A PRIMER ON KERATOCONUS

Susan Gromacki, OD, MS, FAAO, FSLS, Dipl AAO*

*Diplomate, Cornea, Contact Lenses, and Refractive Technologies
The American Academy of Optometry

sgromacki3@hotmail.com

One of our profession's experts in keratoconus (KC) will present a comprehensive discussion to include the most cutting-edge information on keratoconus diagnosis, psychological implications, genetics, non-surgical and surgical treatments. She will discuss peer-reviewed studies and clinical tips for early disease detection, patient education and management. A full spectrum of treatment options from contact lenses to the latest advances in Corneal Collagen Cross-Linking (CXL) and corneal transplantation will be showcased.

Learning Objectives:

*Understand how modern research has helped us detect keratoconus
*Understand the importance of early disease detection and monitoring
*Learn tips for early KC detection, including the impact of advanced imaging using topography and tomography
*Understand treatment and contact lens options for all stages of disease
*Review literature regarding procedures to control disease progression including epi-on and epi-off corneal cross-linking
*Review literature regarding procedures designed to alter corneal shape, including intrastromal corneal ring segments, topography guided PRK, cataract surgery, and corneal transplantation

1. **Keratoconus Overview**
    a. Noninflammatory corneal thinning disorder characterized by a conical protrusion of the central or paracentral cornea
    b. Bilateral and asymmetric
    c. Clinical onset typically between puberty and age 30, it progresses over the next 10-20+ years
    d. Histopathology:
        i. Bergmanson: "the weakening and anterior ectasia in keratoconus…may be due to loss of lamellae, thinning of lamellae, loss of keratocytes, or a combination of these…Corneal ectasia, a forward protrusion of the tissue, cannot be explained by simple loss of thickness…other factors such as lamellar integrity are involved. Thinning appears not to be the only contributing factor for this process…(it) also involves biomechanical factors.
    e. Prevalence and Incidence
        i. Varies with geography, ethnicity

ii. Prevalence 0.05 (US, 1986) to 4.79% (Saudi Arabia, 2018)
iii. Review of recent epidemiology studies involving KC

f. Risk Factors/Associations
   i. Genetics
      - CLEK results on inheritance:
      -Baseline 13.5% reported a family history of keratoconus (Parent, sibling, child, aunt or uncle)
      -Year 7, 18% of patients reported a positive family history
      -No association between positive family history and more severe keratoconus
      - Highlights from a 2024 expert panel discussion on genetics & KC
   ii. Related disorders (e.g. Down syndrome, Ehlers-Danlos syndrome, RP, Floppy Eyelid Syndrome)
   iii. Atopy
   iv. Eye rubbing

2. Hallmark Study: CLEK/The Collaborative Longitudinal Evaluation of Keratoconus

a. Longitudinal observational study of 1209 patients with keratoconus enrolled at 16 clinical centers
b. Inclusion criteria: Fleischer's ring (86%), Vogt's striae (65%) and/or corneal scarring (53%)
   i. 13%: unilateral keratoconus.
   ii. More advanced disease (steeper average K reading) was associated with a greater likelihood of Vogt's striae, Fleischer's ring, and/or corneal scarring
   iii. 58% of eyes in had > or = 20/40 visual acuity with manifest refraction
   iv. Penetrating keratoplasty 12.3% of eyes
c. Corneal scarring and vision
   i. On average, KC pts. fitted 2.86 D flatter than "first definite apical clearance"
   ii. 31% of eyes with flat-fitted GP CL have corneal scarring vs. 9% of those fitted steep
   iii. Corneal scarring in keratoconus is significantly associated with decreased high- and low-contrast visual acuity
d. Estimation of the incidence and factors predictive of corneal scarring in the Collaborative Longitudinal Evaluation of **Keratoconus (CLEK)** Study. Barr JT, Wilson BS, Gordon MO, Rah MJ, Riley C, Kollbaum PS, Zadnik K; CLEK Study Group. *Cornea* 2006 Jan;25(1):16-25.
   i. Baseline corneal curvature, contact lens wear, corneal staining, and younger age were predictive of the development of corneal scarring. 5-year incidence of scarring is 13.7% for overall sample and 38.0% for

corneal curvature greater than 52 D that wore contact lenses. Contact lens wear increased the risk of incident scarring more than 2-fold

3. **Diagnosis: Early Clues for KC Detection with new clinical cutoff values**
    a. Autorefractor: refractive error (RE) and Ks
        i. Consistent error messages
        ii. Intraocular asymmetry in RE or Ks
        iii. Ks > 47D
        iv. High cylinder or cylinder ≥2D that increases over time
        v. Oblique axis or frequent changes in axis
        vi. Mismatch between AR, RE and manifest refraction results
    b. Refraction
        i. BCVA not crisp 20/20
        ii. Inconsistent answers, weak endpoints
        iii. Frequent changes from past
        iv. High or asymmetric astigmatism
    c. Patient complaints
        i. Glare and starbursts, worse at night
        ii. Monocular shadows/diplopia
        iii. Eye strain, headaches
        iv. Itchy eyes
    d. Slit Lamp
        i. Not found in early disease
        ii. Moderate disease corneal findings: thinning, Fleischer's ring, Vogt's striae
        iii. Later Corneal findings: Scarring, significant ectasia and thinning
        iv. Eyelids: Papillae, lid laxity, floppy eyelids
    e. Contact Lens Effects on Ks – may mask Ks and corneal shape
        i. Corneal Molding with GPs, ortho-K, hybrid CL
        ii. Impact of scleral lens wear on Ks and corneal shape

4. **Technology to Detect and Monitor**
    a. Auto-refraction
        i. Placido projections in AR & topography
    b. Corneal topography
        i. 2-D imaging, placido disc based
        ii. Great to detect anterior surface irregularities
    c. Corneal tomography
        i. 3-D imaging
        ii. Offer global pachymetry and rate of pachymetric distribution changes
        iii. Offers anterior and posterior elevation
            1. Posterior elevation often changes in keratoconus before anterior changes

d. Anterior segment optical coherence tomography (AS-OCT)
e. Aberrometry

5. Contact Lenses for Keratoconus

a. Early/mild KC → Spectacles, SCL, hybrids, corneal GP
b. Moderate-advanced → KC designs, Scleral GP lenses
c. Advanced → Scleral GP lenses
    i. Goal to avoid severe scars and transplant
        1. Ling JJ, Mian SI, Stein JD, Rahman M, Poliskey J, Woodward MA. Impact of Scleral Contact Lens Use on the Rate of Corneal Transplantation for Keratoconus. *Cornea* 2021 Jan;40(1):39-42.

6. Corneal Collagen Cross-Linking/CXL

a. AAO practice patterns: Corneal Ectasia PPP 2023
b. Best to detect early, before permanent corneal damage
    i. Closer follow-up & lower threshold for CXL should be adopted in pts < 17 years and steeper than 55 D Kmax
c. If progression noted, offer corneal cross-linking (CXL)
    i. Insurance coverage has improved
    ii. Demonstrate progression
d. CXL
    i. FDA approved in April 2016: epi-off only, one device and solution
        1. New protocols are being developed; waiting for FDA approved epi-on protocol
    ii. Indications: Progressive Keratoconus & Post-LASIK Ectasia
    iii. Risk of delaying CXL
    iv. The Procedure:
        1. Epithelium removal (Epi-off)
        2. 30 min riboflavin application
        3. Corneal thickness minimum: 400 microns (Photrexa if needed)
        4. 30 min exposure 365 nm UV-A light, 3.0 mW/cm2
    v. No specific age range limitations
    vi. Patients ages 14-65, included in FDA studies – but children can be treated younger than 14
e. Post-operative course
    i. After procedure: Topical Antibiotic, Steroid (sometimes NSAID)
    ii. Pros/cons of BCL use
    iii. Week 1: Topical meds, lubrication
    iv. Month 1:
        1. Assess vision
        2. Corneal Imaging – stromal remodeling (with images)

3. Consider CL fitting, getting back into CLs

v. Months 3, 6, 12:
   1. Assess vision – MR and BCVA often change
   2. Corneal Imaging
   3. Corneal flattening following collagen crosslinking for keratoconus: Findings at 5-year follow-up. Hoyek S, Arej N, El Rami H, Saba P, Antoun J. *Eur J Ophthalmol* 2021 Jul;31(4):1525-1531.

f. Understand Implications of CXL on post-op CL wear or fitting
   i. Natural course post CXL may impact post-op CL wear or fitting
g. Epi-Off versus Epi-On
h. Accelerated Cross-Linking

7. Surgical Management of KC

a. Corneal Intacs: FDA approved for KC in 2004
b. Intacs vs. new surgical techniques
   i. CAIRS: Corneal allogenic intrastromal ring segments
   ii. CTAK: Corneal tissue additional keratoplasty
c. Topography Guided PRK (TG-PRK)
   i. Minimal tissue ablation approach
d. Bowman's membrane transplants
e. Corneal Transplantation
   i. Penetrating (PKP) vs. Lamellar Keratoplasty
   ii. 12-20% may require; Rate of PKP for KC decreasing in US

8. Patient Communication and Quality of Life

a. Quality of life in **keratoconus**. Kymes SM, Walline JJ, Zadnik K, Gordon MO; Collaborative Longitudinal Evaluation of Keratoconus study group. *Am J Ophthalmol* 2004 Oct;138(4):527-35.
   i. Binocular entrance VA worse than 20/40 associated with lower quality of life (QoL) scores on all scales except General Health and Ocular Pain
b. The Genetics of KC

   CLEK results on inheritance:
   - At baseline, 163 (13.5%) reported a family history of keratoconus
     - Parent, sibling, child, aunt or uncle
   - At year 7, 18% of patients reported a positive family history
   - No association between positive family history and more severe keratoconus

c. 2024 AAO CCLRT Symposium
d. Handouts, websites, helpful organizations (NKCF, GPLI)