New Contact Lens, Surgical & Medical Management Options for Keratoconus

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It’s not rare…
if it’s sitting in your chair.

1 in 1,800  Kennedy et al. 1986
“Probably more common”  Edrington 2014

Diagnosis of Keratoconus

Noninflammatory?
Low grade inflammatory component
Lema et al. 2009
Tx with Pataday (Alcon) QD or Alrex (B+L) QID X 2 weeks; then BID

Ectasia central / inferior cornea
Irregular astigmatism

ASymmetric Condition

<table>
<thead>
<tr>
<th>Better Eye</th>
<th>Worse Eye</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat Keratometry</td>
<td>45.94 ± 4.10D</td>
<td>49.53 ± 5.83D</td>
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<tr>
<td>Steep Keratometry</td>
<td>48.51 ± 4.49D</td>
<td>52.86 ± 5.75D</td>
</tr>
<tr>
<td>High Contrast Best-Corrected Visual Acuity</td>
<td>7.30 ± 6.83 Letters</td>
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Age of Onset

Puberty
Earlier age of onset; more severe disease
Progressive until the third to fourth decade

CLEK Survey:
Mean age of diagnosis = 27.3 ± 9.5 years

The Manchester KC Study: n = 29
Mean age of diagnosis = 21±8 years
Gender

- Literature reports relatively equal incidence between males and females
- CLEK Study sample: 56.4% male, 43.6% female
- Manchester KC Study: 76% male
- Pellucid patients

Quality of Life (QOL) in KC

- Scores for CLEK subjects on all scales NEI-VFQ (Visual Function Questionnaire) were consistent with patients with category 3 and 4 (advanced AMD) age-related macular degeneration patients, except for...
  - General health was better for CLEK subjects (they’re younger)
  - Ocular pain was worse for CLEK subjects (they are forced to wear GPs)
    - “prior to” scleral lens prescribing

Keratoconus Patient Education

- You will not go blind from the condition
- Have a large and wonderful family
  - Average age of Dx 27.3 years in CLEK Survey
- LASIK is not a good idea
  - Both result in corneal thinning
- Back-off on the eye rubbing
- Corneal cross-linking

Eye Rubbing

- Consider Rxing
  - Lastacaft (category B anti-histimine) QD
  - Alaway (OTC) BID

Corneal Collagen Cross-Linking aka C3-R and CXL

- Photo-polymerization increases the number of collagen cross-links
- Goal is to strengthen (stiffen) the cornea
**Corneal Collagen Cross-Linking (C3-R)**

- Remove corneal epithelium (or not)
  - Corneal thickness should be 455 microns (including epithelium)
- Apply riboflavin 0.1% (Vitamin B2) drops
  - Every 3 min for 30 min pre-op; then every 5 min for 30 min tx
- Expose to ultraviolet (UVA) light (370 nm)

**Coskunseven et al.**
*J of Refractive Surgery, April 09*

<table>
<thead>
<tr>
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<th>Best spectacle Corrected VA</th>
<th>Max K</th>
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<tbody>
<tr>
<td>Pre-Op</td>
<td>0.29 = 20/70</td>
<td>54.02 D</td>
</tr>
<tr>
<td>Mean 9 month Post-Op</td>
<td>0.40 = 20/50</td>
<td>52.45 D</td>
</tr>
<tr>
<td>Can patient stop wearing CL’ s?</td>
<td>Does this help Rx CL?</td>
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**Complication and failure rates after corneal crosslinking**
*Koller et al., J Cataract Refract Surg, August 09*

- 117 eyes of 99 patients
- Baseline, 6 mos, and 12 mos follow-up
- Percentage of eyes losing ≥2 lines of VA
  - 2.9% (95% CI, 0.6-8.5%)
  - Risk factors included >35 years of age
- Percentage of eyes exhibiting progression
  - 7.6%
  - Risk factor of steep K >58 D (or is cornea too thin?)

**Who are good candidates for corneal cross-linking?**

- Disease severity
  - K readings (steep K)
  - Corneal thickness
- Age
- Goal should be stabilization, not improvement

**Cross-Linking in Pediatric Patients**

- Arora et al. (*J Refract Surgery* Nov 2012)
  - 15 eyes of 15 patients; age range 10 to 15 years; 12 month f/u
  - CDVA 20/70 to 20/40; St K 57.18±6.39 to 56.76±6.78 D
- Zotta et al. (*J Refract Surg* Nov 2012)
  - 8 eyes of 4 patients; age range 11 to 16 years; 3 year f/u
  - VA improved 6 eyes (~1.17 lines) and stable in 2 eyes; MR stable

**Cross-Linking in Pediatric Patients**

- Chatzis and Hafezi (*J Refract Surgery* Nov 2012)
  - 59 eyes of 42 patients; age range 9 to 19 years; mean 26.3 mos f/u
  - "the effect of arrest of disease progression might not be as long-lasting as in adults"
- Buzzonetti and Petrocelli (*J Refract Surg* Nov 2012)
  - 13 eyes; age range 8 to 18 years; 18 month f/u
  - St K 48.90±6.60 to 52.90±4.90 D
  - "improved CDVA was noted 18 months after treatment…does not effectively halt keratoconus progression in children"
Other Thoughts about Cross-Linking

- Corneal haze post-procedure peaks at 1 month, generally disappears at 6 months
- Corticosteroids standard tx after cross-linking
- Age and diabetes are protective against keratoconus
- Epi-on procedures decrease infection risk
- Procedure now takes ~1 hour; in future 2min 40sec?
- Fit CL after epithelium is healed

Goal of corneal cross-linking should be stabilization, not improvement.

I fit CLs to enhance or improve vision, not to alter the progression of keratoconus.

Visual Acuity (CLEK Study)

- 88% were 20/40 or better through CLs
- 58% were 20/40 or better through manifest refraction
  - Is manifest refraction repeatable?
  - Is quality of vision adequate?
    - Depends on disease severity

Rigid Contact Lens Fitting Relationships in KC
Edrington, Szczotka, Barr et al. OVS Oct 1999

How flat they’re fitted
88% fitted apical touch

- Mild keratoconus (<45 D) 1.18 D flat (SD±1.84)
- Moderate (45-52 D) 2.38 D flat (SD±2.56)
- Severe (>52 D) 4.01 D flat (SD±4.11)
- Overall 2.86 D flat (SD±3.31)

GP Fitting Philosophies

- Flat = touching the cone apex
  - Better vision? Probably
  - Delay the need for surgery? NOT!
  - Increases risk of corneal scarring? Yes
- Steep = vaulting the cone apex
  - Less disruption to cone apex
Put on a lens!!!

“Pearl” from Tim

“Ideal” Corneal GP KC Fit
- Goal #1: feather “three-point” touch or slightest amount of apical clearance
- Goal #2: minimize area of tear pooling around base of cone
- Goal #3: average (to maximum) peripheral clearance to enhance tear exchange
  
  might not be uniform at all axis

FDACL
first definite apical clearance lens

How much touch?
- Little Bit o’touch (soft borders)
- More o’touch (harsh borders)

Avoid excessive areas of tear pooling around base of cone
- “Dimples aren’t always cute”
  Dr. Brooke Messer

Peripheral Clearance
**More than Round (Designs)**

**Abound**

- Aspheric / Biaspheric
  
  *Tip: start by using manufacturer’s fitting guide and personalize over time*

- Toric GP’s
  
  - Bitoric are tempting, but...
  
  - Prism-ballast front-surface toric

**The Role of OAD in KC**

- Traditional 8 to 9mm
- Intralimbal 10 to 12mm
- Scleral 14 to 23mm

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**Large OADs for KC**

- Intralimbal corneal GPs
  
  - Option for decentered cone apex
  
  - Option to enhance initial comfort?

- Sclerals
  
  - Indicated for KC patients who are intolerant of GP lens wear
  
  - Indicated for KC patients whose GP lenses eject or decenter often

**Scleral Indications**

- Irregular Corneas
- Therapeutic / Ocular Surface Disease
- Corneal GP lens intolerance or ejection
- Cosmesis
  
  - Pupil
  
  - Aniridia
  
  - Prosthesis

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**General Scleral Lens Design**

**Assessment of Scleral Lenses**

- Using an optic section, assess the ratio of the tear reservoir thickness to the central thickness of the contact lens, or the thickness of the cornea

- Example: 1:2 TL:CL ratio. Known lens center thickness is 0.35mm (350 µm), so tear lens reservoir is 175 µm
Assessment of Scleral Lenses

- There is a wide range of acceptable clearance (100-500 microns)
- Typically aim for 150-250 µm
- Tear reservoir thickness affects oxygen transmissibility
- 1 diopter = ~80 µm change
- The amount of clearance may vary throughout the lens
- Keep in mind scleral lenses tend to settle down ~100 µm with longer wear time, which can result in a thinner tear reservoir.

Assessment of Scleral Lenses

- Which of these two lenses has the steeper base curve?
- Cornea curvature ≠ Sagittal depth
- Both of these lenses have the same base curvature, but they have different diameters.
- The larger diameter lens has a deeper sagittal depth than the smaller diameter lens.

Assessment of Scleral Lenses

- Step One:
  - Does the lens vault or touch the cornea?

Assessment of Scleral Lenses

- Step Two:
  - Does the lens clear or touch the limbus?

Assessment of Scleral Lenses

- Step Three:
  - Evaluate the landing curves for proper scleral alignment
    - Focal or sectoral blanching may not require an adjustment
    - Blanching around majority of lens requires adjustment

Assessment of Scleral Lenses

- Step Three:
  - Evaluate the landing curves for proper scleral alignment
    - Slight edge lift can allow for + tear exchange
    - Excess edge lift can cause bubbles or lens awareness
**Assessment of Scleral Lenses**

- Step Four:
  - Perform an over-refraction
    - Spherical first to determine BCVA with sphere alone
    - Spherocylindrical second if ideal VA still not achieved
    - If necessary perform over-keratometry or topography

**Troubleshooting Tips**

**Residual astigmatism may be caused by:**
- Lens Flexure – increase center thickness by 0.1-0.2 mm or use back surface toric periphery
- Lenticular Astigmatism – can order front surface toric or design overlay glasses
- Generally should try with spherical design before moving to F1 toric

**Troubleshooting Tips**

- Air bubbles are most often a product of improper lens application technique, but can also be caused by improper scleral alignment/excessive edge lift.
- Bubbles can cause discomfort and interfere with vision.

**Troubleshooting Tips**

- Follow-up:
  - Patient should return having worn lenses 3-4 hours prior to follow-up to ensure lenses have settled
  - You can instill fluorescein with the lens on to determine whether there is tear exchange

**Troubleshooting Tips**

- Toric Sclera
  - As you move further from the limbus, the sclera becomes more toric
  - Larger overall diameter scleral lenses may require a toric periphery (back-surface toric) design to achieve appropriate alignment.

**Troubleshooting Tips**

- Midperipheral Bearing
  - Pellucid marginal degeneration or inferior displaced cones may require a reverse geometry design to vault the midperipheral area of bearing.
**Troubleshooting Tips**

Lens drop is an area of tear reservoir thinning or absence due to a very heavy and/or steep lens that decinters. It typically occurs in the superonasal quadrant of the lens.

**Troubleshooting Tips**

Pingueculae may cause localized hyperemia and require notching of the lens.

**Troubleshooting Tips**

Other irregular anatomical landmarks, like bulbar conjunctival cysts or filtering blebs, may also require notching.

**Troubleshooting Tips**

Conjunctival Hooding

Mild conjunctival hooding is generally inconsequential. Severe conjunctival hooding can cause neovascularization and may require fit adjustment or a resection procedure.

**Troubleshooting Tips**

Diffuse pancorneal epithelial erosions are often indicative of solution toxicity. Ensure the patient is properly educated on lens hygiene and proper solution use.

**After You Dispense**

A mild impression ring after lens removal without bulbar injection may be acceptable.
An impression ring with bulbar injection or limbal congestion indicates a tight and/or sealed-off fit.

Mild, transient rebound redness upon lens removal is acceptable, but excessive and persistent redness and limbal congestion is indicative of a tight fit/seal off.

Tear reservoir clouding can occur if debris accumulates under the lens. Many patients need to remove/clean lens at least once during the day. Solution “cocktail” of PF saline + Celluvisc may delay clouding.

Poor surface wetting can cause reduced vision. Can use Progent, Miraflow (Walgreens Extra Strength Daily Cleaner), Boston Conditioning, plasma treatment.

“The comfort of a soft lens with the vision of a gas permeable lens.”

After You Dispense

After You Dispense

After You Dispense

Application and Removal

Application and Removal
Application and Removal

Care Regimen & Solutions
- The fluid inside the lens should be a preservative-free saline solution. Preservatives sitting in the tear reservoir can cause a toxic reaction.

Care Regimen & Solutions
- GP lenses made with high Dk material are generally not compatible with abrasive cleaners.
- Acceptable Solutions:

Patient Management
- Considerations to discuss with patient prior to fitting:
  - Cost (fitting + lenses) – can bill as medically necessary with some insurances
  - Time investment – will require multiple visits
  - Application & Removal – may be difficult for patients with poor fine motor skills or dexterity, or anatomically small palpebral apertures

Patient Management
- Always prepare your patient ahead of time – no surprises:
  - Solution to fill scleral bowl should be preservative
  - May need to remove, clean, refill, and reapply lens
  - Transient rebound redness or an impression ring may occur after lens removal
  - Recommend take-home handout with pictures of acceptable solutions and resources

The Sky’s The Limit
- Scleral lenses are a useful tool for a wide range of patients
- They are incredibly customizable, and you have the ability to get creative
  - Many available diameters
  - Reverse geometry
  - Front surface toric
  - Back surface toric (toric periphery)
  - Center near aspheric multifocal
  - “Notching” for pterygia/cysts/blebs
**Soft Lens Options for Keratoconus**

- Available in a silicone hydrogel material
  - Kerasoft IC (Bausch + Lomb Boston Group)
    - 14.5mm OAD and 8.0mm OZD

- Made in Definitive material
  - Silicone hydrogel (Dk = 60)
  - Water content = 74%

- “Front-surface aberration control optics”

**Piggy Back**

- When?
  - Comfort (initial); 3-9 staining; bandage

- How?
  - Minus, plus power - how much?
  - Over-keratometry

- Effect on over-refraction
  - ~23% effect (Daniel Brazeau)

- Materials?
  - S-H? Modulous?

- Care system?

**SynergEyes Fluorescein Patterns**

**Intacs**

- For low myopia (1-3D)
- FDA approved for KC (2004)

- Goal for KC patients
  - To reduce corneal steepness
  - To center the cone apex
  - assists in CL fitting???

- KC candidates for Intacs
  - Clear central cornea
  - Steep K <57 D (too thin?)

**Intracorneal ring segments for KC correction: Long-term follow-up**

*Alio et al., J Cataract Refract Surg, June ’06*

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<th>Max K</th>
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<tr>
<td>Pre-Op</td>
<td>0.46 = 20/50</td>
<td>51.07 D</td>
</tr>
<tr>
<td>Mean 6 month</td>
<td>0.66 = 20/30</td>
<td>47.15 D</td>
</tr>
<tr>
<td>Post-Op</td>
<td>0.62 = 20/32</td>
<td>48.92 D</td>
</tr>
<tr>
<td>Mean 3 year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-Op</td>
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**Post-INTACS Low Dk Toric SCL**

*(photo courtesy of Dr. Long Tran)*
**Corneal Hydrops**

- Rare: 2 to 3% of KC patients
  - Advanced disease
  - Eye rubbing
  - Young males
  - Severe allergies
- High rate of PK
  - High rate of rejection (eye rubbing?)
- Resolves 2 to 4 months
  - Scarring
  - Haze
  - Flattening of K (refit?)

**Therapeutic Treatment for Corneal Hydrops**

- In-office, homatropine or scopolamine for pain
- At home, cool compresses for itch
- Muro 128 5% QID (drops/ointment)
- NSAID TID/QID for pain and inflammation
- Note: avoid (?) steroids because they slow healing (but may decrease scarring)

**Deep Anterior Lamellar Keratoplasty (DALK)**

- DALK involves the removal of the central stroma while leaving the host endothelium and Descemet's membrane intact and has been performed using air injection since 1984.

**Advantages of DALK over PK:**

- Immune rejection of the corneal endothelium cannot occur
- The procedure is extraocular and not intraocular
- Topical corticosteroids can usually be discontinued earlier with DALK
- There is minor loss of endothelial cell density
- Compared with PK, DALK may have superior resistance to rupture of the globe after blunt trauma
- Sutures can be removed earlier with DALK
Advantages of PK over DALK:

- PK can be used to treat corneal conditions that involve the endothelium, although EK (DSEK or DSAEK) may now be preferred.
- PK can treat penetrating corneal trauma, especially if there is loss of corneal tissue.
- PK can be used if there is scarring down to the level of DM, such as post-acute hydrops in keratoconus, old penetrating central corneal injuries, and severe post-infectious corneal ulcers.
- PK is a more familiar operative procedure for most corneal surgeons.

Post-Penetrating Keratoplasty (PK or PKP)

Corneal Buttons

- Many surgeons use a trephine.
- Manual “cut” puts torsional pressure on the corneal button.

Corneal Buttons

- IntraLase femtosecond laser creates smoother graft edges.
  - New cut patterns improve button fit.
  - Reduces surface irregularities.

IntraLase Advanced Keratoplasty

- Increased surface area of contact.
- Early fibrosis leading to early healing.

Slide courtesy of Dr. Dan Tran.

*Zig Square image courtesy of Sharon Days MD.
Full Thickness PK

115.2 Femtosecond Assisted Penetrating Keratoplasty: Dissection of Recipient Button and Donor Suturing
Marjan Farid, Sumit Garg, Roger F. Steinert

Penetrating Keratoplasty Sutures
- Surgeon’s preference
- Depth - approximately 90% into stroma
- Running – faster, fewer knots
- Interrupted – can be removed to control astigmatism (CL refit?)
- Combination – allows for early removal without risk of compromising graft

Management of Penetrating Keratoplasty (Post-PK)

Corneal Graft Rejection
- 1 to 3 months post-op is highest risk period
  - but can happen anytime
- Watch for:
  - sub epithelial infiltrates (SEI)
  - cloudy central cornea
  - pain, redness, sudden blur complaints
  - increased light sensitivity
  - epithelial or endothelial rejection lines
  - IOPs >20mmHg - #1 cause of graft rejection

Corneal Graft Rejection

Management of Penetrating Keratoplasty
- ~3 to 6 months to 1 year post-op “safe” to fit CL’s
- Check ocular health at each F/U
  - Corneal staining
  - IOP’s
  - Watch for signs/symptoms of rejection
- Some patients remain on Pred Forte 1% for the rest of their lives
  - Some are also on oral anti-inflammatory or immunosuppressive meds
- Co-manage with surgeon
Post-Penetrating Keratoplasty
- Over 50% of post-PK pts. have 4 or more diopters of astigmatism
- Irregular astigmatism is most common
- Up to 50% of post-PK patients benefit from CL wear
- Will the results be better with new femtosecond full and partial-thickness surgical procedures?

Post-PK Select lens design based on type of corneal graft
- Nipple / Proud graft
  - Sphere or aspheric
- Sunken / Plateau graft
  - Reverse geometry
- Tilted / Eccentric graft
  - Large OAD / Scleral
- SCLERALS
  - Be Careful with lens removal using DMV

Consider the graft diameter when selecting the lens optic zone diameter
- Reverse geometry design: "Junctional knee"

Large CORNEAL Lenses for Post-PK (and other irregular corneas)
- Start with corneal topography
  - To get the lay of the land
- Start with a large (intralimbal) OAD sphere DxCL
  - Unless graft is highly oblate (reverse-geometry)
- Select initial BC based on...
  - Oblate vs prolate vs...
  - Initial BC 1.0 to 1.5 D steeper than post-operative flat K or sim K
  - or 4mm temporal

Post-PK Reverse geometry (steep/flat option)
**Large Lenses for Irregular Corneas**

- GP lenses can mask *significant* amounts of corneal surface irregularities.
- Start with corneal topography:
  - To get the lay of the land.

**Get a lens on the eye!**

- Original fit
  - FP evaluation (inside-out)
    - Apical relationship
    - Optic zone size
    - Peripheral clearance
  - Lens position and movement

**Get a lens on the eye!**

- At follow-up visits
  - Evaluate fitting relationship
  - Monitor for corneal staining “patterns”
    - Location, density, and appearance

**Minimize Areas of Excessive Clearance and Harsh Bearing**

**Sclerals and PK issues and pearls**

- Varied shapes of grafts can make vaulting with scleral challenging
  - Recommend reverse geometry design to mimic oblate shape of post-graft cornea
- Oxygen transmissibility can be limited by many factors
  - Overall diameter, scleral center thickness, tear reservoir thickness, and Dk of material should all be taken into consideration to maximize oxygen to the eye.