
    - Topography/Keratometry
    - Irregularity scale
    - Medium Lens
  - Bracket with NaFL
    - Central Alignment
    - AEL
    - Centration
**Corneal GP Lenses**

- Central bearing or Clearance
  - Vision
  - Comfort
  - Corneal Health
    - Corneal bearing
    - Dynamic tear exchange
    - 3’ & 9’ staining
    - Edge impingement
    - Edge standoff

- 3 point touch
  - Shared distribution of bearing pressure between the center and the mid-periphery

**Corneal GP Lenses**

- Is apical bearing acceptable?
  - CLS- GP Insights November 2011
    - Comfort
    - Vision
    - Health

**Corneal GP Lenses**

- Patient Case: JR
  - 44 year-old Female
  - Mild/Moderate KC
  - Topography
  - SLE
  - Discussed Options

**Corneal GP Lenses**

- Patient Case: JR
  - Bi-aspheric
    - Diagnostic lens fit bracketing base curve selection.
  - Lens ordered
    - BC = 7.35mm (46 diopters)
    - Diameter = 10.4mm
    - Power = -4.00 20/50
    - OR = +2.00 -1.25 X 015

**Corneal GP Lenses**

- Front surface toric
  - Ballasted with double slab-off
  - Final CL Rx = -2.00 -1.25 X 015 20/25
**Corneal GP Lenses**
- Decentration
  - Vision
  - Comfort
  - Lens Dislodgement
  - Lens Expulsion
- Troubleshoot
  - Sag depth
  - Optical Zone
  - Secondary curves
  - Lid Attachment
  - Different Lens Designs

**Piggybacking Corneal GP**
- Piggyback
  - Potential Advantages
    - Comfort
    - Corneal Health
    - Lens Position
    - VA
  - Potential Disadvantages
    - Hypoxic concerns
    - Handling complexity
    - Daily Disposables
    - Consider SiHy
  - Specialty lathe cut

**Piggybacking Corneal GP**
- Patient Case: DT
  - 35 year-old female
    - mild/moderate KC
  - 9.6mm/6.75(50D)
  - Rx: -12.00  20/30
  - RTC in 2012
  - Growing intolerance
  - CL options discussed
    - High molecular NaFL!
    - Initial Refit, and
    - Follow-ups
  - May continue using same GP design or can improve current GP fit
    - Soft lens Rx contributions
  - Cost
    - Disposable preferred

**Hybrid Lenses: 1977-2007**
- Saturn® lens invented in 1977, and FDA approval in 1984
- SoftPerm® released in 1986 & expanded parameters in 1989
- Early generations with reported incidences
  - Junctional Rippage
  - Tight & Immobile Lens
  - Reduced Tear Exchange
  - Hypoxia
Hybrid Lenses: 2005- Present

- Redefining hybrid platform
  - Fitting Parameters: Central and junctional SAG depth
  - Metabolic requirements: Higher gas diffusion constant
  - Comfort/Cost/Compliance: Junctional adherence
  - Comfort: Surface wetting chemistry

Hybrid Lenses: 2005- Present

- New Reverse Geometry Designs
  - Further improved central and junctional Sagittal depth
  - SiHy skirt available (2013- Present)

Hybrid Lenses: 2005- Present

CLEK Study:
Central (AKA Nipple) ~15-20%

Hybrid Lenses: 2009- Present

- New Reverse Geometry Designs
  - Further improved central and junctional Sagittal depth
  - SiHy skirt available (2013- Present)

Hybrid Lenses: 2009- Present

Oval ~ 50-60%
Globus/PMD ~20%

Hybrid Lenses: 2009- Present

- Reverse Geometry with Hydrogel Skirt
  - 77.8% (14/18) success in post-Intacs study (Shin A, Chang C, and Fry K, 2012)
  - 83% (N=33 KC) reported good VA and comfort with Clearkone® Vs. habitual CL (Carracedo G et al, 2014)
    - HCLA improved ≥1 line in most of habitual GP wearers
    - Pachymetry values remained constant thru 1-Mth study period
  - Significant higher scores in NEI-VFQ 25 despite comparable VA outcome as habitual GPs (Heshemi H et al, 2014)
    - Ocular pain
    - General Vision
    - Total Score
    - Vision Specific Mental Health
    - Distance Activities
Hybrid Lenses: 2009- Present

Scleral Lenses

- **Advantages**
  - Centration
  - Stability
  - Comfort
- **Disadvantages**
  - Application/Removal
  - Reservoir debris
  - Cost

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<tr>
<th>Lens Type</th>
<th>Description</th>
<th>Definition of Fitting Area</th>
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<tbody>
<tr>
<td>Corneal</td>
<td>Lenses rest entirely on the cornea.</td>
<td>Corneal</td>
</tr>
<tr>
<td>Composite</td>
<td>Lenses rest partly on the cornea, partly on the sclera.</td>
<td>Composite</td>
</tr>
<tr>
<td>Scleral</td>
<td>Lenses rest entirely on the sclera.</td>
<td>Scleral</td>
</tr>
</tbody>
</table>

- **Fitting Philosophy**
  - Corneal Zone
    - 100 to 400 microns of corneal vault.
  - Limbal Zone
  - Scleral Zone
  - Haptic alignment

- **Fitting**
- **Case examples**
- **Troubleshooting**

- **Fitting Philosophy**
  - Corneal Zone
  - Limbal Zone
  - Scleral Zone
  - Haptic alignment

- **Fitting**
  - Diagnostic
  - Molding
  - Scleral Topography
Scleral Lenses- Diagnostic

- Diagnostic Lens
  - Formula

Scleral Lenses- Diagnostic

- Scleral sag Calculation Method
  - Topography sag @ 10mm: 
    Weighted Average Height
    1900.0
  - Scleral sag factor:

  - Initial apical clearance: 400um
  - Required Scleral Lens: 4300um

- Initial apical clearance:
- Required Scleral Lens:

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Pacific University College of Optometry

Scleral Lenses- Diagnostic

- Dx Lens Application
  - Fill with saline
  - Stain the saline with a fluorescein strip

Scleral Lenses- Diagnostic

- Assessing lens vault
  - Comparing the thickness of the scleral lens with the thickness of the reservoir by turning the slit beam at a 45 degree angle

Scleral Lenses- Diagnostic

- Assessing lens vault

Scleral Lenses- Diagnostic

- Be aware of the influences of lens settling
  - Scleral lenses rests on the spongy bulbar conjunctiva
  - Expect the lens to lose up to 200 µm (vary with designs)
**Scleral Lenses - Diagnostic**

- Bracket the lens fit until the stained reservoir is 200 microns more than the desired final vault.
- Bracket by 2 to 6 D steps.

**Scleral Lenses - Diagnostic**

- Haptic Examination
  - Ideally, haptic section of a scleral lens should align evenly on the sclera.
  - Without compression or impingement of the bulbar conjunctiva.

**Scleral Lenses - Diagnostic**

- Special KC Considerations
- Keratoglobus
  - Sagittal depth
  - Steepness is to the outside
    - Large optic zones
    - Reverse geometry

**Scleral Lenses - Advanced fitting**

- Molding
- Corneo-scleral topography

**Molding**

Dr. Jeff Sonsino

**Corneo-scleral Topography**
Corneo-scleral Topography

Corneo-scleral Topography

Corneo-scleral Topography

Corneo-scleral Topography

Scleral Lenses
- Hydrogen Peroxide
- Saline

Patient SA
- 68 year-old KC
- s/p cataract surgery OU
- New glasses- no help OS
- Patient was offered a PK from an Ophthalmologist.
- Optometrist unsuccessful with soft contact lens?
- Referred for consultation.

Patient SA
- New glasses
- OD +1.00 -3.50 X 040 20/25
- OS +1.50 -2.25 X 072 20/200
- Slit Lamp
- Cornea clear OU
Patient SA

- Lens Options
  - Specialty Soft
  - Corneal GP
  - Hybrid
  - Scleral
- Advantages
- Disadvantages

Patients SA

- Scleral 18.0
  - 9.0 OZ
  - Reverse geometry designs
  - CT= 0.49
  - Where to start?

Patient SA

- Base Curve= 50 diopters
- Diameter= 18.0mm
- Standard periphery
- Power= -5.75 (OR= +2.50)
  - Final Power= -3.25
  - 20/30

Patient SA

- Daily Wear
  - Fills with 0.9% NaCl
  - Clear Care®

Patient MM

- 47 YO KC
  - ICRS OU 2009
  - MR
    - OD -6.50 -1.00 X 168
    - 20/200
    - OS -12.50 sph
    - 20/200
  - OD Corneal GP
  - OS D/C GP
Patient MM

- **OD**
- **OS**

Patient MM

- **Topos OD**
- **Topos OS**

Patient MM

- **Scleral Lens Fit**
  - 16mm
    - OD Dx Lens
      - 48D/-3.25
      - OR -11.25
    - OS Dx Lens
      - 50D/-4.25
      - OR -13.75

Patient MM

- **OD**
  - 16mm
  - 48 diopter
  - -13.25 20/25

Patient MM

- **OS**
  - 16mm
  - 48 diopter
  - -13.25 20/25

Patient LC

- 56 year-old keratoglobus
- PK OS
Patient LC

- “Difficulty” with hybrid contact lens
  - 20/40 (hybrid/specs)

Patient LC

- Keratoglobus
  - Generally require a lens with a large OZ and reverse geometry profile.
  - “Monster Kone”
    - Dia= 20mm
    - OZ= 10mm
    - Reverse geometry
      - 4 peripheral curves

Patient LC

- 1st diagnostic lens
  - BC= 52 diopters
  - Needs more sagittal depth.

Patient LC

- Dia= 20.00mm
- BC = 55 diopters
- OZ = 10.0mm
- 4D of reverse
- Power = -20.50
  - OR -1.75
- Total sag = 7.68mm
- Dispense
  - Power= -22.25 20/30

Patient LC

- BC= 54
- BC=56
**Multifocal**

- KC
- BCVA
- HOA
- Lens centration

**Future- Customization**

Contact rotation: 0.7 deg

Future- Customization