Keratoconus: The Continuum of Care

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International Keratoconus Academy
Of Eye Care Practitioners

**Mission:** to promote and develop the knowledge base and awareness of the state of the art pertaining to the diagnosis and management of keratoconus and other forms of corneal ectasia. And further to promote the awareness and understanding of the most appropriate and effective treatment strategies for the management of these diseases.
International Keratoconus Academy
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“Keratoconus is a clinical term to describe a condition in which the cornea assumes a conical shape because of thinning and protrusion”
## Continuum of Care for Keratoconus: Contact Lens Choices

<table>
<thead>
<tr>
<th>Corneal Condition*</th>
<th>Topography</th>
<th>Pachymetry</th>
<th>Keratometry Readings</th>
<th>Myopia, Astigmatism and Gene Location</th>
<th>Lens Choices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forme Fruste¹</td>
<td>Topography shows eccentric steepening</td>
<td>Normal: 500µm or greater</td>
<td>Mean central K &lt; 48.000</td>
<td>Myopia and astigmatism less than 5.00D⁴</td>
<td>Soft toric, Custom soft toric, Corneal gas permeable, Hybrid</td>
</tr>
<tr>
<td>Mild</td>
<td>Topography shows inferior steepening</td>
<td>Pachymetry is greater than 2 standard deviations from normal 550µm (less than 500µm)</td>
<td>Mean K ranges from 40.00D to 48.00D³</td>
<td>Myopia and astigmatism 5.00-8.00D</td>
<td>Corneal gas permeable: Keratoconic design, Hybrid, Thick custom soft: Keratoconic design</td>
</tr>
<tr>
<td>Moderate</td>
<td>Topography shows significant steepening</td>
<td>Corneal thickness 300-400µm</td>
<td>Mean K ranges from 48.00D to 52.00D³</td>
<td>Location of cone is central or paracentral (2-5µm from center)</td>
<td>Hybrid, Scieral</td>
</tr>
<tr>
<td>Severe</td>
<td>Topography shows significant steepening</td>
<td>Corneal thickness 200-300µm</td>
<td>Mean K greater than 52.00D³</td>
<td>Apex is peripheral (outside central 5µm)</td>
<td>Scleral, Custom scleral</td>
</tr>
<tr>
<td>Surgical</td>
<td>Topography shows significant steepening</td>
<td>Significant central scarring</td>
<td>Corneal thickness &lt; 200µm</td>
<td>Refraction not measurable</td>
<td></td>
</tr>
</tbody>
</table>

[¹]: Requires corneal maps

**Note:** The table outlines the lens choices based on the severity of keratoconus, with specific topographic and pachymetric criteria for each category. The lens choices vary from soft contact lenses to custom and gas-permeable designs, tailored to the specific needs of each condition.
# Keratoconus Stageing

## Mild/Emerging
1. Multiple SRX re-make
2. Fleischer Ring, Vogt’s Stria or Scissor reflex
3. Unstable topography
4. No scar
5. Light Sensitivity/glare
6. Steep K $< 53$ D
7. Pachymetry $> 475$

## Moderate/Severe
1. Mild to no scarring
2. Refraction not measurable
3. Steep K $> 53$D
4. Pachymetry $< 475$

The difference in reimbursement for one carrier is twice for the various levels of medically necessary contact lens fitting
TOPICS TO DISCUSS

THE KERATOCONUS EPIDEMIC

NEW TECHNOLOGIES FOR DIAGNOSIS

NEW TREATMENTS
Impact of Keratoconus on our patient’s lives... what we don’t hear in the exam rooms:

• “I'm really trying to have positive thoughts and attitudes as I deal with keratoconus but some days it's hard. You never really know what you have until it's gone. Every waking moment we use our eyes so every waking moment I am reminded of this struggle. I want to do all I can to help my vision get better...”

• “I wana take my life because of KC I can’t see proper my friendz nd fam don’t care...”
“Frustrated in my career because the cornea is so clear”

Jay Krachmer, MD
Professor, University of Minnesota
The Vision Challenge with Irregular Corneas

- Monocular Diplopia
- “Ghost” images
- “Asthenopia”
- Polyopia
- Photophobia
- Halos around lights
KERATOCONUS  

**Natural history**

- Incidence approximately 1 in 2,000
  - Reported incidences between 50 – 230/100,000
  - 75- 100,000 + affected in US

- KC remains one of most common reasons for corneal transplants
  - >8,000 corneal grafts per year in US for KC

- $50 million annually on US healthcare
  - Corneal disease ranked 5th among major eye diseases in Medicare beneficiaries in 2003

How common is keratoconus?

• Classically referenced:

1:2,000* based on a registration study in Olmsted County, Minnesota, conducted between 1935-1982; diagnosis was based on the detection of scissors reflex with retinoscopy and keratometry outcomes!

• Scissors Reflex
• Against motion that breaks apart
• Represents multiple refractive powers within the optic zone
Keratoconus- Keratometry

• Initially, mires get small and then there is a lack of parallelism
• Expand perimeters by use of +1.25 SPH and add 7 D to your reading
• Steepening begins infero-temporally and progresses clockwise
• TOPOGRAPHY- more sensitive
• PLACIDO RINGS- get closer
KERATOCONUS: PREVALENCE

• Likely actual prevalence is likely < 1: 1,000
  Variable prevalence between 50 – 230/100,000!
  Prevalence range 1:50 in Israel to < 1:100,000 in Russia!
• This large discrepancy may in part reflect differences in diagnostic criteria, the age group studied, differences in genetic variation in the populations and possibly environmental differences.
Age-specific Incidence and Prevalence of Keratoconus: A Nationwide Registration Study

DANIEL A. GODEFROOIJ, G. ARDINE DE WIT, CUNO S. UITERVAAL, SASKIA M. IMHF, AND ROBERT P.L. WISSE

• PURPOSE: To determine the age-specific incidence and prevalence of keratoconus in the modern era of diagnostics.
• DESIGN: Epidemiologic study.
• PARTICIPANTS: Total of 4.4 million patients from a mandatory health insurance database.
• METHODS: Data were extracted from the largest health insurance provider in the Netherlands. Patients aged 10–40 years were defined as the relevant age category for newly diagnosed keratoconus and the annual incidence of newly diagnosed keratoconus was determined. The prevalence of keratoconus was estimated based on the annual incidence, mean age at diagnosis, and average life expectancy. Main outcome measure was the annual incidence and prevalence of keratoconus.
• RESULTS: The annual incidence of keratoconus was 1:2500 in the relevant age category (13.3 cases per 100 000, 95% confidence interval [CI]: 11.6–15.2) and the estimated prevalence of keratoconus in the general population was 1:375 (265 cases per 100 000, 95% CI: 260–270). These values are 5-fold to 10-fold higher than previously reported values in population studies. The mean age at diagnosis was 28.3 years and 60.6% of diagnosed patients were male.
• CONCLUSIONS: Both the annual incidence and the prevalence of keratoconus were 5-fold to 10-fold higher than previously reported. (Am J Ophthalmol 2017;175:169–172. © 2016 Elsevier Inc. All rights reserved.)

Lenses, complex corneal grafting procedures are ultimately indicated in approximately 10%–20% of keratoconus patients.4–5 The most frequently cited occurrence of keratoconus is 1:2000. This value is based on a registration study in the United States that was conducted from 1935 until 1982. This study reported a prevalence of 54.5 cases per 100 000 individuals.6 Estimates of the annual incidence of keratoconus based on epidemiologic studies range from 1:3000 to 1:80 000 per year.7–8 This wide range may be attributed to the increased sensitivity of modern diagnostic devices, regional differences with respect to accessibility of health care, and/or differences in study design. Furthermore, ethnic differences with respect to the incidence of keratoconus have also been reported.6–8

Incidence is defined as the number of new cases diagnosed within a specific period of time (usually 1 year), whereas prevalence is the number of existing cases at a given point in time. The onset of keratoconus typically occurs in the second to fourth decade of life (ie, from age 10 through age 40) and the condition affects patients for the remainder of their lives.1 Therefore, the prevalence of keratoconus is by definition always higher than the annual incidence.

As computer-based technologies and imaging techniques have improved, the ability to diagnose keratoconus has also increased. New treatment options for keratoconus are currently being implemented. Therefore, determining the incidence and prevalence of keratoconus in the modern era of diagnostics is crucial.
AJO – 2017: Age-specific Incidence and Prevalence of Keratoconus: A Nationwide Registration Study

• Netherlands study: 4.4 million patients from a mandatory health insurance data base

• Prevalence of keratoconus in the general population was 1:375

Annual incidence: (new cases) of keratoconus was 1:7,500

• Conclusion: “Both the annual incidence and the prevalence of keratoconus were five-fold to ten-fold higher than previously reported.”
KERATOCONUS FINDINGS

- VOGT’S STRIAE
- FLEISCHER RING
- STROMAL THINNING
- STROMAL SCARS
- SWIRL-LIKE PATTERN
- ENLARGED CORNEAL NERVES
- ACUTE HYDROPS

- EPITHELIAL THINNING *
- POSTERIOR STEEPENING *
- CORNEAL BIOMECHANICAL PROPERTIES*
WHORL-KERATOPATHY
FLEISCHER RING

abrupt change
in curvature
50%
VOGTS’S STRIA (1st Sign)
STROMAL SCAR

CLEK showed
Overall 13% had scars
K > 52  38% scarred
43% of flat fits scarred
26% of steep fits scarred
8% ↑ with each hour WT
↑ scar w/ stain, ring, age, CL (2 fold), ↑FDACL
CORNEAL HYDROPS

5%
EXTERNAL FINDINGS

MUNSONS SIGN

RIZZUTIS SIGN
Global Consensus on Keratoconus and Ectatic Diseases

José A. P. Gomes, MD, PhD,* Donald Tan, MD, PhD,† Christopher J. Rapuano, MD,** Michael W. Belin, MD,§ Renato Ambrósio, Jr, MD, PhD,¶ José L. Guell, MD,|| François Malecaxe, MD, PhD,** Kohji Nishida, MD,†† and Virender S. Sangwan, MD‡‡, the Group of Panelists for the Global Delphi Panel of Keratoconus and Ectatic Diseases

Background: Despite extensive knowledge regarding the diagnosis and management of keratoconus and ectatic corneal diseases, many controversies still exist. For that reason, there is a need for current guidelines for the diagnosis and management of these conditions.

Purpose: This project aimed to reach consensus of ophthalmology experts from around the world regarding keratoconus and ectatic diseases, focusing on their definition, concepts, clinical management, and surgical treatments.

Methods: The Delphi method was followed with 3 questionnaire rounds and was complemented with a face-to-face meeting. Thirty-six panelists were involved and allocated to 1 of 3 panels: definition/diagnosis, nonsurgical management, or surgical treatment. The level of agreement considered for consensus was two-thirds.

Results: Numerous agreements were generated in definitions, methods of diagnosis, and management of keratoconus and other ectatic diseases. Nonsurgical and surgical treatments for these conditions, including the use of corneal cross-linking and corneal transplantations, were presented in a stepwise approach. A flowchart describing a logical management sequence for keratoconus was created.

Conclusions: This project resulted in definitions, statements, and recommendations for the diagnosis and management of keratoconus and other ectatic diseases. It also provides an insight into the current worldwide treatment of these conditions.

Key Words: keratoconus, corneal ectasia, consensus, corneal cross-linking, corneal transplantation

(Kornea 2015;0:1-11)

Keratoconus and ectatic corneal diseases have been recognized for more than 150 years.6 Over the last 2 decades, there has been a revolution in the knowledge related to the diagnosis and management of these conditions. In terms of diagnosis, the advent of corneal topography, and more recently corneal tomography, has increased the ability of ophthalmologists to identify corneal ectasia at a much earlier stage than was previously possible.7 As a result, the previously established prevalence of keratoconus of approximately 1/2000 among the general population8 has been challenged with much higher prevalence rates found in many parts of the world.8,9

The surgical treatment for keratoconus reflects this evolution.7 Alternative procedures, such as the use of intrastromal corneal ring segment(s) (ICRS),10-12 corneal cross-linking (CXL),13 therapeutic excimer laser treatments including phototherapeutic keratectomy14 and photorefractive

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need 2 or more:

- Abnormal posterior ectasia
- Abnormal corneal thickness distribution
- Clinical non-inflammatory corneal thinning*

*Central pachymetry is the least reliable indicator or KCN
Placido based topography – What’s missing?

- No analysis of posterior corneal surface
- No representation of corneal thickness

With courtesy from Prof. Michael Belin
PLACIDO RING IMAGES

• Rings that are closer together represent areas of steeper curvature
• May indicate a tight suture applicable
KERATOCONUS
Placido
Topography, What are the issues?

Topography

What we can't see with topography
Corneal Tomography

**a two-dimensional image of a slice or section through a three-dimensional object.**

**Pentacam** (Oculus):
**Orbscan** (B&L)
**Galilei** (Zeimer)
Tomography provides:

- True Elevation Anterior & Posterior Cornea
- Curvature (and Tangential) based on true elevation data
- Global Pachymetry
ELEVATION (FLOAT) MAPS

Predicts the relative elevation or depression of the cornea (in mm) using a computer generated BEST FIT SPHERE as a reference and fit at the steepest point.
ELEVATION MAPS PREDICT Na-FL PATTERN

+ VALUES - warm colors
  points higher than sphere = elevation
  Areas of bearing or touch

- VALUES - cool colors
  points lower than sphere = depression
  Areas of pooling
Elevation Map of True Keratoconus
PSEUDOKERATOCONUS

- Corneal warpage topography can mimic KC
- Repeat topography must be performed and a measurable change would indicate pseudo-KC
- Evaluation of elevation maps at steep zone:
- Predicts the elevation or depression of the cornea if the best fit sphere was on cornea
ELEVATION MAP DIFFERENTIATES KERATOCONUS vs WARPAGE
Pellucid Marginal Degeneration vs. KCN
PELLUCID MARGINAL

Tear meniscus can create pseudo-PMD
However, the story or diagnosis is often on the back side!

- **KC**: anterior displacement of both anterior and posterior corneal apex
- **KC**: Can have normal anterior corneal curvature & elevation
- Posterior corneal irregularity has an influence on visual quality albeit less sig vs. anterior corneal irregularity
Normal anterior corneal surface (left side)

Abnormal posterior corneal surface (right side)
Global Pachymetric Progression

Thickness Progression

Central pachymetry is the least reliable indicator or KCN.
“BAD III” – enhanced ectasia detection
POSTERIOR KERATOCONUS

[Image of ORBScan scan showing anterior and posterior maps with various measurements and labels]
POSTERIOR KERATOCONUS
ANTERIOR SEGMENT
OCULAR TOMOGRAPHY
AS-OCT
New Technology in AS-OCT: Measuring EPITHELIAL Thickness

Bowman’s layer
Epithelium
Stroma
Descemet's membrane
Clinical Applications of ETM in Keratoconus

Epithelial Thickness Profile Measurements Keratoconus:

- **Mean** epithelial thickness only slightly less than in normal eyes\(^1\)

- **Greater variability** in thickness measurements\(^1\) in KC eyes compared to normal eyes (thinning over apex w/surrounding thickening: “donut pattern”)

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Epithelial Thickness in KCN via ASOCT

J Refract Surg. 2013 Mar;29(3) SD-OCT analysis of regional epithelial thickness profiles in keratoconus, postoperative corneal ectasia, and normal eyes

“Apical epithelial thickness was significantly thinner in eyes with keratoconus (P < .0001) and ectasia (P = .0007) than in controls.”
Corneal Biomechanical Properties in Keratoconus / Keratectasia

Corvis ST By Oculus

Captures 140 images in the 31 ms after air pulse
Biomechanical Screening Report

Corvis Biomechanical Index (CBI)
Why do we need to be so concerned about Progression of Keratoconus?

Because **We Now Can Stop Progression** of the disease so that:

**We Can Preserve Vision.**
Corneal **Steepening & Thinning**

In KCN: Both anterior and posterior surfaces move forward but the posterior surface moves MORE = Anterior Steepening and Corneal Thinning
What about this case?

With courtesy from Renato Ambrosio
What about this case?

False negative on placido topo, but + Early Ectasia

With courtesy from Renato Ambrosio
Primary Care Detection of Keratoconus

- Frequent refractive changes, especially with changes in astigmatism greater than typically expected.
- Significant difference in astigmatism between the two eyes.
- Increase symptoms related to high order aberrations.
- Mild “K” distortion, scissor’s Ret. reflex.
- Biomicroscopic early findings.
- Family history of keratoconus.
Twenty-four genes were identified as potential contributors to KC and 49 KC-related comorbidities/syndromes were found.

More than 85% of the known KC-related genes are involved in glaucoma, Down syndrome, connective tissue disorders, endothelial dystrophy, posterior polymorphous corneal dystrophy, and cataract.
ASSOCIATED SYSTEMIC CONDITIONS

• Vernal KC
• Atopic Dermatitis
• Down’s Syndrome
• Floppy Eyelid Syndrome
• PKP >31 lbs. *, 8.7x morbid obese
  – Kristinson, IOVS 2003
• Mitral Valve Prolapse
• Ehlers-Danlos Syndrome
• Osteogenesis Imperfecta
• Lawrence-Moon-Biedl
• Neurofibromatosis
• PXE
ETIOLOGY OF KCN

• History of trauma that causes weakness
• Recurrent trauma due to rubbing from
  – Blepharitis, CL/lids, 53% have atopic dx
  – Lieber’s- rubbing produces scotopsias
  – Pressure on corneal nerves is pleasing (right handed)
• Inflammatory component !!!
  – Rubbing increases temperature and raises IOP 150 mm
  – Decrease proteinase inhibitors
  – Increase collagenase, Increase cytokine binding
  – Premature keratocytic apoptosis leads to thinning
Genetics in Keratoconus: Where Are We?

• The identification of genes responsible for this type of KC has been the main focus of many studies done by many research groups around the world.

• Although environmental factors have been involved in KC pathogenesis, strong underlining genetic susceptibility has been proven.

• Several genes have been implicated across these studies, including genes coding for various collagens and related to extracellular matrix production.
RESEARCH MAY INDICATE NEW THERAPIES

• KCN is unlikely a single gene defect
  – Chromosome 5, 21
• Multiple genes in a common pathway
• Those with the defect may develop KCN naturally or only if exposed to factors that induce oxidative stress: CL over-wear, UV, allergy or refractive surgery
• TX: Anti-inflammatory, Anti-oxidant
Global Consensus on Keratoconus and Ectatic Diseases

José A. P. Gomes, MD, PhD,* Donald Tan, MD, PhD,† Christopher J. Rapuano, MD,‡
Michael W. Belin, MD,§ Renato Ambrósio, Jr, MD, PhD,¶ José L. Guell, MD,||
François Malecaze, MD, PhD,** Kohji Nishida, MD,†† and Virender S. Sangwan, MD,‡‡, the Group
of Panelists for the Global Delphi Panel of Keratoconus and Ectatic Diseases
Global Consensus on Keratoconus Diagnosis

• Keratoconus (and other ectatic disorders) was recognized as a multifactorial disease with genetic, biochemical, biomechanical, and environmental components.

• Risk factors for keratoconus: Down syndrome, relatives of affected patients especially if they are young, ocular allergy, ethnic factors (Asian and Arabian), mechanical factors, eg, eye rubbing, floppy eyelid syndrome, atopy, connective tissue disorders (Marfan syndrome), Ehlers–Danlos syndrome and Leber congenital amaurosis.
Association between Family History and Keratoconus Severity.

Naderan M¹, Rajabi MT¹, Zarrinbakhsh P², Naderan M¹, Bakhshi A¹.

Abstract

PURPOSE: The high prevalence of positive family history of keratoconus (KC) in KC patients is well-known. However, the results regarding the association between family history of KC and disease severity are controversial. The aim of this study was to evaluate the possible association between family history and severity of KC.

METHOD: Clinical data of 1496 KC patients were evaluated. All participants were asked if they had had a family member with KC. Topographic and keratometric measurements of KC patients, including central corneal thickness (CCT), thinnest corneal thickness (TCT), mean, flat, and steep keratometry values (K) by the use of Pentacam, best-spectacle corrected visual acuity (BCVA), spherical equivalent (SE), and astigmatism were recorded and compared according to patients with and without a family history of KC, first- or second-degree family members, and the number of family members with KC. Severity of KC was classified according to the Amsler-Krumeich classification.

RESULTS: Family history of KC was present in 292 (19.5%) patients. Of those 292 patients who had a family history of KC, 159 (54.5%) had one family member with KC and 133 (45.5%) had two or more family members with KC. There was not a significant difference between corneal pachymetry and K values of the patients with and without a family history of KC (p > 0.05). However, those with a positive family history of KC had more severe disease, according to the Amsler-Krumeich classification (p < 0.05). KC patients who had more family members with KC had significantly lower TCT and significantly higher steep K and astigmatism (p < 0.05), and had more severe disease, according to the Amsler-Krumeich classification (p < 0.05).

CONCLUSION: We suggest that patients with more family members with KC should be subject to screening to identify early disease.

KEYWORDS: Corneal topography; family history; keratoconus; risk factor; severity
Hello Keratoconus World! As an Optometrist and International Keratoconus Academy board member, I am curious to know how many individuals with Keratoconus have been offered to have their family members (siblings and children/offspring) evaluated for Keratoconus. I want to share this data with my colleagues to help improve timelines of diagnosis and rates of detection. Thanks in Advance!
Contact Lens Management of the Keratoconus Patient
Keratoconus Challenge

Irregular Corneal Optics: HOAs
TREATMENT OPTIONS

• UNI-KONE IN DENIAL
• SPECTACLES (SOLO OR IN TANDEM WITH CLS)
• SOFT TORIC OR SPECIALTY (UNILATERAL, TEMPORARY)
• CORNEAL GAS PERMEABLE
• INTRA-LIMBAL GAS PERMEABLE
• TANDEM SYSTEMS (PIGGY BACK)
• HYBRID LENSES
• SCLERAL LENSES
• ELEVATION SPECIFIC DESIGNS
• CORNEAL CROSS-LINKING
• CORNEAL INLAYS
• CORNEAL TRANSPLANT
Collagen (Corneal) Cross-linking (CXL)

Yaron S. Rabinowitz
“Why don’t we see elderly patients with keratoconus”

- Do they die younger  NO
- Do they not visit OD  POSSIBLE
- Have they CE/PKP  POSSIBLE
- Getting lenses from 1-800
- THEORY BY KRACHMER
  - The eye becomes more rigid as the patient ages and therefore the condition stabilizes
Biomechanics of KCN

- The cross-linking in KCN is abnormal
- Too elastic and the biomechanical resistance is 50%
- Loss of Bowman’s
Biomechanical Effect of Combined Riboflavin-UVA

A photochemical reaction Occurs when riboflavin (a photosensitizer) and UV become a triplet and create oxygen radicals that cross-link collagen fibers.

GOAL:
• Increase cross-linking
• Increase diameter
12% Anterior  5% Posterior
CORNEAL CROSS-LINKING

INDICATIONS
• The treatment of progressive KCN and ectasia after refractive surgery

Photoxon Viscous/Photoxon + KXL System (Avedro) is first and only FDA approved 2017

Riboflavin is used as a photosensitizer and protector

GOAL:
• Stop Progression
• Reduce Steepness
• Improve BCVA: altering index
• Improve CL Tolerance

OFF LABEL INDICATIONS
• < 14 years old > 65 Years old
• Never for pregnant
• Combine with Refractive Sx
• Combine with Intacts
• Recalcitrant MK
General Principles in Contact Lens Fitting for the Keratoconus Patients

Key to Success

- Vision
- Comfort
- Physiological Response

Keys to Fitting

- Avoid mechanical pressure on the apex of the cornea
- Avoid hypoxic corneal stress
- Maximize comfort and vision through design
CLEK

Collaborative Longitudinal Evaluation of Keratoconus

Data courtesy of Drs. Karla Zadnik and Timothy McMahon
STROMAL SCAR

CLEK showed:
Overall 13% had scars @ 5yrs
K > 52 38% scarred
43% of flat fits scarred
26% of steep fits scarred
8% ↑ with each hour WT

INCREASE SCARS if:
Corneas stain, ring, age,
27% CL vs. 9% non-CL wear
↑ FDAACL
Corneal Lens Design Options

Courtesy of Christine Sindt, OD
Scleral Lens Designs
13.0 – 24.0 mm RGP lenses

Pat Caroline, FAAO & Pacific University
Study to evaluate IOP during Scleral Lens wear

• Compare common diameters 15.8/18.0
• Due to tightness, mass, and size, potential for:
  – compression of epi-scleral veins can reduce aqueous drainage facility.
  – Mass may displace fluid
  – Risks: thinner sclera, KCN
• Previous studies vary
• Snow-shoe theory

Michaud, L., Intra-ocular pressure variation associated with the wear of scleral lenses of different diameters. Contact Lens and Anterior Eye (2018)
Intra-ocular pressure variation associated with the wear of scleral lenses of different diameters

METHODS
• Prospective randomized
• N= 21 Avg. Age = 25 non-KC
• Spherical haptics, 15.8/18,pl
• IOPS baseline $T_a/T_t$ $4\text{ hrs}$

RESULTS
• IOP taken with non-standard trans-palpebral technique rises an average of $5\text{mmHg after } 4.3\text{ hours}$ of compared to pre-lens wear
• No difference between different lens diameters
  – Note similar LZ 13.8/14.4
• Limitations but reportable
• Close Monitor those at risk

Michaud, L., Intra-ocular pressure variation associated with the wear of scleral lenses of different diameters. Contact Lens and Anterior Eye (2018)
HYBRIDS
CORNEAL CROSS-LINKING

- Epithelial “OFF”
- 9 mm Debridement
- Followed by Loading dose of Photrexa Viscous x 30 minutes
- If < 400 um, Photrexa q 5-10 seconds until...
- > 400 um, UVA x 30 minutes, PH-V q 2 min
- 365 nm, 3mW/cm²

POST-OP
- Mild Pain, BCL
- Mild haze up to 1 year
- K steepening at month 1 followed by gradual flattening month 3-12
- CL fitting > 1 month with expected changes
POTENTIAL USES OF C3R

- Prevent KCN regression/scars:
  - For young KCN pts. who are getting worse
- Combine w/ Topography-linked ablations to smooth KCN or High Myopic or Hyperopic RX to stabilize results (Kannellopoulos)
- Post-Lasik ectasia
- Post CK or Post CRT-to enforce result
- Combine w/ Intacts or ICL for KCN (Wachler)
- Recalcitrant microbial keratitis
- Suture-less corneal SX- cross-link wounds
Post-CXL CLF Study: Single Center Data

Overall Success Rate = 95.1%

Success with Serial Fitting Strategy

Clark Chang, OD; Angie Shin, OD; Peter Hersh, MD
(Unpublished)
• Typically Disposable Soft Lens
  • (high oxygen transmission materials)
• Any design of GP lens
TIPS ON PIGGYBACKS

- SCL fit under best fit GP
- Improves comfort/ Last resort before surgery
- SCL protects cornea from RGP or environment
- Reduces epithelial damage due to touch
- Protects from apical nodules
- Concurrent EBMD
- High DK, easily replaced= SiHi
- Soft Modulus molds to highly toric/steep K and may have less friction
<table>
<thead>
<tr>
<th>Product</th>
<th>Dk/t</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Night &amp; Day</td>
<td>1.50Dk/t @ -3</td>
<td>175</td>
</tr>
<tr>
<td>Acuvue Oasys</td>
<td>0.72</td>
<td>147</td>
</tr>
<tr>
<td>Biofinity</td>
<td>0.75</td>
<td>160</td>
</tr>
<tr>
<td>True Eye</td>
<td>0.71</td>
<td>65</td>
</tr>
<tr>
<td>Dailies Total 1:</td>
<td>0.70</td>
<td>151</td>
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</table>
PIGGY BACK AFFECTS FIT

• GOAL is to improve centration
• Most use plano power for the therapeutic effect however using higher powers can effect fit more and contributes to over-all power
• (-) SCL to steepen the RGP fit
• (+) SCL to flatten the fitting relationship of the habitual RGP-
  – less sag depth
Standard Tandem Systems

Power Issues

• Soft contact lens component will contribute about 20% of its power in air to the system.

• Typically low power (+/- 0.50) – has negligible influence on GP fit or net system power

• Use of + power to somewhat mask corneal irregularity and possibly improve GP centration - use of apx. +6

(+6 = 1.2D net + effect on system)

• Daniel Brazeau, OD
THICK LENS SYSTEM

The soft lens is no longer a thin lens system in “air”
The Tear Layer created between the GP and Hydrogel “negates” some of the SCL power... but not all..

Calculate power between the area behind back surface of the GP and the cornea AKA the TL and SCL.
BVP= F1/(1-t/n)F1 + F2

EFFECTIVE POWERS OF SCL UNDER GP IN TANDEM DESIGN IS ABOUT 20% OF ORIGINAL POWER (10-30%)

MINHEE WOO OD
AND BARRY WEISMAN OD PhD
Recessed Lens Technology

**Recessed Pillow Lens** (Fusion & EyeVis Technologies)

- **Recessed anterior surface for GP**
- **In development**
- **Advantages:** centering and comfort
- **Indications:**
  - Irregular corneas
  - Multifocal GP
  - Regular corneas
  - *Other Recess: Flexlens Piggyback*
Recessed Hydrogel Platform

- Straight Walled
- Angle Walled
- Overhang

*Courtesy of Rob Davis, OD,  S. Barry Eiden, OD
EyeVis Vision Technologies
Standard Tandem Systems

Care System Issues

• Option 1:
  – GP solutions for GP
    convenience
  – SCL solutions for SCL
    (multipurpose or peroxide)

• Option 2:
  – “One for all & all for one!”
  – (multipurpose SCL solution or peroxide)
GP Issues

- **Materials:** Hyper Dk (> 100)
- **Designs:** Unlimited***
- **Fitting:**
  - If thin low power SCL = to direct corneal fit
  - If thick high power SCL do topo. over SCL and refit