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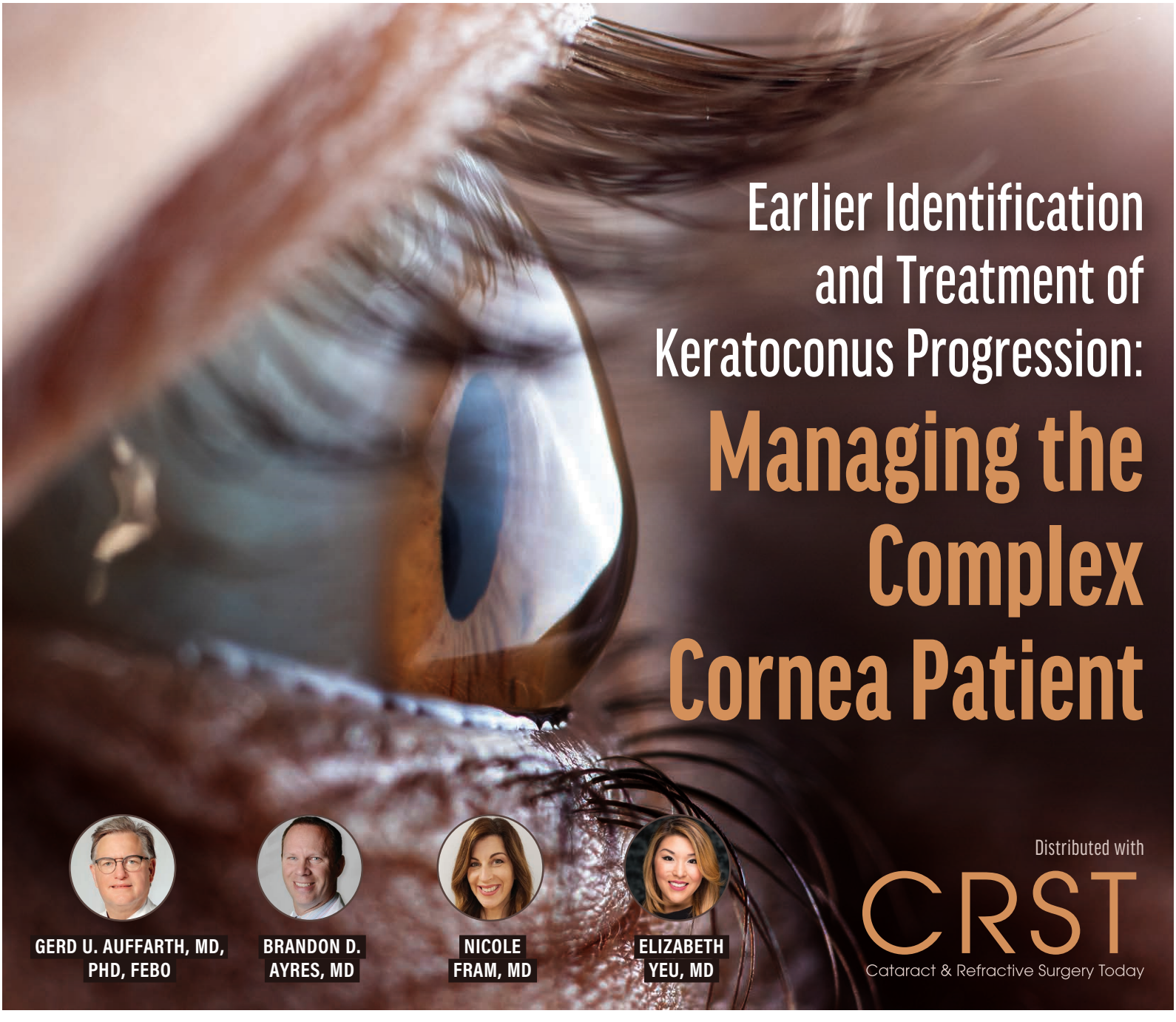

Earlier Identification and Treatment of Keratoconus Progression: Managing the Complex Cornea Patient

GERD U. AUFFARTH, MD, PHD, FEBO

BRANDON D. AYRES, MD

NICOLE FRAM, MD

ELIZABETH YEU, MD

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Faculty

Gerd U. Auffarth, MD, PhD, FEBO
Chairman, Department of Ophthalmology
Heidelberg University Eye Hospital
Director (Head), International Vision Correction Research Centre
Director (Head), David J. Apple Center for Vision Research
Heidelberg, Germany

Brandon D. Ayres, MD
Cornea Service
Wills Eye Hospital
Philadelphia, Pennsylvania

Nicole Fram, MD
Managing Partner
Advanced Vision Care
Clinical Instructor of Ophthalmology
Stein Eye Institute, UCLA
Los Angeles, California

Elizabeth Yeu, MD
Virginia Eye Consultants
Medical Director, CVP Mid-Atlantic
Cornea, Cataract, External Disease, and Refractive Surgery
Assistant Professor, Department of Ophthalmology
Eastern Virginia Medical School
Norfolk, Virginia

Content Source

This continuing medical education (CME) activity captures content from a live satellite symposium.

Activity Description

This supplement summarizes presentations by an expert panel that focused on earlier identification and treatment of keratoconus progression and best practices in managing complex corneas in their patient populations.

Target Audience

This certified CME activity is designed for ophthalmologists.

Learning Objectives

Upon completion of this activity, the participant should be able to:

- **Review** the prevalence of keratoconus, subclinical ectasia, and complex corneas among refractive surgery and cataract surgery candidates
- **Improve** understanding of new technologies for the identification of inherited risk factors before or early in the progression of corneal disease
- **Understand** how crosslinking technology can help halt the progression of keratoconus
- **Identify** techniques and technologies to improve visual quality and patient satisfaction in complex cornea patients presenting for cataract and refractive surgery

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PRETEST QUESTIONS

Please complete prior to accessing the material and submit with Posttest/Activity Evaluation/Satisfaction Measures for credit.

1. Please rate your confidence in your ability to identify techniques and technologies to improve visual quality and patient satisfaction in complex cornea patients presenting for cataract and refractive surgery (based on a scale of 1 to 5, with 1 being not at all confident and 5 being extremely confident).
- a. 1
- b. 2
- c. 3
- d. 4
- e. 5

2. Keratoconus is characterized by:
- a. A thinning cornea protruding into a cone shape
- b. A cloudy natural lens
- c. Inflammation
- d. Flattening of the cornea

3. According to material presented here, which of the conventional exams for diagnosing keratoconus is most important to use?
- a. Epithelial mapping
- b. Wavefront aberrometry
- c. Corneal topography and tomography
- d. Corneal biomechanical testing

4. Which of the following is known to be a risk factor for keratoconus?
- a. Habitual eye rubbing
- b. Collarettes on the lashes
- c. History of dry eye disease
- d. Sleeping face down

5. Approximately how many people have keratoconus?
- a. 8 million
- b. 27 million
- c. 63 million
- d. 120 million

6. Approximately how many people are considered "at risk" for keratoconus?
- a. 250 million
- b. 370 million
- c. 420 million
- d. 500 million

7. What percentage of corneal refractive surgery candidates have at least one risk factor for keratoconus?
- a. 20%
- b. 40%
- c. 50%
- d. 70%

8. To approve payment for a collagen crosslinking procedure, insurance companies generally look for:
- a. A high Kmax number
- b. Stable refraction
- c. Documented progression of keratoconus
- d. Epithelial thinning

9. What surface irregularity index score is considered to be visually significant?
- a. 0.1 to 0.2 µm
- b. 0.2 to 0.3 µm
- c. 0.3 to 0.4 µm
- d. 0.5 µm or greater

10. What is a typical length of time to wait for postoperative stability following radial keratotomy?
- a. Approximately 2 weeks
- b. Three to 4 weeks
- c. Six to 8 weeks
- d. At least 10 weeks

Early Detection of Keratoconus Patients

BY ELIZABETH YEU, MD

Keratoconus is a bilateral progressive ectasia that results in corneal distention and thinning, irregular astigmatism, and loss of visual function. Corneas appear more like a peak or pyramid than round in shape, and the greater the protrusion, the worse the vision (Figure 1). We must diagnose the condition as early as possible so we can make a difference in patients' lives.

RISK FACTORS

There is a genetic component to keratoconus, but it's really a "two-hit hypothesis," in which every patient presents a little differently. Triggers of keratoconus are multifactorial and include environmental and behavioral factors as well as genetic.

Genetics, age, and allergies are all risk factors. There are comorbidities such as Down syndrome or other connective tissue disorders, and there may be a relationship to sleep apnea.[1-3] Eye rubbing, either from allergies or out of habit, is a huge risk factor. Ethnicity is another factor, with Asian and Middle Eastern patients exhibiting higher levels of keratoconus risk.[4]

There are about 40 different genes and multiple GWAS SNPs that have been associated with keratoconus.[5] Fortunately, we are now able to better identify the genetic predisposition for keratoconus with advanced corneal genetic testing, through buccal swabs.

PROGRESSION OF KERATOCONUS

Progression has been defined as "consistent change in at least two of the following parameters [steepening of the anterior corneal surface; steepening of the posterior corneal surface; and thinning and/or an increase in the rate of corneal thickness change from the periphery to the thinnest point], where the magnitude of the change is above the normal noise of the testing system."[6] Although progression is often accompanied by a decrease in best spectacle-corrected visual acuity (BSCVA), a change in both uncorrected visual acuity and BSCVA is not required to document progression.

PREVALENCE

Around 63 million people have keratoconus, and 370 million more are at risk worldwide. Around 309 million patients have curvatures that are ≥46.00 D to <48.00 D, and those are the patients for whom we should be on alert. We should take note of the fact that almost 2 million preclinical teens and young adults have suspicious factors, and that's that ≥2.00 D of cylinder and K ≤46.00 D.[7]

IMPACT ON VISUAL OUTCOMES AND QUALITY OF LIFE

More patients are now seeking LASIK and PRK as a result of wearing masks during the COVID-19 pandemic. I turn away about

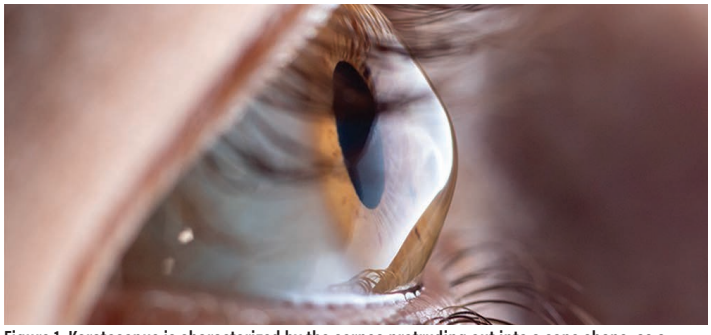

Figure 1. Keratoconus is characterized by the cornea protruding out into a cone shape, as a result of corneal thinning.

20% of patients from any kind of corneal refractive surgery due to keratoconus. I'll consider an implantable contact lens, but not LASIK or PRK, because they are too risky based on the tomography or the actual thickness of the corneal curvature (Figure 2).

Keratoconus significantly impacts vision-related quality-of-life (VRQL), with a substantial number of patients experiencing a decline in their VRQL over time.[8,9] Undiagnosed keratoconus prior to corneal refractive surgery can lead to poor visual outcomes and complications.[10]

DIAGNOSTIC WORKUP PROTOCOLS AND PRE-EMPTIVE TESTING INDICATIONS

Clinical signs for keratoconus include gross cone, high irregular myopic astigmatism, scissoring reflex on retinoscopy, corneal thinning, Fleischer ring, Vogt striae, apical scarring, and Munson sign.

Of the conventional exams for diagnosing keratoconus, the most important ones are corneal topography and tomography. Topography provides the I/S ratio, the ratio of the average power differences between the inferior hemisphere and superior hemisphere on the cornea, and tomography reveals if the posterior cornea is pushing forward and is steeper than the best-fit sphere.

Indications of keratoconus in topography include:[11,12]

- Keratometry values greater than 47.00 D
- Axis skew between the steepest superior and inferior semimeridians of greater than 20° with greater than 1.50 D of corneal astigmatism
- I/S keratometry value differences greater than 1.40 D on an axial curvature map
- Changes over time

Indications of keratoconus in tomography include:[13-15]

- Thinnest pachymetry less than 500 µm
- Anterior elevation greater than 10 µm to 15 µm
- Posterior elevation greater than 15 µm to 20 µm
- Belin/Ambrosio display (BAD) score
- Percentage Thickness Increase (PTI)
- Posterior elevation

OCT for epithelial thickness mapping, wavefront aberrometry for visual disturbances, and corneal biomechanical testing for hysteresis can provide even more information.

In the 2021 Keratoconus Testing Consensus Statement,[16] all

20% of corneal refractive surgery candidates have **at least one risk factor of keratoconus**

1 in 400 LASIK procedures are performed on keratoconus patients who will develop signs and symptoms during the next 10 years

12 of 13 believe that it is extremely important to **review keratoconus risk factors in *every* corneal refractive surgery candidate**

Figure 2. Prevalence of keratoconus in refractive surgery.[16]

panelists said they believe that corneal tomography is the most accurate diagnostic tool to detect keratoconus prior to loss of visual function.[16] Panelists all recommended corneal tomography for all corneal refractive surgery candidates to help identify keratoconus suspects.

Nine of 13 panelists believe that at least 25% of corneal refractive surgery candidates have red flags/corneal concerns that would lead doctors to recommend a genetic test, including:

- Topography anomalies
- Changes in oblique astigmatism, axis, or astigmatism power changes
- Lack of BCVA hitting 20/20
- Thin pachymetry/thin residual LASIK bed
- Unstable refractions
- Steep corneal curvature

Twelve of 13 panelists said all corneal refractive surgery candidates who are keratoconus suspects should receive a genetic test.

TALKING TO PATIENTS ABOUT THEIR DIAGNOSTIC TEST RESULTS

BY ELIZABETH YEU, MD

It's important to counsel your patients regarding what to potentially expect with their genetic test results and the potential associated risks. For a patient who is a habitual eye rubber, we can convince them to stop rubbing their eyes by explaining in grave detail that it can lead to keratoconus or keratoconus progression. Pair this with a positive recommendation for patients to be more aggressive on allergy treatments or schedule more frequent follow-up visits.

It's important to have informed discussions on refractive surgery options. Providing a patient with information about what is available and setting appropriate expectations makes for a happier patient.

Genetic counselors can be utilized for both clinicians and patients as a resource for additional information after initial discussions, especially for moderate to high-risk patients.

When a patient has keratoconus, consider asking if they have children. If the answer is yes, explain there is a genetic component, and that children can be screened with a simple mouth swab.

IMPORTANCE OF EARLY DETECTION

Early detection of keratoconus can help in patient communications and counseling. It also informs surgical decisions by matching corneal refractive candidates with the right procedure for their risk profile, including the decision to perform corneal crosslinking. It equips eye care professionals with their broadest range of treatment options and can protect and improve vision for entire families with multigenerational genetic vision testing. ■

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Earlier Intervention With Crosslinking to Prevent Keratoconus Progression

BY BRANDON D. AYRES, MD

I tell my patients with keratoconus that it is clear on exam they have keratoconus. I explain in layman's terms that keratoconus is a condition in which the cornea, the front of the eye, changes from spherical to cone shaped and that leads to reduced vision over time.

I'll explain that this sometimes can't be corrected with glasses or regular contact lenses and that they might need to use some kind of specialty contact lens. I also inform these patients that during the next several years, they may find that their keratoconus worsens.

For years, the discussion with keratoconus stayed the same and it wasn't encouraging. There was really nothing we could do to help prevent progression, and about 20% of patients progressed so far they needed a corneal transplant.[1]

COLLAGEN CROSSLINKING

In 2016, the FDA approved collagen crosslinking for progressive keratoconus and ectasia after refractive surgery, using a UV light source and riboflavin.

Data submitted to the FDA revealed that keratoconus progressed over the course of a year in patients who were not crosslinked.[2] Patients who were crosslinked showed some improvement in their overall exam findings, not only stabilization. There is a bit of regression, although we usually tell patients this is purely to stop the keratoconus. I don't specifically state to the patient that crosslinking will improve their condition.

The problem is with young patients. We know from a meta-analysis published in 2019 that young patients with keratoconus will typically progress.[3] Therefore, in my opinion, if you have a patient with keratoconus who is 16 to 18 years old, you can almost guarantee that their condition will become more severe.

Indeed, studies have shown that collagen crosslinking is effective in young patients who would otherwise very likely progress.[4] The results of one study indicated that when these patients were treated with epithelium-off collagen crosslinking, disease progression was halted to some degree and they had a fair amount of regression.[4]

EARLY INTERVENTION IS IMPORTANT

By the time a patient presents to our office for an exam, they generally have at least stage 2 keratoconus, meaning about 5.00 D to 8.00 D of cylinder. An analysis of a group of newly diagnosed keratoconus patients showed that only 13% were diagnosed before the age of 18.[4] We all know that younger patients develop keratoconus, even as early as 7 years of age. To make sure we diagnose keratoconus as early as possible, we should watch for changes in topography and tomography, in epithelial thickness, and in refraction (Figure 1).[5]

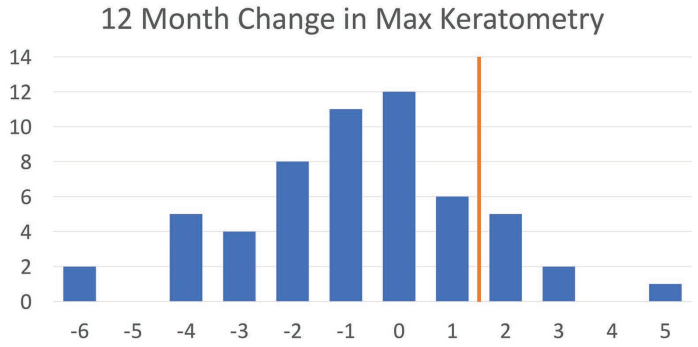

Figure 1. Early intervention is most effective in patients who are first starting to present. Most young keratoconus patients (≤17 yrs) or with ≥ 55 Kmax will show ≥ 1.50 D of progression within 12 months.[4]

Prior to approving a patient for collagen crosslinking, insurance companies will sometimes look for progression over 2 years, an increase of 1.00 D in steep K, changes in the manifest refraction, or a change in contact lens wear. You are not required to provide all of these, only one indicator of progression.

Thinning of the epithelium where the cornea is becoming thin could be a sign of early progression of keratoconus.

— Brandon D. Ayres, MD

Changes in epithelial thickness may be a way to identify early progression. The epithelium covers the cornea, and it tries its best to keep that cornea somewhat spherical. We see this in compensatory epithelial hypertrophy after a corneal scar. The same is true when that cornea begins to change shape. The epithelium will modify itself to keep the cornea spherical. Thinning of the epithelium where the cornea is becoming thin could be a sign of early progression of keratoconus.

Changes in refraction should also be monitored. These patients are hard to refract because there are so many irregular spots in their cornea. When a patient is referred to me, I'll ask for a previous autorefraction, auto-Ks, the last two manifest refractions, and any additional data to help evaluate possible progression. By taking this approach, I don't have to wait for another visit to begin the approval process for collagen crosslinking.

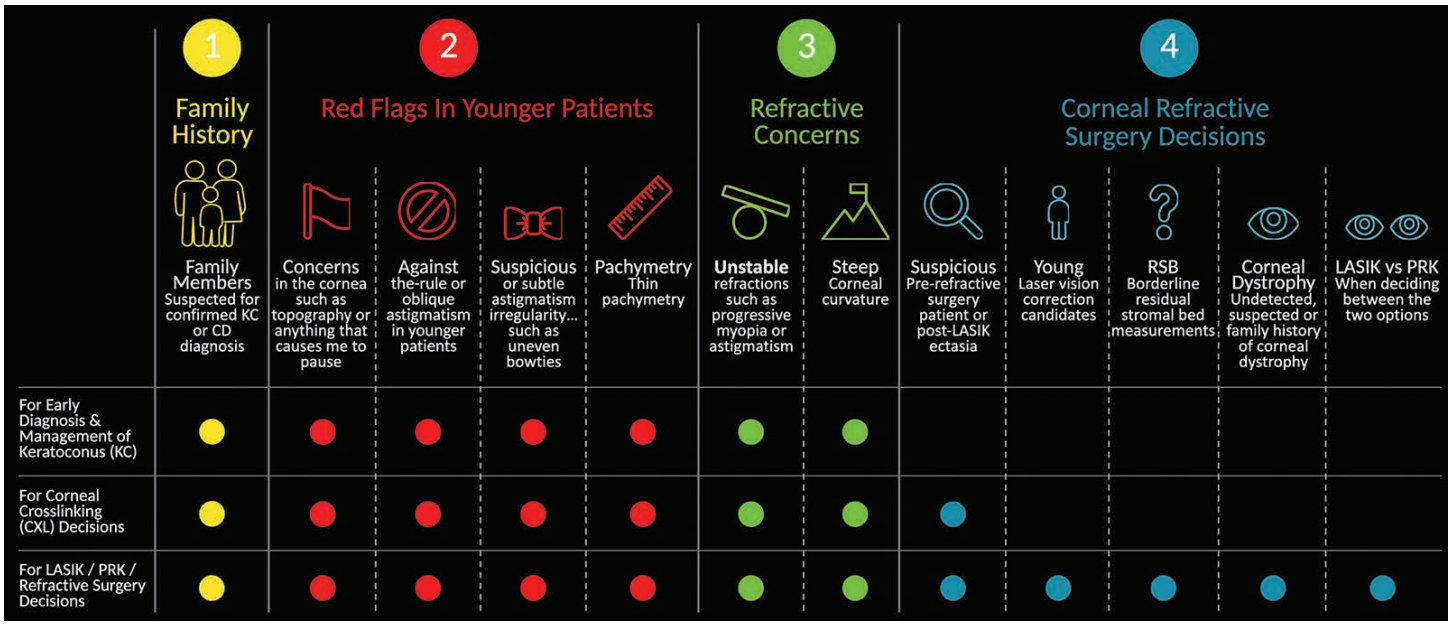

Figure 2. The benefits of genetic testing. *Image courtesy of Avellino.*

ROLE OF GENETIC TESTING IN GUIDING EARLIER TREATMENT INTERVENTIONS

Genetic testing is a tremendous leap forward in the detection of keratoconus. Allergy, atypia, and eye rubbing (and especially a combination of these) are associated with keratoconus, but until recently, we did not fully understand the genetic link.

There is now a genetic test that helps to determine a patient's genetic risk of keratoconus and is designed to provide earlier identification, and theoretically earlier treatment, of keratoconus (Figure 2). We can test our patients who may have a family history and have more data to follow these patients more adequately. Once we have the genetic data, we can create a concise assessment in the chart to be reviewed by an insurance company. ■

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Keys to Planning Treatments of Complex Cornea Patients

BY NICOLE FRAM, MD

When a patient with keratoconus presents with a cataract, a review of specific test results can help plan the best surgical approach. To make an educated decision, we need ocular history, topography, tomography, and Placido imaging.

In one survey,[1] most cataract surgeons said they see several conditions as indications the patient may have an irregular cornea, including keratoconus, ectasia, irregular astigmatism, corneal trauma, corneal therapeutic surgery, radial keratotomy, and laser vision correction.

Recent data from a consensus panel of ophthalmologists[2] determined that higher order aberrations scores of 0.5 µm or greater was visually significant.

UNIQUE PREOPERATIVE DIAGNOSTICS AND IOL CALCULATION CONSIDERATIONS

If a patient is accustomed to wearing contact lenses and has a highly aberrated cornea, a monofocal IOL may be the best choice. In this scenario, the patient's best vision will always be with a hard contact lens after surgery. But patients continually want more, so it becomes all about the IOL selection.

We look at factors such as if the patient is contact lens dependent and tolerant, if their cornea is stable, and the status of their other eye. Can they rely on the other eye while we're figuring this out? Is the astigmatism reproducible across all testing? Are there any considerations for extended depth of focus (EDOF) lenses, particularly if you have regular astigmatism in the central 3 mm, which would push the limits?

Ocular surface disease can lead to error in preoperative measurements,[3] and should be addressed prior to any decisions about IOL selection, or symptoms may worsen postoperatively.

KERATOCONUS

Several questions must be answered when evaluating a patient

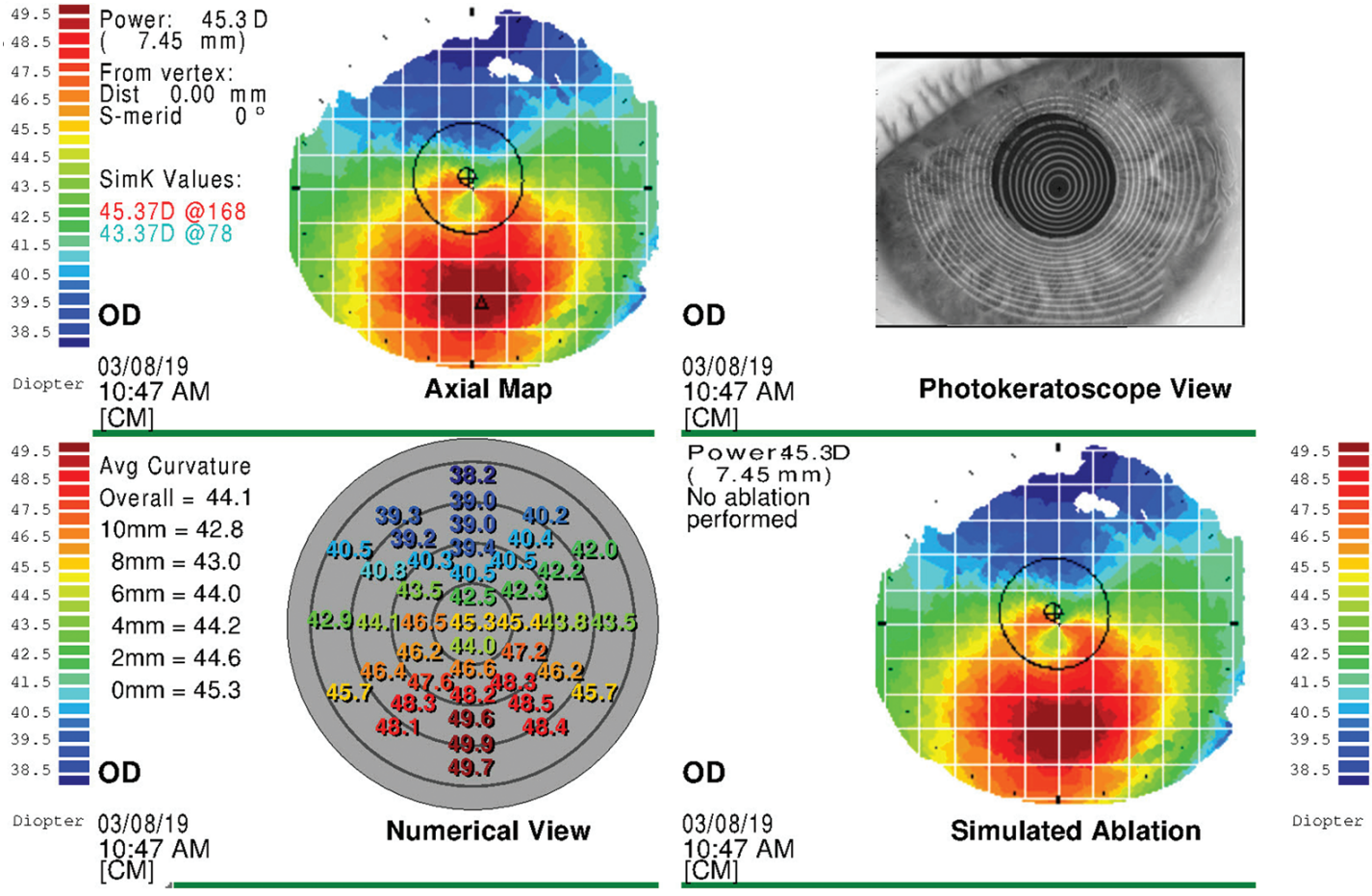

Figure. Topography showing 2.00 D x168. *Image courtesy of Nicole Fram, MD.*

RK Cuts	Adjusted Target
4	-0.75-1.00
8	-1.25-1.50
12	-1.75
16	-2.00

Table. Radial keratotomy nomogram (courtesy of Samuel Masket, MD). The longer the cuts and smaller the zone, the more power you add.

with keratoconus. Can we do genetic testing to assess the risk stratification need for crosslinking prior to surgery? People are having surgery at increasingly younger ages, so if they're in their 50s and having cataract surgery or lens replacement surgery, how progressive is this disease?

We've learned that the steeper the cornea, the greater the hyperopic error. Also, the steeper the posterior cornea, the greater the hyperopic error.[4] We may need to aim more myopic in these eyes, particularly with K values greater than 49.00 D.

CURRENT AND NEW FORMULAS

Over the years we've used different standard formulas and would arbitrarily aim 2.00 D myopic, which is very nonspecific. Fortunately, we're developing better formulas, such as the Kane formula for keratoconus, and the Barrett True-K Toric calculator with measured posterior corneal astigmatism (PCA).

With stage 1 keratoconus, which is typically what we see, the Kane formula is hitting targets 60% within +/-0.50 D, but the Barrett Universal II is at 53% and the regular Barrett is at 59%. According to Barrett's recent paper,[5] it's looking much better when measured PCA is included, hitting targets within 0.50 D 87.5% of the time. We've used SRK-T for years and just aimed -2.00 D with varying results. I think we're getting closer and closer to target by using better formulas and diagnostics.

CASE PRESENTATION

The first thing I always look at is the patient's uncorrected vision, their best corrected vision, and what have they been wearing in their glasses before they had the cataract.

In this case, manifest refraction was -3.25-2.00x94, 20/60 and -5.25-0.50 x99, 20/40. There was 2.00 D of cylinder at approximately 166 across all diagnostics and topography is lining up with the biometry (Figure).

Importantly, in my opinion, a toric IOL should only be placed if there is a symmetric bowtie within the 3-mm zone and stability is documented. This patient was very motivated, and I had evidence from his optometrist that prior to his cataract with glasses, his VA was 20/30 or 20/25, so I knew this was a good cornea without a contact lens.

Importantly, a toric IOL should only be placed if there is a symmetric bowtie within the 3-mm zone and stability is documented.

— Nicole Fram, MD

I did place a toric IOL, and I aimed -1.50 D because the Ks were only about 45.00 D. I placed a 12.50 D toric IOL at 163. At postoperative week 2, the patient's VA was 20/100, hyperopic with a spherical equivalent +2.00 D. When you do get a hyperopic outcome, you can use the Gills-Hoffer shortcut, which is 1.5 times spherical equivalent. You get the error, 3.00 D, and you add that to your original power, and then you have the new power of lens that you can place.

In this patient, postoperative IOL exchange was good and he achieved 20/25 VA. However, if the patient had abnormal Placido imaging and an aberrated cornea, I most likely would not have put in a toric lens.

COUNSELING PATIENTS PRIOR TO SURGERY

These patients should understand that IOL power calculations are less accurate than average and they may need more than one procedure. Some patients may need collagen crosslinking, Intacs, or topography-driven excimer laser therapy, and then an IOL implant.

Unfortunately, many patients do not understand why we can't match the IOL to their aberrated cornea. During the consenting process, for any aberrated cornea I have the patient sign a consent that says, "I understand that my best visual acuity will be with a hard contact lens after surgery."

RADIAL KERATOTOMY

Radial keratotomy (RK) is the gift that keeps on giving. We have hyperopic progression over time, AM to PM fluctuation, and often, you add minus power to understand how to reach your target.

I recommend that refractive surgeons remain cautious with toric IOLs. We want to avoid transecting the RK cuts (Table). In these patients, you can use an arbitrary nomogram. Barrett looked at this in 52 eyes[6] and found you could hit within +/- 0.50 D 75% of the time.

There are specific intraoperative considerations that are important. I mark all the RK incisions with a fine marking pen, particularly if it's greater than 8 cut RK because I don't want to intersect them. I also like to stain the capsule because sometimes everything looks good and then suddenly you can't see anything because the cornea really starts to hydrate. You might need to do a scleral tunnel in these patients to avoid bisecting the incisions.

The postoperative stability can take time. You want to confirm the preoperative topography matches the postoperative

topography. This typically occurs 6 to 8 weeks postoperatively. We do counsel RK patients and keratoconus patients that they may need an IOL exchange due to limitations of our IOL calculations.

SMALL APERTURE TECHNOLOGY

I believe small aperture technology will be a tremendous help in patients with aberrated corneas. The small aperture IOL has a 1.36 mm pinhole aperture that will help decrease higher order aberrations and allow for the best optical quality in these compromised corneas.

Utilized in more aberrated corneas, the small aperture IOL could provide better distance uncorrected vision, a larger range of vision, plus a potentially larger refractive landing zone, as patients with RK fluctuate from being hyperopic to more myopic as the cornea changes throughout the day.

1. Custom Survey Report of 123 US cataract surgeons by Market Scope, September 2020.
2. Lindstrom R, Al-Mohtaseb Z, Auffarth G, et al. 2020 Global consensus on corneal irregularity. Supplement to *CRST/CRSTE*. (January 01, 2021) https://crstoday.com/wp-content/uploads/sites/4/2021/01/0121CRST-CRSTES_Evolve-2032-Corneal-Irregularity-Consensus-Paper.pdf.
3. Epitropoulos AT, Matossian C, Berdy GJ, et al. Effect of tear osmolarity on repeatability of keratometry for cataract surgery planning. *J Cataract Refract Surg*. 2015;41(8):1672-1677.
4. Khandelwal S, Koch D, Montes de Oca I, Wang L, Weikert M. Predictive accuracy of intraocular lens calculation formulas in eyes with keratoconus. 2019. Abstract, American Society of Cataract and Refractive Surgery Annual Meeting.
5. Ton Y, Barrett GD, Kleinmann G, Levi A, Assia EI. Toric intraocular lens power calculation in cataract patients with keratoconus. *J Cataract Refract Surg*. 2021;47(11):1389-1397.
6. Turnbull AMJ, Crawford GJ, Barrett GD. Methods for intraocular lens power calculation in cataract surgery after radial keratotomy. *Ophthalmology*. 2020;127(1):45-51.

WATCH IT NOW!

ON-DEMAND: Follow the link to view the CME webinars that are part of this curriculum:
https://evolvemeded.com/course-group/complex-corneas

Treating Complex Cornea Cataract Patients

BY GERD U. AUFFARTH, MD, PHD, FEBO

Compromised corneas are found in patients with corneal dystrophies like keratoconus and following surface ablation/radial keratotomy. Many other patients have some slight or more pronounced pathology relating to irregular astigmatism—post-PKP, postpterygium surgery, keratitis, traumatic scars, and others. When these are present, it can be problematic to achieve a good refractive outcome or even apply refractive implants to achieve spectacle independence.

WHAT IS A COMPROMISED CORNEA?

Studies are underway to look at normative data. Diagnostic tools continue to improve, and the new Scheimpflug tomography with an integrated axial length biometer module can measure the wavefront and differentiate between corneal, internal, and total wavefront and/or higher order aberrations.

My group is conducting a retrospective study comparing parameters of healthy eyes (n=218) to keratoconus eyes (n=100). The Table shows significant differences between the two groups.

The Figure shows the distribution of higher order aberrations.

Parameters	group	mean	± SD	
Pachy Vertex N. [µm]	H	546	32	*
	KC	487	40	
Pachy Thinnest [µm]	H	542	33	*
	KC	473	40	
Pachy Difference [µm]	H	4.6	2,8	*
	KC	13.4	6,7	
Chord µ [mm]	H	0.22	0.13	*
	KC	0.36	0.19	
Chord α [mm]	H	0.45	0.14	
	KC	0.47	0.16	
Axial/Sag. B/F Ratio [%]	H	82.3	1.4	*
	KC	81.5	1.7	
Total Corneal HOA - 4mm [µm]	H	0.131	0.073	*
	KC	0.832	0.527	

Table. Significant differences in parameters are found between the two groups in a study underway by Prof. Auffarth.

Higher order aberration and irregularities of the cornea greater than 0.5 µm can be considered abnormal.

– Gerd U. Auffarth, MD, PhD, FEBO

Readings greater than 0.4 or 0.5 are abnormal. Keratoconus eyes go up to 2.5 µm or 3 µm in terms of higher order aberrations.

According to a consensus paper,[1] surface irregularity index of -0.5 µm or greater is considered visually significant, as well as higher order aberrations of 0.5 µm or greater. This can be translated into understanding that premium IOLs should not be placed in corneas like this.

SMALL APERTURE TECHNOLOGY

The small aperture IOL can be a very good solution for a patient who comes in for cataract surgery desiring spectacle independence, when you realize even though the spectacle values were normal, there is irregular astigmatism due to pterygium.

In one such patient, we calculated for the left eye the small aperture IOL for emmetropia target refraction. Normally, you go slightly minus for a refractive purpose, but we did this to compensate for the 2.84 D of astigmatism. The VA outcome after a week and after 1 to 2 months, was 20/25 in distance and near, which is excellent. In combination with the other eye, in which we placed a refractive bifocal lens, we had a very nice outcome in this patient.

A series of patients with a history of hyperopic and myopic LASIK implanted with the small aperture IOL all had impressive outcomes with no dysphotopsia or side effects.[2] Another series of 17 patients with different pathologies including keratoconus, keratoplasty, and radial keratotomy showed success, demonstrating that the small aperture IOL is well suited for patients with lens exchange in highly irregular corneas.[3] The Haigis formula worked best for this patient group, and visual acuity improved in 80% of the cases with uncorrected distance visual acuity and intermediate vision improvement over 3 months.

Cataract surgery should be done before complex treatment in keratoconus patients, such as surface ablation plus crosslinking, which can be done

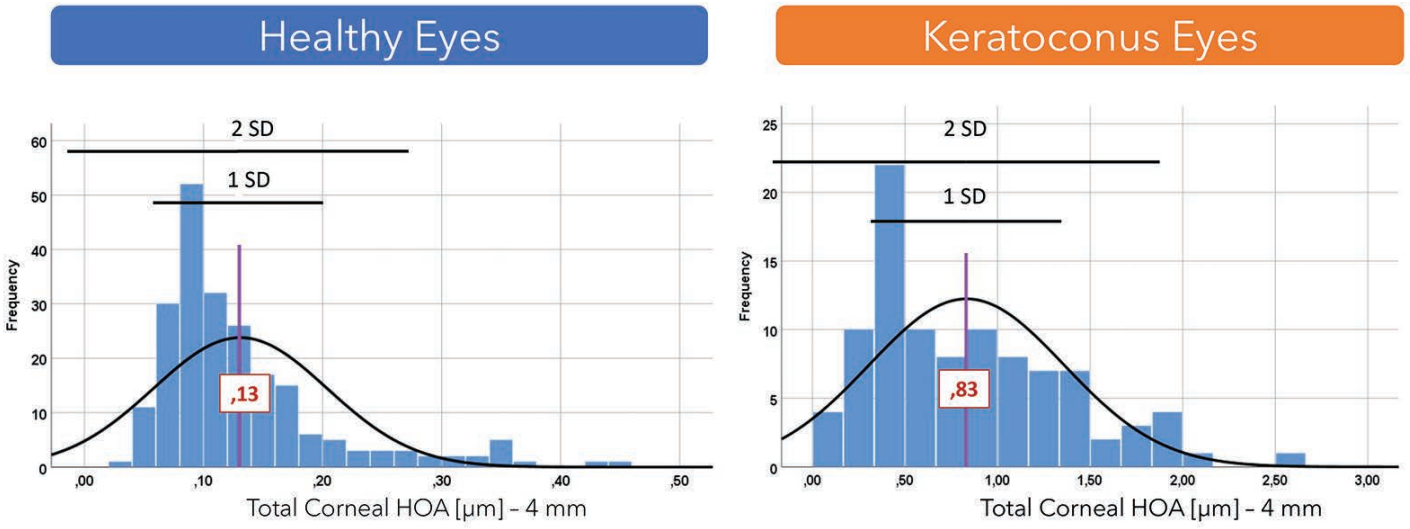

Figure. Distribution of higher order aberrations between healthy and keratoconus eyes in a study underway by Prof. Auffarth.

simultaneously. Then, the small aperture IOL would be very forgiving in terms of the final refractive outcome. This was applied in a study in four eyes with very good results.[4]

Small aperture technology can also be used following radial keratotomy if cataract surgery has been performed and the patient has a fluctuating refractive outcome with a normal monofocal lens.[5] A small aperture IOL can be implanted into the sulcus as an add-on lens.

SUMMARY

Higher order aberration and irregularities of the cornea greater than 0.5 µm can be considered abnormal. We can successfully treat these eyes with small aperture technology. The resulting pinhole effect is sufficient to compensate for aberrations and astigmatism and provide some depth of focus. ■

1. Lindstrom R, Al-Mohtaseb Z, Auffarth G, et al. 2020 Global consensus on corneal irregularity. Supplement to *CRST/CRSTE*. (January 01, 2021). https://crstoday.com/wp-content/uploads/sites/4/2021/01/0121CRST-CRSTE_Evolve-2032-Corneal-Irregularity-Consensus-Paper.pdf
2. Agarwal S, Thornell EM. Cataract surgery with a small-aperture intraocular lens after previous corneal refractive surgery: Visual outcomes and spectacle independence. *J Cataract Refract Surg*. 2018;44(9):1150-1154.
3. Langer J, Shajari M, Kreutzer T, Priglinger S, Mayer WJ, Mackert MJ. Predictability of Refractive outcome of a small-aperture intraocular lens in eyes with irregular corneal astigmatism. *J Refract Surg*. 2021;37(5):312-317.
4. Northey LC, Holland SP, Lin DTC, Moloney G. New treatment algorithm for keratoconus and cataract: small-aperture IOL insertion with sequential topography-guided photorefractive keratectomy and simultaneous accelerated corneal crosslinking. *J Cataract Refract Surg*. 2021;47(11):1411-1416.
5. Son HS, Khoramnia R, Mayer C, Labuz G, Yildirim TM, Auffarth G. A pinhole implant to correct postoperative residual refractive error in an RK cataract patient. *Am J Ophthalmol Case Rep*. 2020;20:100890.

EARLIER IDENTIFICATION AND TREATMENT OF KERATOCONUS PROGRESSION: MANAGING THE COMPLEX CORNEA PATIENT

Release Date: April 2022
Expiration Date: April 2023

INSTRUCTIONS FOR CREDIT

To receive credit, you must complete the attached **Pretest/Posttest/Activity Evaluation/Satisfaction Measures Form** and mail or fax to Evolve Medical Education LLC, 353 West Lancaster Avenue, Second Floor, Wayne, PA 19087; Fax: (215) 933-3950. To answer these questions online and receive real-time results, please go to http://evolvemeded.com/course/2161-supp. If you experience problems with the online test, email us at info@evolvemeded.com. *NOTE: Certificates are issued electronically.*

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DEMOGRAPHIC INFORMATION

Profession
___ MD/DO
___ OD
___ NP
___ Nurse/APN
___ PA
___ Other

Years in Practice
___ >20
___ 11-20
___ 6-10
___ 1-5
___ <1

Patients Seen Per Week (with the disease targeted in this educational activity)
___ 0
___ 1-15
___ 16-30
___ 31-50
_____ >50

Region
___ Midwest
___ Northeast
___ Northwest
___ Southeast
___ Southwest

LEARNING OBJECTIVES

Did the program meet the following educational objectives?	Agree	Neutral	Disagree
Review the prevalence of keratoconus, subclinical ectasia, and complex corneas among refractive surgery and cataract surgery candidates	_____	_____	_____
Improve understanding of new technologies for the identification of inherited risk factors before or early in the progression of corneal disease	_____	_____	_____
Understand how crosslinking technology can help halt the progression of keratoconus	_____	_____	_____
Identify techniques and technologies to improve visual quality and patient satisfaction in complex cornea patients presenting for cataract and refractive surgery	_____	_____	_____

POSTTEST QUESTIONS

Please complete at the conclusion of the program.

1. Based on this activity, please rate your confidence in your ability to identify techniques and technologies to improve visual quality and patient satisfaction in complex cornea patients presenting for cataract and refractive surgery (based on a scale of 1 to 5, with 1 being not at all confident and 5 being extremely confident).
a. 1
b. 2
c. 3
d. 4
e. 5

2. Keratoconus is characterized by:
a. A thinning cornea protruding into a cone shape
b. A cloudy natural lens
c. Inflammation
d. Flattening of the cornea

3. According to material presented here, which of the conventional exams for diagnosing keratoconus is most important to use?
a. Epithelial mapping
b. Wavefront aberrometry
c. Corneal topography and tomography
d. Corneal biomechanical testing

4. Which of the following is known to be a risk factor for keratoconus?
a. Habitual eye rubbing
b. Collarettes on the lashes
c. History of dry eye disease
d. Sleeping face down

5. Approximately how many people have keratoconus?
a. 8 million
b. 27 million
c. 63 million
d. 120 million

6. Approximately how many people are considered "at risk" for keratoconus?
a. 250 million
b. 370 million
c. 420 million
d. 500 million

7. What percentage of corneal refractive surgery candidates have at least one risk factor for keratoconus?
a. 20%
b. 40%
c. 50%
d. 70%

8. To approve payment for a collagen crosslinking procedure, insurance companies generally look for:
a. A high Kmax number
b. Stable refraction
c. Documented progression of keratoconus
d. Epithelial thinning

9. What surface irregularity index score is considered to be visually significant?
a. 0.1 to 0.2 µm
b. 0.2 to 0.3 µm
c. 0.3 to 0.4 µm
d. 0.5 µm or greater

10. What is a typical length of time to wait for postoperative stability following radial keratotomy?
a. Approximately 2 weeks
b. Three to 4 weeks
c. Six to 8 weeks
d. At least 10 weeks

ACTIVITY EVALUATION

Your responses to the questions below will help us evaluate this activity. They will provide us with evidence that improvements were made in patient care as a result of this activity.

Rate your knowledge/skill level prior to participating in this course: 5 = High, 1 = Low_____

Rate your knowledge/skill level after participating in this course: 5 = High, 1 = Low_____

This activity improved my competence in managing patients with this disease/condition/symptom. _____ Yes _____No

Probability of changing practice behavior based on this activity: _____High _____ Low _____No change needed

If you plan to change your practice behavior, what type of changes do you plan to implement? (check all that apply)

Change in pharmaceutical therapy _____ Change in nonpharmaceutical therapy _____

Change in diagnostic testing _____ Choice of treatment/management approach _____

Change in current practice for referral _____ Change in differential diagnosis _____

My practice has been reinforced _____ I do not plan to implement any new changes in practice _____

Please identify any barriers to change (check all that apply):

_____ Cost _____ Lack of consensus or professional guidelines

_____ Lack of administrative support _____Lack of experience

_____ Lack of time to assess/counsel patients _____ Lack of opportunity (patients)

_____ Reimbursement/insurance issues _____ Lack of resources (equipment)

_____ Patient compliance issues _____ No barriers

_____ Other. Please specify: _____

The design of the program was effective for the content conveyed	___ Yes	___ No
The content supported the identified learning objectives	___ Yes	___ No
The content was free of commercial bias	___ Yes	___ No
The content was relative to your practice	___ Yes	___ No
The faculty was effective	___ Yes	___ No
You were satisfied overall with the activity	___ Yes	___ No
You would recommend this program to your colleagues	___ Yes	___ No

Please check the Core Competencies (as defined by the Accreditation Council for Graduate Medical Education) that were enhanced through your participation in this activity:

_____ Patient Care

_____ Practice-Based Learning and Improvement

_____ Professionalism

_____ Medical Knowledge

_____ Interpersonal and Communication Skills

_____ System-Based Practice

Additional comments:

_____

_____ I certify that I have participated in this entire activity.

This information will help evaluate this activity; may we contact you by email in 3 months to inquire if you have made these changes to your practice based on this activity? If so, please provide your email address below.

_____

_____