Advances in Keratoconus Management

The Incidence of Keratoconus is Approximately 1 in 2,000

What We Know About Keratoconus

The condition occurs in every country throughout the world, rules out
1. Environment
2. Diet

Occurs equally in men and women

Usually begins between the ages of 12 and 32

Condition of unknown etiology
Corneal Thinning
Ectatic Conditions

Stromal Loss
Ectatic Conditions
Post refractive surgery ectasia
Post infection ectasia

Puberty Onset Keratoconus
- Begins in early adolescence approx. age 12 to 16.
- Usually bilateral with one eye affected worse than the other.
- The younger the patient, the more severe the condition.
Late Onset Keratoconus

- Usually begins in late 20’s or early 30’s
- Both eyes can be affected the same.
- The incidence of progression reduces greatly with the age of onset.

Keratoconus Fruste

- A mild non-progressive form KC
- Can occur anytime throughout life.
- No positive slit lamp findings associated with KC.
- Normal corneal thickness.
Theories as to the Cause of Keratoconus

- Aberration in normal tissue development
- Eye rubbing
- Hereditary
- A segment of a yet unidentified syndrome

The Cascade Hypothesis of KC

Cristina Kenney Ph.D.

- Collagen fibers are degraded due to exposure to UV light, mechanical trauma (contact lenses, eye rubbing) and atopic disease.

- With the accumulative traumas, there is a resultant deposition of cytotoxic by-products causing an alteration of corneal proteins that can.
  - disrupt Bowmans layer
  - thin the stroma
  - result in corneal scarring

Things We Can Do To Limit Oxidative Stress

- Suggest UV protection in CL’s and glasses.
- Pharmacological intervention
  - Non-steroidal anti-inflammatory
  - PF artificial tears
  - Allergy medications
- Minimize mechanical and physiological epi trauma;
  - Proper fitting RGP lenses
  - Soft lenses / Piggyback lenses
  - High Dk/t lens
Hallmarks of Keratoconus

- Decline in visual acuity
- Changes in cylindrical power and axis
- Increased myopia
- Squeezing of the eyelids, artificially creating a pinhole effect
- Appearance of halos around street lights

Congenital and Development Defects Associated with Keratoconus

- Anirida
- Congenital cataracts
- Microcornea
- Blue sclera
- Martens’ syndrome
- Down syndrome
- Mongolism
- Pigmentary retinopathy
- Ectopic lentis
- Optic atrophy
- Glaucoma
- Anterior polar cataracts
- Addisons’ disease
- Thyroid disease

Associated Conditions

- Atopic eczema
- General allergic disposition
- Vitamin D and E deficiencies
- ? Hard contact lenses
Technology History

- Biomicroscope
- Placido disc/Photokeratoscopy
- Keratometer
- Corneal topographer
- Anterior Segment Optical Coherence Tomographer (OCT)

Corneal Topography

Map Settings:
- Axial
- Tangential
- Elevation
- Photokeratoscopic
- Numeric
Corneal Topography

Map Settings:
• Axial
• Tangential
• Elevation
• Photokeratoscopic
• Numeric
Anterior Segment
Optical Coherence Tomography

Traditional Ultrasound: ~150 micron resolution
Visante OCT: ~18 micron resolution
- Time delay of reflected / backscattered light
- Multiple A-Scans
  - 2,000 axial scans / second
  - Cross-sectional images created analogous to B-scan ultrasound
- 1310 nm wavelength

Types of Visante OCT Scans
- Anterior Segment
  - 16 mm x 6 mm
- Pachymetry Map
  - 10 mm x 10 mm
- High Resolution Corneal Scan
  - 10 mm x 3 mm
Visante OCT
Traditional Applications
– Refractive surgery management
– Diagnosis and monitor corneal conditions
  • Assessment of angles
  • Monitor anomalies of the anterior chamber

Current OCT Applications
• Anterior chamber
  – Corneal Diameter
  – Sagittal Depth
• Corneal ectasia
  – Elevation vs. Curvature
• Scleral curvatures
  – Tangent angles
  – Toricity

Corneal Cross-Linking
Corneal Crosslinking (CXL)

CXL uses Riboflavin (Vitamin B2) and UVA light to strengthen corneal tissue to slow down or stop corneal thinning disorders.

First used in 1998.

Today: In October 2011 FDA granted orphan drug status to Avedro for riboflavin ophthalmic solution for the treatment of;
• Progressive Keratoconus
• Post LASIK Ectasia

Surgical Procedure

• Topical anesthetic and Alphagan-P are applied.
• The corneal epithelium is removed (9 mm diameter zone) exposing the ectactic zone.
• 0.1% Riboflavin drops are applied every 2 min for 30 min and CT verified (400 microns).

Surgical Procedure

• The UVA Diode (370nm) is positioned 5 cm from the eye for 30 minutes.
• Closure with antibiotic, corticosteroid, NSAID and bandage contact lens.
Who Might be a Candidate for Corneal Crosslinking

Puberty Onset Keratoconus
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Normal Corneal Anatomy = 540 um

- Epithelium
- Bowmans Layer
- Stroma
- Descemets Membrane
- Endothelium
In Corneal Crosslinking the Epithelium is Removed

- Keratoconus: 20 to 50 um
- Normal Cornea: 50 um

UV Absorption Post Epi Removal

- 400 um
Patient AC

At the cone apex, this patient’s minimum CT is 335 um (with epithelium) Approx 300 um (without).

Hypotonic 0.1% Riboflavin swells the cornea BUT...perhaps not enough to treat this patient.

Corneal Crosslinking Complications

Post-op epithelium staining (UV Toxicity?)

Anterior stromal haze for two to six months. (Stromal Keratocyte Damage?)

Electromagnetic Spectrum
Far Ultraviolet Light
Current UV Frequency
365 - 370 nm

Irradiation of Pathologic Organisms (Corneal Sterilization) with Riboflavin and UV Light

265 nm Disinfection
Normal         Keratoconus           PMD            Keratoglobus

Only 10% of People with KC Undergo Corneal Transplant Surgery
• When the patient can no longer be fitted with contact lenses.
• When contact lenses no longer provide adequate visual acuity due to corneal scarring.
• Patients who require sharp binocular vision for their profession.

Effect of Contact Lenses in Keratoconus
• Do contact lenses stop or slow the progression of keratoconus?
• Do contact lenses cause keratoconus?
Apical touch vs. apical clearance in keratoconus, which is the fitting technique of choice in 2015?

<table>
<thead>
<tr>
<th>Apical Touch</th>
<th>Apical Clearance</th>
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<tbody>
<tr>
<td>#1 Disruptions in Bowmans</td>
<td></td>
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<tr>
<td>#2 Subepithelial Fibrosis</td>
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</tbody>
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- #1 Disruptions in Bowmans
  - Intact Bowmans
  - Rupture in Bowmans

- #2 Subepithelial Fibrosis
  - Keratoconus
  - Normal Cornea
KC Lens Eccentricities

*Range from .80 to 1.60*

Traditional KC Lens Design
Bi-Ashperic

Oval Keratoconus

Bi-Aspheric Lens Design
Effect of Base Curve
Ideal

2 Diopters Flatter
Slightly Flat

2 Diopters Steeper
Slightly Steep
Bi-Aspheric Lens Design

1.65 mm Temporal of the Apex

50.37 D
6.70 mm
**Base Curve:** 50.00 D. (6.75 mm)  
**Power:** -7.25 D  
**Diameter:** 9.6 mm  
**Design:** Bi-aspheric

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**Patient: JM  Age: 23  Gender: M**  
- Diagnosed with Keratoconus in 2007 at a LASIK surgery screening consult  
- Has a history of soft toric contact lens wear with poor visual acuities  
- Currently wears glasses with decreased best corrected visual acuity  
  
  **Rt:** -11.00 – 5.00 x 105  20/70-  
  **Lt:** -7.00 – 3.25 x 103  20/50

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**Steep central apical curvatures with superior flattening and high eccentricity OU**
Patient: JM

IKONE / 64.00 D (5.27 mm) / -22.25 DS
/ 8.8 mm / Optimum Comfort

IKONE / 59.00 D (5.72 mm) / -19.25 DS
/ 8.8 mm / Optimum Comfort

minimal edge lift OD
minimal edge lift OS

Modified with 11.5 mm diamond tool and polished with 12.0 mm tool

IKONE / 64.00 D (5.27 mm) / -22.25 DS
IKONE / 59.00 D (5.72 mm) / -19.25 DS
/ 8.8 mm / Optimum Comfort

Patient reported good vision and a comfortable wearing time of 12-14 hours / day

IKone

Effect of Peripheral Curve

1 Step Steeper
2 Steps Steeper
3 Steps Steeper
Advantages of Bi-Aspheric Design

- Aspheric Optics
  - Controls spherical aberration
  - Reduces lens mass
- Larger Diameter
  - Distributes weight more evenly across the corneal surface
  - Reduces glare / halos
  - Improves lens stability

Anterior Segment OCT

Sagittal Height
Unilateral Keratoconus

Soft Contact Lenses for KCN

- Initial Base Curve Selection
  - Mean K + 1.00 mm
  - Example:
    - 54.00 D (6.25 mm) @ 165 / 55.50 D (6.08 mm) @ 077
    - Mean K = (6.25 mm + 6.08 mm) / 2 = 6.16 mm
    - Initial BC = Mean K + 1.00 mm = 7.16 mm
  - Initial Base Curve = 7.20 mm
- Select Fitting Curve
  - 8.3 mm, 8.6 mm or 8.9 mm
- Select Overall Diameter
  - 10.0 mm to 17.0 mm
Patient: KB  Age: 50 M
History: Keratoconus OU with history of GP intolerance
K’ s: OD 61.62 @ 174 / 55.00 @ 084
OS 51.75 @ 030 / 46.00 @ 120
MR: OD  +3.00-3.25 x 088
VA 20/60
OS  +4.50-4.25 x 105
VA 20/70

- Mean K
  - OD 58.37 D (5.79 mm)
  - OS 48.85 D (6.91 mm)

- Base Curve
  - OD 5.79 mm + 1.00 = 6.8 mm
  - OS 6.91 mm + 1.00 = 7.9 mm

Custom SCL’s for KC
OD: 6.8 mm / -1.50-3.25 x 072 / 14.8 / 8.9 mm fitting curve
OS: 7.9 mm / -0.25-2.75 x 104 / 14.8 / 8.9 mm fitting curve
Soft Contact Lenses for KCN

- **Thickness**
  - Center: 0.30 mm or greater
  - Periphery: thinner outside optical zone

- **Lens Material**
  - Water Content 55% or greater HEMA
  - Silicone Hydrogel

- **Fitting Tips**
  - One eye at a time
  - Refit most needy eye first
  - Sphere power only for first lens
  - Monitor topographical changes
  - Caution with hydrogen peroxide systems

Lathable Silicone Hydrogel

- **Contamac**
  - FDA approved
  - Dk = 60, Water Content 74%
  - No Surface Treatment
  - Non-Ionic
  - Vary center thickness
  - MPS recommended
  - Sphere and Toric
Contamac, Definitive Silicone Hydrogel Material

- FDA Approved Laboratories
  - Art Optical
  - X-CEL
  - Metro Optics
  - Unilens

Soft Contact Lenses for Irregular Astigmatism

- Lathable Silicone Hydrogel Material
  - Keratoconus
  - Post Refractive Surgery
    - Increase in Center Thickness
    - Reverse Geometry Designs

Lathable Silicone Hydrogel

- Manufacturing
  - Lathing
  - Wetting properties
- High Refractive Errors
  - Plus lenses vs. Minus lenses
- Corneal Irregularities
  - Custom parameters
  - Increase center thickness