Refractive Management/Intervention
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Practicing Ophthalmologists Curriculum
Authors and Financial Disclosures

The Practicing Ophthalmologists Curriculum was developed by a group of dedicated ophthalmologists reflecting a diversity of background, training, practice type and geographic distribution.

Jeffrey A. Nerad, M.D., American Academy of Ophthalmology Secretary for Knowledge Base Development, serves as the overall project director for the acquisition and review of the topic outlines.

The Academy gratefully acknowledges the contributions of the International Society of Refractive Surgery.

Practicing Ophthalmologists Curriculum Panel
Christopher L. Blanton, M.D., Chair
Rajesh K. Rajpal, M.D., Vice Chair
William J. Dupps, M.D., Ph.D
David A. Goldman, M.D.
Mark A. Kontos, M.D.
Sonia H. Yoo, M.D.

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Contributors who have disclosed financial relationships:
Christopher L. Blanton, M.D.
Consultant/Advisor: Abbott Medical Optics, Allergan
Lecture Fees: Abbott Medical Optics, Allergan
Grant Support: Abbott Medical Optics
William J. Dupps, M.D., Ph.D
Consultant/Advisor: Ziemer
Grant Support: Avedro, Carl Zeiss Meditec, National Eye Institute
Patent/Royalty: Cleveland Clinic Innovations
David A. Goldman, M.D.
Consultant/Advisor: Alcon Laboratories, Inc., Allergan, Inc., Bausch Lomb Surgical
Mark A. Kontos, M.D.
Consultant/Advisor: Abbott Medical Optics, Inc.
Rajesh K. Rajpal, M.D.
Consultant/Advisor: Abbott Medical Optics, Alcon Laboratories, Inc., Allergan, Inc., Avedro, Bausch Lomb
Equity Owner: Avedro
Lecture Fees: Alcon Laboratories, Inc., Allergan, Inc., Avedro, Bausch Lomb
Grant Support: Allergan, Inc., Avedro
Sonia H. Yoo, M.D.
Consultant/Advisor: Alcon Laboratories, Inc., Bausch & Lomb Surgical, Optimedica, Transcend
Lecture Fees: Alcon Laboratories, Inc.,
Grant Support: Allergan, Inc., Carl Zeiss Meditec, Transcend

Contributors who state they have no significant financial relationships to disclose:
Jeffrey A. Nerad, M.D.
Background on Maintenance of Certification (MOC)

Developed according to standards established by the American Board of Medical Specialties (ABMS), the umbrella organization of 24 medical specialty boards, Maintenance of Certification (MOC) is designed as a series of requirements for practicing ophthalmologists to complete over a 10-year period. MOC is currently open to all Board Certified ophthalmologists on a voluntary basis; time-limited certificate holders (ophthalmologists who were Board Certified after July 1, 1992) are required to participate in this process. All medical specialties participate in a similar process.

The roles of the American Board of Ophthalmology (ABO) and the American Academy of Ophthalmology relative to MOC follow their respective missions.

The mission of the American Board of Ophthalmology is to serve the public by improving the quality of ophthalmic practice through a process of certification and maintenance of certification that fosters excellence and encourages continual learning.

The mission of the American Academy of Ophthalmology is to advance the lifelong learning and professional interests of ophthalmologists to ensure that the public can obtain the best possible eye care.

The role of the ABO in the MOC process is to evaluate and to certify. The role of the Academy in this process is to provide resources and to educate.

Background on the Practicing Ophthalmologists Curriculum (POC)
At the request of the ABO, the Academy developed the Practicing Ophthalmologists Curriculum (POC), a knowledge base that identifies and defines areas of knowledge important to the delivery of quality eye care as a basis for the content of examinations for the MOC process. The content in the POC is comprised of the information deemed as the most relevant clinical information for a practicing ophthalmologist.

The ABO has agreed that their Periodic Ophthalmic Review Test (PORT) and closed-book Demonstration of Ophthalmic Cognitive Knowledge (DOCK) examinations will be based on the POC. The ABO is solely responsible for creating the PORT and DOCK exams and for certifying MOC candidates. The Academy has developed study tools based on the POC to assist doctors preparing to meet these MOC requirements.

Organization of the POC
The Practicing Ophthalmologists Curriculum comprises 10 practice emphasis areas (PEA), plus Core Ophthalmic Knowledge. The ABO has designated the following as practice emphasis areas:

- Comprehensive Ophthalmology
- Cataract/Anterior Segment
- Cornea/External Disease
- Glaucoma
- Neuro-Ophthalmology and Orbit
- Oculoplastics and Orbit
- Pediatric Ophthalmology/Strabismus
- Refractive Management/Intervention
- Retina/Vitreous
- Uveitis
In addition to two practice emphasis areas of choice, every diplomate sitting for the DOCK examination will be tested on Core Ophthalmic Knowledge. Core Ophthalmic Knowledge is defined as the fundamental knowledge every practicing ophthalmologist must have whatever their area of practice.

Each PEA is categorized into topics presented in an outline format for easier reading and understanding of the relevant information points by the reader. These outlines are based on a standard clinical diagnosis and treatment approach found in the Academy’s Preferred Practice Patterns.

For each topic, there are Additional Resources that may contain journal citations and reference to textbooks. These resources are supplemental to the topic outline, and should not be necessary for MOC exam preparation purposes.

**Creation of the POC**
The POC was developed by panels of practicing ophthalmologists in each of the ten practice emphasis areas. The panels reflect a diversity of background, training, practice type and geographic distribution, with more than 90 percent of the panel members being time-limited certificate holders.

The panels ranked clinical topics (diseases and procedures) in terms of clinical relevance to the subspecialist or comprehensive ophthalmologist. The panelists created outlines for the topics deemed Most Relevant, based on what an ophthalmologist in a specific practice emphasis area needs to know to provide competent, quality eye care (i.e., directly related to patient care). These outlines were reviewed by subspecialty societies and the American Board of Ophthalmology.

**Revision Process**
The POC is intended to be revised every three years. The POC panels will consider new evidence in the peer-reviewed literature, as well as input from the subspecialty societies, the American Board of Ophthalmology and the Academy’s Self-Assessment Committee, in revising and updating the POC.

Prior to a scheduled review the POC may be changed only under the following circumstances:
- A Level I (highest level of scientific evidence) randomized controlled trial indicates a major new therapeutic strategy
- The FDA issues a drug/device warning
- Industry issues a warning
Refractive Management/Intervention

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Snellen fraction visual acuity measurement

I. List the indications/contraindications
   A. Indications
      1. To determine the level of vision quantitatively
   B. Contraindications
      1. Deferred in ocular emergencies, e.g., chemical burns

II. Describe the pre-procedure evaluation
   A. Medical and ophthalmic history

III. List the alternatives to this procedure
   A. Visual field testing
   B. Quality of vision measurements such as contrast sensitivity (see below)

IV. Describe the instrumentation and technique
   A. Standard eye lane with Snellen acuity chart typically placed 20 feet, (6 meters in the metric system) in front of the patient either directly or with mirrors. An alternative system is the EDTRS chart which is placed 4 meters in front of the patient
   B. Patient uses occluder to test each eye individually and is instructed to read the smallest possible line
   C. Attention is directed to maximizing the patient effort in order to minimize subjectivity related to effort
   D. The vision is recorded as a fraction
   E. The numerator of the fraction represents the distance (either feet or meters) from the patient to the chart
   F. The denominator is the distance at which the letter subtends the standard visual angle of five minutes
   G. The smallest line for which the patient is able to read at least half the letters is recorded as the denominator
   H. For higher accuracy, +/- notation is used to identify the number of letters made on the next smallest line or missed on the recorded line respectively
   I. The fraction is sometimes reported in decimal notation or metric terms and sometimes converted to a logMAR (logarithm of the minimal angle of resolution) equivalent
V. Describe the considerations in interpretation of this diagnostic procedure

A. It must be remembered that there is some level of subjectivity to this test and that there are alternative methods for assessing vision (see above)

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 3: Optics, Refraction, and Contact Lenses, 2013-2014.

Near vision testing

I. List the indications

A. Patients presenting for refractive surgery evaluation, or routine examination including refraction, particularly in those aged 40 and above

B. Patients with near vision symptoms of blurred vision or discomfort

II. Pre-procedure evaluation

A. Ophthalmic and social history with particular regard to vocation, hobbies and lifestyle

III. Instrumentation and technique

A. A handheld reading card is typically used at approximately 14 to 16 inches or the patient's preferred reading distance

1. The handheld card has Jaeger (J) numbers or points (P) which are used by printers to denote letter sizes commonly used in printed material

2. These are helpful notations to avoid confusing a near acuity measurement with a distance measurement

3. The M unit has also been developed and is particularly useful in low vision patients to calculate comparable distance acuity.

B. Ideally, the patient is tested for both the uncorrected and best-corrected state at an appropriate distance as determined by the patient's needs

C. One technique recommends testing at 40 cm allowing for easy comparison between near and distance vision measured at 4 m

D. Another important component of near vision is the accommodative amplitude

1. Near point of accommodation

   a. The eye is corrected for distance and the near blur point is determined

   b. Far point (infinity) allows near point to be calculated in diopters of amplitude

2. Prince rule

   a. A reading card and ruler calibrated for diopters and centimeters are used along with a +3.0 diopter lens

   b. The far point becomes 33 cm in an emmetropic eye and the near point is 3D closer

   c. Near point minus far point equals amplitude

3. Plus and minus spheres

   a. Reading target is placed at 40 cm

   b. Progressively stronger minus spheres are placed until near blur
c. This is followed by successively stronger plus lenses until blur

d. The difference between the lenses at the two endpoints is the amplitude

E. Range of accommodation

1. This measures the useful range of near vision when a certain lens is employed and helps determine the functional capabilities of a near lens

IV. Considerations in interpretation

A. Subjective nature of measurement

B. Range of near point needs will vary from patient to patient

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 3: Optics, Refraction, and Contact Lenses, 2013-2014.
Quality of vision testing

I. List the indications
   A. To evaluate postoperative quality of vision symptoms.
   B. To evaluate procedure outcome by comparing postoperative to preoperative tests

II. Describe the instrumentation and technique
   A. Questionnaire (patient reported outcomes)
      1. Quantifies subjective symptoms on a numeric scale
      2. A variety of complex vision symptoms can be evaluated, such as difficulty with night driving
      3. Several surveys are available, including the NEI Visual Function Questionnaire
      4. Questionnaires have different validity for different disease conditions
   B. Contrast sensitivity test categories
      1. Optotype charts, also termed contrast acuity
         a. Measures acuity at a set contrast level
         b. The patient reads an optotype chart similar to a high contrast Snellen eye chart
      2. Sine wave grating charts
         a. Measures contrast threshold using sine wave gratings at different cycles per degree
         b. The patient indicates the direction of the grating
      3. Landolt ‘C’ charts
         a. Measures contrast threshold using a letter ‘C’ which can be rotated
   C. The patient indicates the direction of the break in the ‘C’.
   D. Testing conditions
      1. Photopic
      2. Mesopic
      3. With or without a glare source
   E. Generally performed using best eyeglass corrected vision

III. Describe the considerations in interpretation of this diagnostic procedure
   A. Diseases affecting the cornea, lens, retina, and optic nerve may all affect the results
   B. No test has been deemed a universal standard
   C. The correlation between contrast threshold, questionnaire responses and visual performance has
not been clearly established

D. Mesopic and glare contrast threshold test conditions are more difficult to perform and require

1. Reproducible lighting conditions
2. A patient adaption period
3. Trained staff to administer the test

Additional Resources

Refractive stability

I. Refractive stability

A. Refractive stability is an important eligibility requirement for refractive surgery
   1. An eye that is not stable will likely be unstable after surgery
   2. The surgeon does not know what refraction to treat when the refraction is changing

B. There is no universally accepted definition for refractive stability
   1. However, most clinical trials have defined stability as no more than a 0.5 diopter (D) change in the sphere or cylinder of the refractive error over a 12 month period

C. For refractive surgery retreatment, stability is typically defined as no more than a 0.5 D shift in the sphere or cylinder measured one to six months apart

II. Factors affecting quality/reliability of refraction

A. Patient cooperation
B. Normal ocular surface
C. Clear visual media
D. Accommodative capability
E. Examiner's skill level
F. Contact lens wear
   1. Recent contact lens wear or long history of contact lens use can alter corneal shape and refraction
G. Patient age
   1. Young actively growing patients will typically become more myopic until physiologic maturity
H. Corneal pathology
   1. Keratoconic patients and patients with other corneal degenerations can have shifting refractions
I. Other eye disease
   1. A hallmark of malignant myopia is progression of myopia throughout adult life
J. Systemic conditions
   1. Diabetes mellitus
   2. Pregnancy
   3. Lactation

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 3: Optics, Refraction, and Contact Lenses,
2. AAO, Focal Points: Choosing the Appropriate PRK patient, Module #9, 1998, p. 4.


Cross-cylinder technique for subjective refraction

I. List the indications/contraindications
   A. Indications
      1. To determine the amount and axis of astigmatism
   B. Contraindications
      1. Patients unable to communicate
      2. Patients with significant vision loss or other abnormality that limits their ability to perceive differences

II. Describe the pre-procedure evaluation
   A. Visual acuity
   B. Retinoscopy
   C. Lensometry (old eyeglasses if available)

III. List the alternatives to this procedure
   A. Autorefraction
   B. Retinoscopy
   C. Astigmatic dial
   D. "Rocking" the cylinder
   E. Wavefront mapping
   F. Stenopeic slit

IV. Describe the instrumentation and technique
   A. Phoropter or trial frame with lens set is used
      1. Starting refraction can be current prescription or determined with retinoscopy, autorefraction or wavefront refraction
   B. Sphere is adjusted first
   C. The Jackson Cross cylinder is a compound lens with spherical equivalent of zero
      1. It has minus power in one meridian and equal plus power in the other meridian
   D. Cylinder axis is determined prior to axis power
1. Axis is determined based on subjective responses of patient to flipping of the lens aligned 45 degrees from the principal meridian of the correcting cylinder

E. After axis is determined, power is determined based on subjective responses of patients to flipping of lens with cross-cylinder aligned along same axis as principal meridian of correcting cylinder

F. The spherical equivalent is maintained and then refined

V. Describe the considerations in interpretation of this diagnostic procedure

A. Subjective test

B. Attention to appropriate power of cross cylinder, i.e., larger powers for poorer vision

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 3: Optics, Refraction, and Contact Lenses, 2013-2014.

2. AAO, Focal Points: Choosing the Appropriate PRK Patient, Module #9, 1998, p.3.
Refraction: manifest and cycloplegic

I. List the indications
   A. To measure the refractive error
      1. When the refraction is performed in the natural state, it is known as a manifest reaction
      2. A cycloplegic refraction is typically used to ensure that accommodation is suspended, especially important in younger or hyperopic patients
      3. Measurement of vertex distance is important

II. Describe the pre-procedure evaluation
   A. Medical and ophthalmic history
   B. Visual acuity without correction
   C. Retinoscopy to obtain refraction for starting point
   D. Lensometry (old eyeglasses if available)
   E. Autorefraction or wavefront can be used to obtain refraction for starting point

III. List the alternatives to this procedure
   A. No real substitute
      1. Autorefraction and wavefront measurements provide similar information and can be used to confirm general accuracy of manifest

IV. Describe the instrumentation and technique
   A. The patient is placed at the phoropter or in trial frames
   B. Usually a preliminary refractive error can be determined using old eyeglasses, an autorefraction or retinoscopy
   C. Then, the patient is offered a series of choices to correct the spherical component of the refractive error until the best vision is achieved with the least amount of minus prescription (or most plus if this be the case)
   D. The cylinder component of the refractive error is then determined using the cross-cylinder method (See Cross-cylinder technique for subjective refraction)
   E. For manifest refraction, the endpoint should be verified
      1. Fogging
         a. To minimize chance of accommodation
      2. Red/green test
To verify accuracy of spherical correction

3. Visual acuity
   a. Healthy eyes should read 20/20

F. The refraction is cycloplegic if the patient has received cycloplegic eyedrops to paralyze the accommodative mechanism prior to the refraction

V. Describe the considerations in interpretation of this diagnostic procedure

   A. Test is subjective

   B. Careful attention must be paid to the accommodative mechanism, particularly in the manifest refraction

   C. The usual cause of a disparity between the manifest and cycloplegic refraction is accommodation where the cycloplegic sphere will have less minus power than the manifest sphere

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 3: Optics, Refraction, and Contact Lenses, 2013-2014.


Lenses used to correct cylinder are with either plus or minus lens notation

A. In the plus lens notation, the correcting plus cylinder is aligned along the steepest corneal meridian and noted in plus terminology
   1. For example, +1.75+1.50 X 085 indicates a cornea with 1.5 diopters (D) of astigmatism in which the steep meridian is at 85 degrees

B. In the minus lens notation, the correcting minus cylinder is aligned along the flattest corneal meridian.
   1. For example, the above refractive error would be recorded as +3.25-1.50 X 175 to indicate a cornea with 1.5D of astigmatism in which the flat meridian is at 175 degrees

C. To transpose refractive errors within the two notations
   1. Add the sphere and cylinder magnitude arithmetically
   2. Switch the cylinder sign, i.e., make minus plus or make plus minus
   3. Change the axis of cylinder by 90 degrees

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 3: Optics, Refraction, and Contact Lenses, 2013-2014.
Corneal pachymetry

I. List the indications
   A. This is typically done to determine eligibility for refractive surgery
   B. To monitor flap thickness intraoperatively
   C. To check for corneal pathology such as keratoconus or pellucid marginal degeneration (comparing central and peripheral corneal thickness)
   D. Assess accuracy of intraocular pressure measurements (See section on Issues of intraocular pressure measurements after laser in situ keratomileusis and laser surface ablation)

II. List the alternatives to this procedure
   A. There are several ways to perform this measurement
      1. Primarily single function ultrasound devices are used
      2. However more recently, videokeratoscopy devices have incorporated the ability to measure corneal thickness.
   B. There are also methods that rely on optical focusing and doubling
      1. Less accurate
      2. More difficult to perform

III. Describe the instrumentation and technique
   A. In the optical doubling technique, a scale is used to measure the distance between images from the anterior and posterior surfaces of the cornea
   B. Optical focusing relies on measuring the distance between a focused image of the endothelium and a focused image of the anterior surface of the cornea
   C. Ultrasound technique is based on the knowledge of the velocity of sound waves in corneal tissue (1640 m/sec)
      1. By sending out a sound wave and measuring the time for it to traverse the cornea, a distance, i.e., thickness can be calculated

IV. List the complications of this procedure, their prevention and management
   A. Ultrasound
      1. Possible to cause a corneal abrasion
      2. Peripheral displacement of the probe can result in inaccurately thick measurements
      3. Inaccurate measurements can also be obtained if the probe is not perpendicular to the surface
V. Describe the considerations in interpretation of this diagnostic procedure

A. A typical average normal central pachymetry of 540 micron and +/- 30 micron is in the general range of normal, which is approximately 480-600 microns

B. The placement of the ultrasound probe is important
   1. It needs to be placed normal to the corneal surface (or perpendicular to a tangent at the surface) and over the area of interest
      a. For laser in situ keratomileusis (LASIK), this would be the thinnest area, the central cornea
      b. For limbal relaxing incisions, this would be over the peripheral cornea
      c. For conductive keratoplasty, this would be over the midperiphery

C. The quality of the optical image is important in doubling and focusing techniques (surface issues, edge detection)

D. Intraoperative ultrasound measurements can be affected by overhydration or dehydration of the stromal bed

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 3: Optics, Refraction, and Contact Lenses; Section 8: External Disease and Cornea, Section 14: Refractive Surgery, 2013-2014.


Corneal shape analysis

I. List the indications/contraindications

A. Indications
   1. All cases where a keratorefractive procedure is considered
   2. To help with the diagnosis of corneal disease
   3. To aid diagnosis of decreased spectacle-corrected visual acuity or visual quality complaints such as monocular diplopia

B. Contraindications
   1. As a non-invasive, low risk procedure, there are no obvious contraindications, but certain conditions as outlined below may render accurate measurement or appropriate interpretation difficult

II. List the alternatives to this procedure

A. Depending upon the topographic technique used, information obtained by computerized corneal modeling include the following
   1. Central corneal power
      a. Alternatives
         i. Standard keratometry
   2. Corneal irregularity
      a. Alternatives
         i. Slit-lamp biomicroscopic evaluation
         ii. Retinoscopy
         iii. Wavefront analysis of higher order aberrations
         iv. Rigid contact lens over-refraction
   3. Corneal thickness
      a. Alternatives
         i. Ultrasonic pachymetry
   4. Geometry indicative of keratoconus
      a. Alternatives
         i. Slit-lamp biomicroscopic evaluation
         ii. Retinoscopy
         iii. Wavefront analysis
III. Describe the instrumentation and technique

A. Two main instrument designs are commonly used to obtain corneal topographic information

1. Placido disk-based systems (require smooth optical surface for reflection)
   a. Description
      i. The Placido disk features concentric, alternating regularly spaced light and dark circles
      ii. If an image of the disk is reflected perpendicularly from a flat surface, the circles will retain their relative spacing, but if reflected from a spherocylindrical surface, the spacing of the ring images are reduced as a function of increasing curvature of the surface
      iii. If the cornea is spherical, the rings will appear round. If the cornea is cylindrical, the rings will appear elliptic with shorter distances between rings in the meridian of greatest curvature (lowest radius of curvature)
      iv. Therefore, relative ring spacing across the reflected image can be used to calculate regional radii of curvature of the reflecting surface and thereby generate a map of anterior corneal curvature
   b. Creation of corneal maps
      i. Computerized Placido-based corneal modeling systems digitize the reflected ring images, convert ring spacing to a mathematical representation of curvature (slope), and generate color-coded maps of the cornea, with areas of lower curvature indicated by colors at the blue end of the spectrum and areas of greater curvature indicated by colors towards the red.
      ii. To obtain a corneal map using these devices, the patient's head is stabilized with a chin rest and forehead strap, the ring image is focused on the cornea and centered on the entrance pupil, a digital image of the ring reflection is captured and the image processed by the topographer's computer
   c. Considerations for accurate imaging
      i. These systems are sensitive to the reflecting quality of the cornea and to alignment
      ii. Alignment of the corneal apex with the reference center of the rings is also important, and misalignment and defocus will lead to inaccurate modeling
      iii. Shadows from the nose and eyelid can prevent accurate and complete imaging
      iv. Dry eye and a poor tear film can reduce the quality of the reflected image and also prevent accurate imaging
        i) If a dry eye precludes image capture, a minimal quantity of non-viscous artificial tear can be placed, but excessive lubrication can distort the image leading to inaccurate modeling
      v. A deep orbit might put the corneal plane out of focal range for image capture
vi. To avoid these problems, careful attention must be paid to patient instruction and positioning, including proper fixation and alignment of the eye

2. Slit-based corneal tomography systems
   
a. Description
   
i. These systems use pixel-by-pixel capture of a cross-sectional beam intersecting the corneal surfaces to reconstruct anterior and posterior contours
   
ii. These instruments combine one or more scanning illumination sources (for example, horizontally translating vertical slit beams or rotating Scheimpflug beams) with static or moving video cameras that capture cross-sectional corneal images spanning most of the corneal diameter
   
iii. Since the angles of the light sources and their distances from the camera are known, corneal height data can be determined
   
iv. The posterior edge of the slit image can also be identified, which describes the contour of the posterior surface as observed through the anterior ocular surface and allows specific analysis of the posterior corneal shape
   
v. By combining anterior and posterior surface data, pan-corneal thickness maps can be generated that allow regional analyses of corneal thickness
   
vi. Optical coherence tomography (OCT) and high frequency ultrasound can be used to capture high-resolution images of the anterior and posterior corneal surfaces. With sufficient resolution, these imaging modalities can also allow visualization and quantification of corneal sub-layers arising from the epithelial-stromal junction and lamellar interfaces formed by LASIK flaps
   
b. Creation of corneal maps
   
i. The pixels comprising each surface are represented as elevation data and compared in color maps to some user-selectable best-fit surface (often a sphere)
   
ii. Color-coded elevation maps describe the height difference between the measured corneal surface and the best-fit surface, and axial or instantaneous radius of curvature algorithms are used to display conventional color-coded dioptric power maps
   
c. Considerations for accurate imaging
   
i. These systems are less sensitive to the reflecting quality of the cornea, but will be affected by nose or eyelid obstruction
   
ii. Scanning systems involve acquisition of numerous images as opposed to a single Placido image, so the resulting measurements are susceptible to patient motion artifact and blinking
   
iii. Placido disc technology has been coupled to some scanning slit systems to improve accuracy of anterior curvature data.
   
iv. Corneal light scattering from edema or scar can affect the edge detection algorithms that define the posterior corneal surface and lead to errors in posterior curvature and corneal thickness
IV. Describe the considerations in interpretation of this diagnostic procedure

A. Scales for color coded maps
   1. Absolute standard scales
      a. A given dioptic power is assigned a specific color
      b. Consistently represent specific degrees of steepening by particular colors, and, in so doing, facilitates both immediate power-color association and pattern recognition
      c. Most commonly, the absolute scale is set with an interval of 1.5 diopters (D), which provides acceptable sensitivity and topographic detail for most clinical applications
   2. Normalized scales
      a. Entire range of corneal surface powers is identified, and equally divided amongst the colors available for display
      b. A disadvantage is that a given color can represent vastly different surface powers from one cornea to another, which makes comparisons between topographic maps and the application of color recognition guidelines difficult

B. Measures of corneal contour
   1. Color-coded computer-generated maps convey an overall impression of corneal topography that includes much of the peripheral cornea, indicate the degree of surface regularity, and reveal local areas of flattening or steepening, oftentimes in patterns characteristic of specific conditions
   2. The analysis systems can also provide a number of useful quantitative measures of corneal contour
   3. Simulated keratometry value
      a. One of the most commonly used measures is the simulated keratometry value, which estimates the keratometry reading
      b. Data from rings that are positioned at the approximate locus of the keratometer mires are used to determine the power and axis of the steepest and flattest meridians
      c. To simulate keratometry data, these values are usually expressed as the power and axis of the steepest meridian and the power of the meridian 90 degrees away
      d. The power and orientation of the flattest meridian (which is not necessarily at 90 degrees to the steepest) is also reported as the "min K"
   4. Indices of regularity
      a. A measure of central corneal optical quality
      b. Measures irregular change in power rather than a steady increase or decrease
      c. Appears to correlate with best eyeglass-corrected visual acuity.
   5. Indices of asymmetry
      a. A measure of central corneal symmetry
b. Measures differences in power for corresponding points 180 degrees apart and equidistant from the apex

C. Patterns of corneal curvature
   a. Corneal topographic imaging studies across the normal population indicate that the cornea is typically steeper centrally than peripherally (prolate), with significant variation in central corneal curvature
   b. Patterns that represent the shape of central regions of relatively greater power seen in the normal cornea can be described as four common types:
      c. Round
      d. Oval
      e. Symmetric bow tie
      f. Asymmetric bow tie

2. In addition, there is a smaller group of irregular corneas with no readily described pattern.

D. Recognition of pathological patterns
   1. It is important to recognize particular pathological patterns that are associated with poor refractive surgery outcomes.
      a. Forme fruste or fully expressed keratoconus pattern
         i. Characterized by inferior steepening
         ii. Keratorefractive surgery performed in such cases is associated with a risk of keratectasia and devastating visual results
      b. Irregularity of rigid contact lens associated corneal warpage
         i. Characterized by
            i) Central irregular astigmatism
            ii) Loss of radial symmetry
            iii) Reversal of the normal corneal topographic pattern of progressive flattening from the center to the periphery
      c. Pellucid marginal degeneration
         i. Characterized by against-the-rule astigmatism and the "inferior smile"

E. High resolution corneal imaging techniques such as OCT and high frequency ultrasound can facilitate in situ measurement of the residual stromal bed after LASIK. Such measurements may be useful in decision-making about the safety of LASIK enhancement surgery

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 3: Optics, Refraction, and Contact Lenses, Section 14: Refractive Surgery, 2013-2014.
2. Lombardo M, Lombardo G, Manzulli M, et al. Relative contribution of central and peripheral

Refractive Management/Intervention 32 © AAO 2014-2016


Wavefront testing

I. List the indications
   A. To perform wavefront guided corneal vision corrective surgery
   B. To evaluate postoperative quality of vision symptoms
   C. To evaluate procedure outcomes by comparing postoperative to preoperative tests

II. List the alternatives to this procedure
   A. There is no alternative procedure which can be used to quantitate all of the optical aberrations of the eye
      1. Corneal topography can be used to generate the wavefront pattern of the anterior cornea surface.
   B. Retinoscopy can be used to qualitatively assess ocular aberrations, such as scissoring in keratoconus

III. Describe the instrumentation and technique
   A. Wavefront techniques
      1. All wavefront devices evaluate aberrations for the entire optical system of the eye (i.e. anterior and posterior corneal surface as well as the crystalline lens)
         a. Some devices attempt to differentiate aberrations that originate from the cornea from those in the crystalline lens and other ocular media by combining whole-eye wavefront sensing with corneal topography.
      2. Hartmann Shack
         a. Most common system in use today; using a lenslet array to analyze the wavefront emanating from the eye
      3. Ray tracing
      4. Scanning skiascopy
      5. Tscherning
   B. Wavefront measurement
      1. Measurements are made over the pupillary area
      2. Adequate fixation, centration, and focus are required
      3. Highly aberrated eyes, such as severe keratoconus, may not be able to be imaged
      4. The quality of the measurement can be assessed by (Hartmann Shack)
         a. The reproducibility of the sphere and cylinder terms on repeated testing
         b. Sharpness of the lenslet array
c. Lenslet dropout (inadequate tear film or optical opacity)
   a. Cross-over of lenslets (highly aberrated eyes)
5. The wavefront is usually reconstructed using Zernike polynomials.
   a. These polynomials are then used to describe the wavefront by its components
   b. Fourier analysis is another mathematical system that has been used to reconstruct the wavefront.
6. Aberrations are divided into lower and higher order
   a. Lower order are sphere (defocus) and cylinder
   b. Higher order encompass all other ocular aberrations
7. The display of the wavefront:
   a. Typically made with a color coded map, with elevation above and below a perfect "flat" wavefront
   b. A map is usually displayed for all aberrations and a second map of higher aberrations
   c. Can also be displayed as a point spread function. This is the calculated appearance of a point source of light.

C. Higher order aberrations
1. The most common in a normal population are:
   a. Coma (a third order term), so named for the "comet" like pattern produced by a point source of light
   b. Spherical aberration (a fourth order term)
D. Higher order aberrations are generally increased after conventional laser vision correction
1. In particular, spherical aberration can be increased when treating myopia
2. The amount of increase is related to the level of treated myopia
E. Significant amounts of higher order aberrations can be responsible for visual disturbances, such as glare and halos

IV. Describe the considerations in interpretation of this diagnostic procedure
A. A manufacturer's wavefront unit is mated to its laser for custom procedure
B. The tear film greatly influences the quality of the wavefront
C. Accommodation can be a significant factor and needs to be controlled during the measurement
D. Optical opacities, such as cataracts, make the measurement unreliable
E. The wavefront can only be calculated over the entrance pupil size
F. A larger pupil size generally increases higher order aberrations
2. AAO, Focal Points: Wavefront Analysis, Module #10, 2005.
Lensometry

I. List indications and contraindications

A. Indications
   1. To determine the refractive power of spectacles or a contact lens

B. Contraindications
   1. None

II. Describe the instrumentation and technique

A. Manual lensmeter
   1. Components
      a. Illuminated target
      b. Platform
      c. Eyepiece
      d. Standard lens
   2. Badal principle-the standard lens
      a. Linear dioptric scale
      b. Practicality of instrument size
   3. Technique
      a. Mark optical center
      b. Illuminated target moved back and forth behind "unknown" lens; when target reaches focal length of "unknown" lens emergent light rays will be parallel and give clear image. Inverse of focal length equals power
      c. 2 sets of perpendicular lines allows determination of cylinder
      d. Can also measure prism and bi-focal add by appropriate placement over corresponding lens

B. Automatic lensmeter
   1. Measures deviation of light beam as it passes through "unknown" lens
   2. Multiple beams are used to measure displacement of light as it passes through "unknown" lens
   3. Multiplicity of beams allows calculation of spherical power, cylindrical power and axis

III. List the complications of the procedure, their prevention and management
A. Lens orientation important
B. Measure back vertex power for distance correction and front vertex power for bi-focal add

IV. Describe the considerations in interpretation of this diagnostic procedure
   A. Attention to focusing on manual lensmeter
   B. Proper position of lens on automated lensmeter
   C. Careful marking of pupil center while the patient is wearing the glasses is important in the determination of prism

Additional Resources
Myopia

I. Describe the approach to establishing the diagnosis
   A. Describe the etiology of the disease
      1. Hereditary
      2. Axial myopia
      3. Disease states such as keratoconus
      4. The percentage of patients that suffer from myopia in the U.S. is about 25%
      5. The distribution of refractive errors is roughly:
         a. 66% of patients with myopia have less than 2 Diopters (D)
         b. 95% of patients with myopia have less than 6 D
   B. List the pertinent elements of the history
      1. Vision worse distance than near
   C. Describe pertinent clinical features
      1. Myopia on refraction
      2. Uncorrected visual acuity (UCVA) worse distance than near

II. Define the risk factors
   A. Family history

III. List the differential diagnosis
   A. Other forms of decreased vision associated with ocular pathology

IV. Describe patient management in terms of treatment and follow-up
   A. Describe medical therapy options
      1. Eyeglasses
      2. Contact lenses
      3. Observation
   B. Describe surgical therapy options
      1. Refractive surgery
         a. Laser in situ keratomileusis (LASIK)
b. Laser surface ablation (PRK/LASEK)

c. Refractive lensectomy

d. Phakic intraocular lenses

V. List the complications of treatment, their prevention and management

A. Eyeglasses
   1. Traumatic fracture of eyeglasses
      a. Management
         i. Use of shatter resistant materials

B. Surgical treatment
   1. Infections
   2. Scar
   3. Management and prevention are problem specific
   4. Glaucoma and or cataract with phakic intraocular lens (IOL)
   5. Retinal detachment with clear lens extraction and IOL

C. Contact lens
   1. Infections
   2. Warpage (See Ocular surface problems related to contact lenses)

VI. Describe disease-related complications

A. Risk factor for other problems such as glaucoma and retinal detachment and early cataract

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 3: Optics, Refraction, and Contact Lenses, Section 14: Refractive Surgery, 2013-2014.

2. AAO, Focal Points: Choosing the Appropriate PRK Patient, Module #9, 1998.


Hyperopia

I. Describe the approach to establishing the diagnosis
   A. Describe the etiology of this disease
      1. Hereditary
      2. Short axial length
      3. Flat cornea
   B. List the pertinent elements of the history
      1. Symptoms, vision worse near than distance
   C. Describe pertinent clinical features
      1. Hyperopia on refraction
      2. Uncorrected visual acuity (UCVA) worse near than distance
      3. Accommodative esotropia may occur
      4. Latent hyperopia in younger patients is often masked; need cycloplegic refraction to reveal

II. Define the risk factors
   A. Family history

III. List the differential diagnosis
   A. Other forms of decreased vision associated with ocular pathology

IV. Describe patient management in terms of treatment and follow-up
   A. Define medical therapy options
      1. Eyeglasses
      2. Contact lenses
      3. Observation
   B. Define surgical therapy options
      1. Refractive surgery
         a. Laser in situ keratomileusis (LASIK)
         b. Laser surface ablation
         c. Pseudophakic intraocular lenses (IOLs)
d. Consider conductive keratoplasty

V. List the complications of treatment, their prevention and management

A. Eyeglasses
   1. Traumatic fracture of eyeglasses
      a. Management
         i. Use of shatter resistant materials

B. Surgical treatment
   1. Infections
   2. Scar
   3. Management and prevention are problem specific
   4. Retinal detachment (in the case of IOLs)

C. Contact lens
   1. Infections
   2. Warpage (See Ocular surface problems related to contact lenses)

VI. Describe disease-related complications

A. Risk factor for other problems such as narrow angle glaucoma
B. Very shallow chamber may increase risk of corneal complications with lens extraction
C. Latent hyperopia may cause premature presbyopic symptoms

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 3: Optics, Refraction, and Contact Lenses; Section 14: Refractive Surgery, 2013-2014.
Anisometropia

I. Describe the approach to establishing the diagnosis
   A. Definition: Anisometropia is when there is a difference of refractive power between fellow eyes
   B. Describe the etiology of this disease
      1. Hereditary
      2. Disease states such as keratoconus
      3. Postsurgical (e.g., unilateral aphakia)
   C. List the pertinent elements of the history
      1. Symptoms
         a. Vision decreased at different distances in fellow eyes
         b. One eye with blurry vision
         c. Vision fatigue
   D. Describe pertinent clinical features
      1. Uncorrected visual acuity (UCVA) difference in fellow eyes
      2. Symptoms of visual asthenopia
      3. Aniseikonia

II. Define the risk factors
   A. Postsurgical is most common
   B. Congenital is often well tolerated except in that it may cause amblyopia

III. List the differential diagnosis
   A. Cataract
   B. Corneal disease
   C. Retinal disease

IV. Describe patient management in terms of treatment and follow-up
   A. Define medical therapy options
      1. Eyeglasses
      2. Contact lenses
      a. Knapp’s rule: aniseikonia based on axial length disparity is best corrected at the eyeglass
plane (i.e., with glasses)

i. Therefore, someone well adjusted in glasses could do worse with contact lenses or laser in situ keratomileusis (LASIK)

3. Observation

B. Define surgical therapy options

1. Refractive surgery
   a. LASIK
   b. Laser surface ablation
   c. Refractive lensectomy
   d. Astigmatic keratotomy

V. List the complications of treatment, their prevention and management

A. Surgical treatment

1. Infections
2. Corneal problems
3. Scar

B. Contact lens

1. Infections
2. Warpage
3. Endothelial cell loss

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 3: Optics, Refraction, and Contact Lenses, 2013-2014.
Aniseikonia

I. Describe the approach to establishing the diagnosis
   A. Definition: Aniseikonia is a defect of binocular vision in which fellow eye retinal images of an object differ in size. It is typically induced by a difference in refractive power between eyes.
   B. Describe the etiology of this disease
      1. Hereditary
      2. Disease states such as keratoconus
      3. Post surgical anisometropia (e.g., unilateral aphakia)
   C. List the pertinent elements of the history
      1. History of surgery or ocular condition
      2. Symptoms
      3. Vision decreased at different distances in different eyes, associated with different image size perception by patient, typically with eyeglass correction
      4. Vision fatigue
      5. Headaches
   D. Describe pertinent clinical features
      1. Significant difference in any area of refraction, sphere, cylinder or axis (typically over 1 to 3 diopters) in the refraction between fellow eyes
      2. Uncorrected visual acuity testing in fellow eyes
      3. Symptom differences between glasses and contact lenses

II. Define the risk factors
   A. Postsurgical is most common

III. Describe patient management in terms of treatment and follow-up
   A. Define medical therapy options
      1. Contact lenses
         a. Knapp rule: aniseikonia based on axial length disparity is best corrected at the eyeglass plane (i.e., with eyeglasses)
            i. Therefore, someone well adjusted in glasses could do worse with contact lenses or laser in situ keratomileusis (LASIK)
      2. High index refraction glasses may be tried
3. Observation

B. Define surgical therapy options

1. Refractive surgery
   a. LASIK
   b. Laser surface ablation
   c. Refractive lensectomy

IV. List the complications of treatment, their prevention and management

A. Contact lens

1. Contact lens intolerance
   a. Discontinue contact lenses
   b. Reduce wearing time

2. Corneal infections
   a. Culture
   b. Antibiotic treatment
   c. Discontinue contact lenses

3. Corneal scar
   a. Rigid contact lenses
   b. Phototherapeutic keratectomy (PTK)
   c. Corneal transplant

4. Loss of vision

B. Surgical treatment

1. Infections
   a. Culture
   b. Antibiotic treatment

2. Corneal scar
   a. Rigid contact lenses
   b. PTK
   c. Corneal transplant

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 3: Optics, Refraction, and Contact Lenses, 2013-2014.
Regular astigmatism

I. Describe the approach to establishing the diagnosis
   A. Describe the etiology of this disease
      1. Hereditary
      2. Disease states such as keratoconus
   B. List the pertinent elements of the history
      1. Symptoms, vision decreased at all distances
      2. May have monocular diplopia or blurring
   C. Describe pertinent clinical features
      1. Astigmatism on refraction
      2. Uncorrected visual acuity poor at all distances
      3. Excellent best corrected visual acuity with eyeglass correction

II. Define the risk factors
   A. Family history

III. List the differential diagnosis
   A. Other forms of decreased vision associated with ocular pathology

IV. Describe patient management in terms of treatment and follow-up
   A. Describe medical therapy options
      1. Eyeglasses
      2. Contact lenses
      3. If astigmatism is high, may require contact lenses
      4. Observation
   B. Describe surgical therapy options
      1. Refractive surgery
         a. Laser in situ keratomileusis (LASIK)
         b. Laser surface ablation
         c. Refractive lensectomy with toric intraocular lens implant
d. Astigmatic keratotomy
e. Limbal relaxing incisions (LRI)

V. List the complications of treatment, their prevention and management

A. Eyeglasses
   1. Traumatic fracture of eyeglasses
      a. Management
      i. Use of shatter resistant materials

B. Surgical treatment
   1. Infections
   2. Corneal problems
   3. Scar
   4. Management and prevention are problem specific (See Excimer laser in situ keratomileusis for myopia and myopia with astigmatism and Excimer laser surface ablation for myopia and myopic astigmatism)

C. Contact lens
   1. Infections
   2. Warpage (See Ocular surface problems related to contact lenses)

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 3: Optics, Refraction, and Contact Lenses, Section 14: Refractive Surgery, 2013-2014.
2. AAO, Focal Points: Choosing the Appropriate PRK Patient, Module #9, 1998, p. 11-12.
3. AAO, Focal Points: Contact Lens Fitting for Regular Astigmatism, Module #11, 1997.
Irregular astigmatism

I. Describe the approach to establishing the diagnosis

A. Describe the etiology of this disease
   1. Disease states such as:
      a. Keratoconus
      b. Corneal epithelial basement membrane dystrophy
      c. Corneal scars
      d. Ocular dermoid
      e. Terrien marginal corneal degeneration
      f. Pellucid marginal degeneration
      g. Pterygium
      h. Lacrimal gland tumors
      i. Post ocular surgery
      j. Ocular surface disease

B. List the pertinent elements of the history
   1. Symptoms, vision decreased at all distances
   2. Monocular diplopia

C. Describe pertinent clinical features
   1. Vision not correctable with standard refraction
   2. Vision is correctable with a rigid contact lens overrefraction
   3. Uncorrected visual acuity poor at all distances

D. Describe appropriate testing and evaluation for establishing the diagnosis
   1. Corneal topography showing an irregular corneal surface
   2. Gas permeable contact lens overrefraction with improvement in best corrected visual acuity
   3. Wavefront diagnostic examination showing a significant amount of higher order aberrations
      a. In spherical aberration, the incoming light rays are refracted more in the periphery than in the center of the eye
      b. In coma aberrations, the incoming light rays are refracted more on one side of the eye than the other

II. Define the risk factors
A. Trauma
B. Family history of keratoconus
C. Family history of corneal dystrophies
D. Corneal surgery
E. Post refractive surgery/refractive surgery complications

III. List the differential diagnosis

A. Other forms of decreased vision associated with other ocular pathology

IV. Describe patient management in terms of treatment and follow-up

A. Describe medical therapy options
   1. Gas permeable contact lenses are the mainstay of medical therapy
   2. Eyeglasses and soft contact lenses typically work poorly
   3. Observation is an option

B. Describe surgical therapy options
   1. Phototherapeutic keratectomy
   2. Superficial keratectomy
   3. Corneal transplant
   4. Intrastromal corneal ring segments

V. List the complications of treatment, their prevention and management

A. Eyeglasses
   1. Traumatic fracture of eyeglasses
   2. Management
      a. Use of shatter resistant materials

B. Surgical treatment
   1. Infections
   2. Persistent epithelial defects
   3. Scar
   4. Management and prevention are problem specific

C. Contact lens
   1. Infections
2. Warpage

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 3: Optics, Refraction, and Contact Lenses, 2013-2014.

2. AAO, Preferred Practice Patterns Committee, Refractive Errors Panel. Refractive Errors Preferred Practice Pattern, 2007.

Presbyopia

I. Describe the approach to establishing the diagnosis
   A. Describe the etiology of this disease
      1. Age related
         a. The accommodative amplitude of the crystalline lens gradually decreases with age
         b. While wearing correction for ametropia, this reduction ultimately impairs reading vision
         c. An emmetrope, or corrected myope, is usually affected during the 5th decade of life
         d. An uncorrected hyperope is usually affected earlier in life because of the additive accommodative effort
   B. Define the relevant aspects of epidemiology of this disease
      1. All patients develop presbyopia with age
   C. List the pertinent elements of the history
      1. Vision worse near than distance without correction in pure presbyopia or with correction in patients with concomitant myopia or hyperopia
      2. Latent hyperopia may cause symptoms of premature presbyopia
      3. Myopes corrected with spectacles may experience presbyopia symptoms later than those wearing contact lenses, especially if they slide their glasses down their noses while reading
      4. Presbyopia symptoms usually are worse when the patient is tired or has dry eyes or under-corrected astigmatism, or when the lighting is poor
   D. Describe pertinent clinical features
      1. Uncorrected visual acuity (UCVA) worse near than distance

II. Define the risk factors
   A. Age related

III. List the differential diagnosis
   A. Other forms of decreased vision associated with ocular pathology

IV. Describe patient management in terms of treatment and follow-up
   A. Describe medical therapy options
      1. Eyeglasses
         a. Typically bifocal lenses, progressive lenses or reading eyeglasses
2. Contact lenses
   a. Using monovision with one eye corrected for distance and the other for reading
   b. Bifocal

B. Describe surgical therapy options
   1. Refractive surgery with monovision correction
      a. Laser in situ keratomileusis (LASIK)
      b. Laser surface ablation
      c. Conductive keratoplasty
   2. Refractive lensectomy or cataract surgery with multifocal or accommodative IOLs
   3. Intracorneal implants (not FDA approved)

V. List the complications of treatment, their prevention and management

A. Surgical treatment
   1. Infections
   2. Scar
   3. Management and prevention are problem specific (See Excimer laser in situ keratomileusis for myopia and myopia with astigmatism and Excimer laser surface ablation for myopia and myopic astigmatism)

B. Contact lens
   1. Infections
   2. Warpage (See Ocular surface problems related to contact lenses)

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 3: Optics, Refraction, and Contact Lenses; Section 14: Refractive Surgery, 2013-2014.
2. AAO, Focal Points: Choosing the Appropriate PRK Patient, Module #9, 1998.
I. Describe the approach to establishing the diagnosis

A. Describe the etiology of this disease
   1. Progressive irregular steepening of the cornea associated with thinning and irregular astigmatism or eventual scar

B. Define the relevant aspects of epidemiology of this disease
   1. Occurs in 1:500 to 1:2000 in population
   2. Other family members may have known keratoconus or may not be aware of subclinical (forme fruste) keratoconus

C. List the pertinent elements of the history
   1. Vision decreased at all distances
   2. Monocular diplopia
   3. Typically, vision not correctable in past with eyeglasses
   4. Progressive symptoms

D. Describe pertinent clinical features
   1. Vision not correctable with standard refraction, or correctable with high cylindrical correction
   2. Uncorrected visual acuity poor at all distances
   3. Vision is correctable with a rigid contact lens overrefraction in early stages
   4. Irregular topography, typically showing inferior corneal steepening
   5. Apical scarring in advanced cases
   6. Vogt striae
   7. Scissoring on retinoscopy
   8. Iron line around the cone (Fleischer ring)
   9. Wavefront measurement would show a high amount of higher order aberrations

E. Describe appropriate testing and evaluation for establishing the diagnosis
   1. Corneal topography
      a. Videokeratoscopy
      b. Keratometry
      c. Photokeratoscopy
      d. Placido disk
   2. Gas permeable contact lens overrefraction will typically show an improvement in vision, confirming that the reduction in vision is due to an irregular cornea
3. Evaluation of higher order aberrations (wavefront examination)
4. Slit-lamp biomicroscopic examination

II. Define the risk factors
   A. Family history of keratoconus
   B. Eye rubbing
   C. Atopy

III. List the differential diagnosis
   A. Forme fruste keratoconus
      1. Topographical anomalies, typically mild inferior steepening, in a normal eye with otherwise correctable vision
   B. Pellucid and other corneal degenerations

IV. Describe patient management in terms of treatment and follow-up
   A. Describe medical therapy options
      1. Eyeglasses and soft contact lenses typically work well in early stages
      2. Gas permeable contact lenses are the mainstay of medical therapy
   B. Describe surgical therapy options
      1. Superficial keratectomy may be used to remove superficial scars that prevent contact lens wear
      2. Penetrating or lamellar keratoplasty, if contact lens wear unsuccessful
      3. Intrastromal corneal ring segments and conductive keratoplasty have also been described for surgical therapy
         a. Intrastromal corneal ring segments (Intacs®) has been approved by the FDA for contact lens intolerant patients with keratoconus, clear central corneas, corneal thickness of 450 microns or greater at proposed incision site and who have corneal transplantation as only remaining option
   C. Collagen cross-linking with riboflavin and ultraviolet A light is under U.S. Food and Drug Administration clinical trials to evaluate its safety and efficacy of for the treatment of progressive keratoconus and corneal ectasia

V. List the complications of treatment, their prevention and management
   A. Eyeglasses
      1. Traumatic fracture of eyeglasses
      2. Management
a. Use of shatter resistant materials

B. Surgical treatment
   1. Infections
   2. Scar
   3. Management and prevention are problem specific

C. Contact lens
   1. Infections
   2. Corneal scar

D. Corneal transplant
   1. Infection
   2. Glaucoma
   3. Cataract
   4. Rejection

VI. Describe disease-related complications

A. Keratoconus - hydrops
B. Progressive irregular astigmatism eventually requiring contact lenses or surgical therapy

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 4: Ophthalmic Pathology and Intraocular Tumors; Section 6: Pediatric Ophthalmology and Strabismus; Section 8: External Disease and Cornea, 2013-2014.

2. AAO, Focal Points: LASIK, Module #3, 2000, p.3.


Pellucid marginal corneal degeneration

I. Describe the approach to establishing the diagnosis

A. Describe the etiology of this disease
   1. Unknown
   2. Very likely a variant of keratoconus

B. Describe the epidemiology of this disease
   1. Uncommon disorder
   2. May be seen in patients who also have more typical changes of keratoconus or relatives of keratoconus patients
   3. Associated with allergy and atopy

C. List the pertinent elements of the history
   1. Increasing against-the-rule astigmatism
   2. Onset in the teens or later, may be seen even in elderly patients
   3. Visual acuity initially often correctable with eyeglasses until later in the disorder

D. Describe pertinent clinical features
   1. Corneal thinning and ectasia usually 1 to 2 mm central to the inferior limbus in an oval pattern from 4 to 8:00
   2. Corneal ectasia is most prominent just above the area of thinning
   3. Usually no iron ring but there may be deep stromal striae
   4. High against-the-rule astigmatism
   5. Area of involvement is clear (pellucid) without vascularization or lipid deposition and with intact epithelium

E. Describe appropriate testing and evaluation for establishing the diagnosis
   1. Keratometry confirms against-the-rule astigmatism which is often regular
   2. Corneal topography shows inferior steepening near the inferior limbus, usually in a loop-like pattern

II. Define risk factors

A. Unknown

B. Atopy/allergy

C. Eye rubbing

D. Keratoconus family history
III. List the differential diagnosis

A. Keratoconus

B. Senile furrow degeneration
   1. Usually not ectatic and is closer to and more concentric with the limbus

C. Terrien marginal corneal degeneration
   1. Often listed in the differential diagnosis but this is associated with vascularization and lipid deposition as well as, at times, inflammatory episodes

D. Mooren ulcer
   1. Often listed in the differential diagnosis but is an inflammatory ulcer, not really similar to pellucid marginal corneal degeneration

IV. Describe patient management in terms of treatment and follow-up

A. Describe medical therapy options
   1. Contact lens fitting, often with a large rigid gas-permeable lens

B. Describe surgical therapy
   1. Large eccentric penetrating keratoplasty
   2. Lamellar keratoplasty - total or crescentic
   3. Excision of stroma overlying the thinned area with oversewing of the tissue (corneal imbrication)
   4. Unstable results after photorefractive keratectomy or laser in situ keratomileusis (LASIK)

V. List the complications of treatment, their prevention and management

A. High rejection rate in large eccentric penetrating keratoplasty

VI. Describe disease-related complications

A. Decreased vision

B. Hydrops may occur

VII. Describe appropriate patient instructions

A. Avoid eye rubbing

B. Treat atopy
1. AAO, Basic and Clinical Science Course. Section 8: External Disease and Cornea, 2013-2014.
Eyeglasses

I. List the indications/contraindications
   A. Refractive errors
      1. Eyeglasses are the simplest and safest means to correct refractive errors
   B. Protection against accidental injury
      1. Individuals involved in certain sports and hazardous activities in which there is risk of eye trauma
      2. Individuals with good vision in only one eye

II. Describe the evaluation
   A. History
      1. Symptoms suggestive of a refractive error
      2. Level of visual difficulties
      3. Patient's visual needs in terms of occupation, lifestyle, and recreation
   B. Physical examination
      1. Distance visual acuity for each eye with current correction
      2. Near visual acuity
      3. Refraction for each eye
         a. Distance refraction performed with accommodation relaxed
         b. Cycloplegic refraction is indicated when:
            i. Accommodation cannot be relaxed (e.g., in children)
            ii. Patient's symptoms are not consistent with manifest refractive error
            iii. Hyperopes

III. List the alternatives
    A. Contact lenses
    B. Refractive surgery
    C. Eyeglasses should be recommended first prior to contact lenses and refractive surgery

IV. Describe considerations in prescribing and fitting eyeglasses
    A. Myopia
1. Individuals with asymptomatic myopia may not need eyeglass correction except for activities such as driving or school work

2. Overcorrection can cause excessive accommodation

3. Some patients become symptomatic at low levels of illumination and may require increased minus correction for clearer vision at night

B. Hyperopia

1. Slight undercorrection may be desired in young and middle-aged individuals, because of some physiologic accommodative tone

2. As the patient ages, full correction may be needed to provide optimal distance vision and minimize problems with near vision

C. Astigmatism

1. Individuals with regular astigmatism may not require full correction

2. Adults may not accept full cylindrical correction in their eyeglasses if their astigmatism has been only partially corrected or is at an oblique axis

3. Children usually adapt to their full cylindrical correction

4. To reduce distortion, use minus cylinder lenses and minimize vertex distance

D. Presbyopia

1. Need to accommodate is increased when patient with myopia changes from eyeglasses to contact lenses or if they have refractive surgery. The opposite is true for hyperopia

2. Bifocals
   a. Height of the segment is more critical than the width
   b. Top of the segment is generally set about 3 to 5 mm below optical center of distance lens and is usually positioned to align with level of lower limbus
   c. Modifications are needed for certain occupations or because of personal preference

3. Trifocals
   a. Consider for patients with specific intermediate-vision needs
   b. May be helpful for individuals who use computers
   c. Specific working distances allow more accurate prescribing of trifocal powers
   d. Top of the segment is set higher than that of a bifocal

4. Progressive addition lenses
   a. Can be used to increase range of vision
   b. Cosmetically well accepted
   c. Major disadvantages
      i. Peripheral distortion inherent in lens design
      ii. Smaller size of reading zone and intermediate zone compared to bifocals or trifocals

Refractive Management/Intervention © AAO 2014-2016
iii. Difficulty in properly fitting the lenses
iv. May have trouble getting used to if patient has previously used segmented design

5. Computer bifocal, top intermediate power for focal length of the computer screen and bottom for focal point of reading. The benefit is avoiding neck strain of chin up trying to read computer screen with intermediate band of progressive lens

E. Eye protection
   1. Polycarbonate lenses more impact and shatter resistant than other lens materials

V. List the difficulties and complications of eyeglass wear
   A. Incorrect prescription
   B. Base curve and location of cylinder on the front or back surface
   C. Bifocal power and segment position (height and size)
   D. Anisometropia (if large)
      1. Reduction of symptomatic aniseikonia may be accomplished by under correcting at the expense of acuity or modifying the lens base curve or lens thickness to alter relative image size
   E. Prisms or prism effects
      1. Vertical prism-induced diplopia can be found in presbyopic patients who wear bifocals
         a. Correction of small amounts of induced prism
            i. Slabbing-off the bifocal segment
            ii. Slabbing-on the bifocal segment
   F. Pantoscopic tilt
   G. Centration of lenses with respect to the pupil
   H. Vertex distance
   I. Spherical and chromatic aberrations
   J. Lens distortions, including magnification and minification
   K. Image jump and object displacement

VI. Describe the follow-up care
   A. If visual symptoms develop, evaluate the patient's eyeglasses and refraction

Additional Resources
   1. AAO, Basic and Clinical Science Course. Section 3: Optics, Refraction, and Contact Lenses, 2013-2014.


5. AAO, Preferred Practice Pattern Committee, Refractive Errors Panel. Refractive Errors Preferred Practice Pattern, 2002.

Monocular diplopia

I. Describe the approach to establishing the diagnosis

A. Definition
   1. Monocular diplopia is a visual phenomenon of image doubling or multiple images in polyopia, caused by aberrations in either the cornea or crystalline lens, dry eye and surface irregularities, or with some forms of macular edema or posterior capsular opacities

B. Describe the etiology of this disease
   1. The most common cause is regular astigmatism (lower order aberrations)
   2. Any disease that induces higher order aberrations can also cause monocular diplopia, such as
      a. Keratoconus
      b. Pellucid marginal degeneration
      c. Corneal epithelial basement membrane dystrophy
      d. Corneal scars
      e. Cataract
      f. Post-laser in situ keratomileusis (LASIK) or post-photorefractive keratectomy (PRK) conditions
         i. Irregular astigmatism
         ii. Ectasia
         iii. Small effective optical zone
         iv. Large pupils
   3. Trauma or surgery can also induce aberrations

C. List the pertinent elements of the history
   1. Symptoms
      a. Image doubling
      b. Vision decreased at all distances
   2. Monocular diplopia

D. Describe pertinent clinical features
   1. Image doubling resolves with full eyeglass correction (regular astigmatism)
   2. Image doubling not correctable with eyeglasses (higher order aberrations)
      a. Image doubling improves with rigid contact lens overrefraction

E. Describe appropriate testing and evaluation for establishing the diagnosis
   1. Corneal topography showing regular or irregular astigmatism
2. Gas permeable contact lens overrefraction
3. Wavefront diagnostic examination demonstrating significant higher order aberrations
4. Slit-lamp biomicroscopic examination

II. Define the risk factors
A. Trauma
B. Corneal surgery
C. Family history of keratoconus
D. Family history of corneal dystrophies
E. Risk factors for cataract
   1. Corticosteroids
   2. Diabetes mellitus

III. List the differential diagnosis
A. Other forms of decreased vision associated with other ocular pathology

IV. Describe patient management in terms of treatment and follow-up
A. Describe medical therapy options
   1. Gas permeable contact lenses are the mainstay of medical therapy
   2. Eyeglasses and soft contact lenses typically work poorly
B. Observation is an option
C. Describe surgical therapy options
   1. Phototherapeutic keratectomy
   2. Superficial keratectomy
   3. Corneal transplant
   4. Cataract extraction

V. List the complications of treatment, their prevention and management
A. Eyeglasses
   1. Traumatic fracture of eyeglasses
      a. Management
         i. Use of shatter resistant materials
B. Surgical treatment
1. Infections
2. Corneal problems
3. Scar
4. Management and prevention are problem specific

C. Contact lens
1. Infections
2. Corneal scar

Additional Resources
Prescribing contact lenses for refractive errors

I. List the indications/contraindications

A. Indications
   1. Patients who do not wish to wear eyeglasses
   2. Patients who have occupational needs not met by eyeglasses
   3. Patients who achieve optimal visual function only with contact lenses, which may include
      a. Patients with high refractive errors
      b. Patients with symptomatic anisometropia or aniseikonia
      c. Patients with an irregular corneal surface or shape (including corneal dystrophies and degeneration)

B. Relative contraindications
   1. Patients with significant eyelid, tear film or ocular surface abnormalities related to the following disorders
      a. Keratoconjunctivitis sicca
      b. Blepharoconjunctivitis
      c. Acne rosacea
      d. Conjunctival cicatrisation
      e. Corneal exposure
      f. Neurotrophic keratopathy
      g. Other corneal abnormalities
   2. Monocular or functionally monocular patients
   3. Patients with inflammation of the anterior segment
   4. Patients with a filtering bleb
   5. Patients in certain environmental or work settings (e.g., dust, volatile chemicals)
   6. Patients with a history of contact lens-related corneal complications
   7. Patients who are unable to understand the risks and responsibilities involved or are unable to properly care for their contact lenses
   8. Phorias requiring prism correction

II. Describe the pre-procedure/therapy evaluation
A. **History**
   1. Symptoms suggestive of a refractive error
   2. Level of visual difficulties
   3. Patient's visual needs in terms of occupation and recreation
   4. Past contact lens experience

B. **Physical examination**
   1. Distance visual acuity for each eye with current correction
   2. Near visual acuity
   3. Refraction for each eye
      a. Distance refraction performed with accommodation relaxed
      b. Cycloplegic refraction is indicated when:
         i. Accommodation cannot be relaxed
         ii. Patient's symptoms are not consistent with manifest refractive error
   4. External examination, with attention to
      a. Lid function
      b. Lid margins
      c. Meibomian glands
      d. Tear film
      e. Conjunctival surface
      f. Cornea

III. **List the alternatives to this therapy**
   A. **Eyeglasses**
   B. **Refractive surgery (corneal or lenticular)**

IV. **Describe the technique**
   A. Optimize lens fit, including lens size, lens centration and lens movement to minimize contact lens interference with normal ocular function
   B. Keratometry or corneal topography can be performed to assist in fitting process
   C. Lens type and method of wear depends on the needs of the patient
      1. Correction of spherical refractive errors
         a. Soft hydrogel lenses
         b. Rigid gas-permeable lenses
Silicone hydrogel lenses
d. If high refractive error, thicker and heavier lenses increase physiologic demands on cornea, potentially leading to hypoxia and overwear

2. Correction of low to moderate astigmatism
   a. Soft toric lenses
   b. Rigid gas-permeable lenses

3. Correction of high astigmatism
   a. Rigid gas-permeable lenses
   b. Bitoric or back surface toric design, or aspheric designs if greater corneal astigmatism
   c. Scleral lenses

4. Correction of presbyopia
   a. Soft hydrogel multifocal contact lenses
   b. Rigid gas-permeable multifocal contact lenses
   c. Monovision

V. List the complications of the procedure/therapy, their prevention and management
   A. Microbial keratitis (most serious)
      1. Bacterial
         a. Risk of ulcerative keratitis was 10-15 times greater in patients using extended wear lenses (overnight wear), compared to those using daily wear lenses
         b. Contact lenses of lower oxygen transmission more likely associated with corneal epithelial binding of Pseudomonas aeruginosa than higher oxygen transmissible lenses
         c. Disposable lenses for extended wear more often associated with gram-positive organisms than with gram-negative organisms
      2. Acanthamoeba
      3. Fungi
   B. Tarsal papillary conjunctivitis (See Ocular surface problems related to contact lenses)
   C. Bulbar conjunctival changes
   D. Epithelial keratopathy
   E. Corneal neovascularization (See Ocular surface problems related to contact lenses)
   F. Sterile (non microbial) infiltrates
   G. Marginal keratitis
   H. Corneal warpage
   I. Endothelial changes
1. Polymegathism
2. Pleomorphism
3. Reduction of endothelial cell density (rarely)

VI. Describe the follow-up care

A. History
   1. Visual problems, such as irritation, redness, itching, discharge, decreased vision or prolonged eyeglass blur
   2. Review of wear schedule and lens care regimen

B. Physical examination
   1. Visual acuity with current contact lenses
   2. Evaluation of lens fit and examine for deposits or defects
   3. External examination
      a. Possible problems of contact lens wear indicated by:
         i. Conjunctival injection
         ii. Corneal edema
         iii. Staining
         iv. Infiltrates
         v. Changes at superior limbus
         vi. Tarsal papillary conjunctivitis

C. If signs of corneal hypoxia are found, then lens fit, material or wearing time should be adjusted for improved oxygenation

D. If corneal warpage is suspected, compare keratometry or corneal topography and refraction without contact lenses to initial readings

VII. Describe appropriate patient instructions

A. Association of risks with contact lens wear
   1. Vision threatening keratitis can occur, especially with overnight use of lenses
   2. Development of Acanthamoeba keratitis has been associated with swimming with contact lenses and with homemade contact lens solution use; also a higher risk with hot tub use, with or without contact lenses

B. Remove lenses if eye becomes red, irritated or painful and seek medical care if these symptoms do not promptly resolve with lens removal or if visual acuity decreases

C. Understand and practice lens insertion and removal

D. Appropriate lens care
1. Daily wear soft lenses
   a. Use a lens cleaner daily to remove biofilm and deposits from lens surface, followed by rinsing with sterile saline or a multi-solution (cleaning, disinfectant, conditioning or storage)
   b. Disinfect lens using either a chemical, peroxide, ultraviolet or thermal system
   c. For some patients, perform periodic enzymatic cleaning
   d. Clean and replace contact lens cases frequently
   e. Discard damaged or cracked cases

2. Extended-wear soft lenses and silicone hydrogel lenses
   a. Remove overnight-wear soft hydrogel lenses at least once a week for cleaning and disinfection
   b. Discard disposable lenses for extended wear after no more than 2 weeks of wear
   c. Care for extended-wear soft and silicone hydrogel lenses same as daily wear soft lenses (see above)

3. Rigid gas-permeable lenses
   a. Surface clean and rinse lenses and store overnight in a disinfecting/conditioning solution
   b. Periodically perform enzymatic cleaning

VIII. Orthokeratology

A. Definition of orthokeratology (also referred to as corneal refractive therapy)
   1. Rigid gas permeable contact lenses used in overnight wear for temporary correction of myopia

B. Describe the mechanism of action
   1. Contact lenses apply slight pressure to center of cornea, causing flattening
   2. Causes central corneal epithelial thinning
   3. Causes midperipheral stromal thickening

C. Food and Drug Administration (FDA)-approved indications for use
   1. Temporary reduction of myopia up to 6.00 diopters (D) in nondiseased eyes with astigmatism up to 1.75 D

D. Contraindications (as described by FDA)
   1. Inflammation or infection of the eye
   2. Disease or injury of the eye or eyelids
   3. Dry eye syndrome
   4. Other medical condition that might interfere with contact lens wear

E. Advantages
   1. Provides a nonsurgical option

F. Disadvantages
1. Temporary reduction
2. Risks of infection with overnight contact lens wear

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 3: Optics, Refraction, and Contact Lenses, 2013-2014.
2. AAO, Focal Points: Contact Lens Fitting for Regular Astigmatism, Module #11, 1997.
3. AAO, Focal Points: Corneal Complications of Contact Lens, Module #2, 1993.
8. AAO, Focal Points: Pearls for Fitting Contact Lenses, Module #4, 2006.
Ocular surface problems related to contact lenses

I. Describe the approach to establishing the diagnosis

A. Describe the etiology of the disease
1. Direct mechanical trauma from contact lens
2. More common with soft contact lens wear than with rigid gas permeable contacts
3. Immune-mediated response to mechanical trauma
4. Hypersensitivity reaction, allergic reaction (i.e. thimerosal)
5. Hypoxic response with metabolic epithelial damage
6. Toxicity from contact lens solution (i.e. hydrogen peroxide, benzalkonium chloride, etc.)
7. Limbal stem cell deficiency

B. List the pertinent elements of the history
1. Redness
2. Itching, irritation, mucoid discharge
3. Pain
4. Blurred vision
5. Decreased tolerance or inability to wear contact lenses (common)
6. Contact lens decentration, bloody tears, ptosis (rarely)

C. Describe pertinent clinical features
1. Conjunctival changes
   a. Papillary reaction on the superior tarsal conjunctiva
   b. Giant papillary reaction (papillae larger than 0.3 mm) in severe cases, referred to as giant papillary conjunctivitis
   c. Conjunctival injection and mucoid conjunctival discharge
2. Corneal changes
   a. Punctate epithelial erosions on the cornea
   b. Peripheral subepithelial corneal infiltrates
   c. Corneal neovascularization (initially superiorly and then extending 360 degrees)
   d. Corneal haze
   e. Microcystic epitheliopathy- most commonly with extended-wear soft contact lenses
f. Interstitial keratitis

3. Mild iritis

II. Define the risk factors
   A. Extended contact lens wear
   B. Overnight contact lens wear
   C. Lower oxygen permeability (more common with soft contact lenses than gas permeable contact lenses)
   D. Dry eye disease

III. List the differential diagnosis
   A. Viral conjunctivitis
   B. Microbial conjunctivitis, including bacteria and chlamydia
   C. Allergic conjunctivitis/keratitis
   D. Toxic conjunctivitis
   E. Staphylococcal marginal keratitis
   F. Microbial keratitis, especially bacterial

IV. Describe patient management in terms of treatment and follow-up
   A. Describe medical therapy options
      1. Acute
         a. Stop contact lens wear
         b. Topical antibiotics (typically topical fluoroquinolone)
         c. Consider topical corticosteroids, usually low dose (if significant corneal inflammation present)
      2. Chronic
         a. Decrease contact lens wearing time
         b. Discontinue overnight wear
         c. Refit patient with a different type of contact lens (i.e., daily disposable soft contact lens or a rigid gas permeable contact lens)
         d. Improved contact lens hygiene
            i. Clean lenses with agents free of preservatives (especially thimerosal)
            ii. Use hydrogen peroxide systems for disinfection
            iii. Use enzymatic treatment regularly to remove contact lens deposits
iv. Clean contact lens cases on regular basis

e. Topical mast cell stabilizers such as cromolyn sodium four times daily in mild cases

f. Medical treatment using cyclosporine A (Restasis®)

g. Consider punctual plugs

h. Brief course of topical corticosteroids in severe cases

i. Consider refractive surgery in patients intolerant of contact lens wear

j. Follow-up in 1-6 weeks depending on severity of presentation

k. Follow-up in 3-7 days depending on severity of presentation

V. List the complications of treatment, their prevention and management

A. Complications of topical corticosteroids
   1. Glaucoma
   2. Cataracts
   3. Worsening of infection

B. Complications of topical antibiotics
   1. Allergy
   2. Resistance

C. Prevention and management
   1. Use topical corticosteroids judiciously
   2. Use corticosteroids concurrently with antibiotics
   3. Non steroidal anti-inflammatory drugs (NSAIDs) and mast cell stabilizers can be helpful

VI. Describe disease-related complications

A. Microbial keratitis
B. Loss of vision
C. Corneal scarring
D. Contact lens intolerance

VII. Describe appropriate patient instructions

A. Emphasize importance of compliance with therapy and follow-up
   1. Follow-up in 3-7 days depending on severity of presentation

B. Patients should be counseled to call if increasing pain develops or the vision changes
C. Importance of proper contact lens hygiene should be stressed

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 8: External Disease and Cornea, 2013-2014.
2. AAO, Focal Points: Corneal Complications of Contact Lens, Module #2, 1993.
3. AAO, Focal Points: Pearls for Fitting Contact Lenses, Module #4, 2006.
Monovision for correction of presbyopia

I. Describe the approach to establishing the diagnosis
   A. Describe the etiology of this disease
      1. Age-related
      2. Post lenticular surgery
      3. Associated with certain centrally acting medications
   B. Define the relevant aspects of epidemiology of this disease
      1. All patients develop presbyopia with age
   C. List the pertinent elements of the history
      1. Vision worse near than distance without correction in pure presbyopia or with correction in patients
         with concomitant myopia or hyperopia
   D. Describe pertinent clinical features
      1. Uncorrected visual acuity (UCVA) worse near than distance, distance and near refraction

II. Define the risk factors
   A. Presbyopia is age related
   B. Lenticular surgery
   C. Centrally acting medications

III. List the differential diagnosis
   A. Other forms of decreased vision associated with pathologic or pharmacologic conditions

IV. Describe patient management in terms of treatment and follow-up
   A. Describe medical therapy options
      1. Contact lenses for various degrees of imbalance between the eyes
      2. Can try eyeglasses with various degrees of imbalance between the eye as a first step before
         contact lens use or surgical management
   B. Describe surgical therapy options
      1. Refractive surgery options can also induce or under correct myopia to reduce presbyopic
         symptoms
      2. Laser in situ keratomileusis, (LASIK)
      3. Laser surface ablation
4. Refractive lensectomy
5. Conductive keratoplasty
6. Laser thermal keratoplasty

C. Consider dominance and tolerance for monovision
D. Consider occupation and/or other specific visual requirements
E. Patients with prior strabismus with a very strong fixation preference may be unable to switch fixation preference to the monovision eye

V. Describe appropriate patient instructions

A. Describe the pros and cons of monovision
   1. Intolerance
   2. Possible decreased depth perception, but improved function at both distance and near compared to distance only or near only vision correction
   3. Night driving symptoms (halo, glare) may occur from uncorrected myopia in the near vision eye. Night driving spectacles may be prescribed

B. Variable degrees of monovision, e.g., 1.0 diopter (D), 1.5D, 2.0D, etc.

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 3: Optics, Refraction, and Contact Lenses, 2013-2014.
2. AAO, Preferred Practice Patterns Committee, Refractive Errors Panel. Refractive Errors Preferred Practice Pattern, 2007.
3. AAO, Focal Points: Pearls for Fitting Contact Lenses, Module #4, 2006.
I. List the indications/contraindications

A. Indications
   1. Therapeutic
      a. Relieve pain
      b. Promote epithelial healing
      c. Act as a splint in the treatment of lacerations, perforations and ulcerations
      d. Protect the cornea from mechanical damage secondary to abnormalities of the eyelid
      e. Improve visual acuity by correcting irregular corneal surface

   2. Clinical
      a. Corneal edema
      b. Persistent epithelial defects
      c. Corneal ulcerations or small perforations
      d. Recurrent corneal erosions
      e. Filamentary keratitis
      f. Keratitis sicca
      g. Neurologic conditions leading to exposure
      h. Irregular corneal surfaces secondary to anterior corneal dystrophies
      i. Corneal scars or opacities
      j. Cosmetic tinted and painted lenses
      k. Postsurgical

B. Relative contraindications
   1. Ocular surface abnormalities
      a. Severe dry eye
      b. Stevens-Johnson syndrome
      c. Ocular mucous membrane pemphigoid
   2. Anatomical considerations leading to an inability to place or center a contact lens
   3. Poor patient compliance
   4. Acute microbial keratitis
II. Describe the pre-therapy evaluation
A. Complete comprehensive eye examination
B. Determination of etiology of corneal pathology
C. Fluorescein/rose bengal staining when appropriate
D. Evaluation of contact lens fit

III. List the alternatives to this therapy
A. Non-surgical
   1. Patching
   2. Lubrication
   3. Autologous serum
   4. Botulinum toxin induced temporary ptosis
B. Surgical
   1. Tarsorrhaphy
   2. Amniotic membrane
   3. Gunderson conjunctival flap
   4. Excimer PTK

IV. List the complications of the therapy, their prevention and management
A. Infection (prophylactic antibiotics often prescribed)
B. Decentration
C. Loss of contact lens

V. Describe the follow-up care
A. The patient seen at slit-lamp biomicroscope within the first 24-48 hours after placement
B. Seen at slit-lamp biomicroscope thereafter on a 1 to 2-week basis
C. Prophylactic antibiotics
D. Proper lens lubrication with preservative-free artificial tear drops and ointments
E. Lens replacement schedule

VI. Describe appropriate patient instructions
A. Therapeutic modality with possible complications
B. If lens dislodges from eye, do not attempt to replace
C. If lens decenters, seek proper care
D. Use medications as directed
E. Lens replacements on a regular basis
F. Persistent or new onset ocular pain, seek reassessment

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 3: Optics, Refraction, and Contact Lenses; Section 8: External Disease and Cornea, 2013-2014.
6. AAO, Focal Points: Pearls for Fitting Contact Lenses, Module #4, 2006.
Radial keratotomy

I. List the indications
   A. Radial keratotomy was the first widely applied refractive procedure in the US
      1. Indications were to treat low levels of myopia with or without astigmatism
      2. With the advent of excimer laser procedures, radial keratotomy fell out of favor and is now seldom performed

II. List the alternatives to this procedure
   A. Laser in situ keratomileusis
   B. Laser surface ablation
   C. Intrastromal ring segments
   D. Phakic intraocular lenses and lens-based surgery
   E. Reverse CLAPIKS (Contact Lens Assisted Pharmacologically Induced Kerato Steepening)

III. Describe the instrumentation and technique
   A. The procedure involved making a series of deep radial incisions into the cornea with a guarded diamond blade
   B. The refractive correction was titrated by the number of incisions, typically 4, 6, 8, or 16, and the diameter of the central clear zone
   C. Astigmatism was corrected by transverse or arcuate incisions

IV. List the complications of this procedure, their prevention and management
   A. Loss of best corrected visual acuity
   B. Bacterial keratitis
   C. Endophthalmitis
   D. Anterior chamber perforation
   E. Traumatic rupture of the globe
   F. Instability of refraction
      1. Diurnal fluctuation
      2. Progressive hyperopia
      3. Acute hyperopic shift in hypoxic conditions (high altitudes)
   G. Irregular astigmatism, associated with
1. Central clear zone less than 3.0mm
2. More than 8 incisions
3. Intersecting incisions

Additional Resources

I. List the indications/contraindications

A. Definition: astigmatic keratotomy (AK) is a procedure where transverse or arcuate incisions are made in the paracentral cornea to change its curvature thereby reducing or eliminating corneal astigmatism. AK incisions may be either transverse or arcuate in shape. The incision flattens the corneal meridian in which it is made and steepens the meridian 90° away.

B. Indications

1. Myopia with astigmatism
2. Hyperopic astigmatism
3. Astigmatism greater than or equal to 1.0 diopter (D)
4. Astigmatism after ocular surgery
   a. Cataract surgery
   b. Corneal trauma repair
   c. Retinal detachment repair
   d. Keratoplasty
   e. Refractive surgery
5. Adequate corneal thickness

C. Contraindications

1. Corneal ectasias (keratoconus)
2. Astigmatism less than 1.0 D
3. Significant ocular surface abnormalities
   a. Severe dry eye
   b. Uncontrolled blepharitis
   c. Autoimmune disease
   d. Collagen vascular disease
   e. Connective tissue disease
4. Irregular astigmatism (relative)

II. Describe the pre-procedure evaluation

A. Complete eye examination
B. Cycloplegic refraction when accommodation is still present
C. Corneal topography
D. Keratometry
E. Pachymetry
F. Tear film assessment
G. Informed consent

III. List the alternatives to this procedure

A. Nonsurgical
   1. Eyeglasses
   2. Toric soft contact lenses
   3. Gas permeable contact lenses - spherical or toric

B. Surgical
   1. Toric pseudophakic IOL (including piggyback)
   2. Toric phakic IOL (not FDA approved)
   3. Toric LASIK or surface ablation
   4. Limbal relaxing incisions

IV. Describe the instrumentation, anesthesia and technique

A. Instrumentation
   1. Keratometer and/or corneal topographer
   2. Corneal pachymeter
   3. AK blade or femtosecond laser
   4. Axis marker
   5. Arcuate incision guide
   6. Marking pen to mark axis
   7. Micrometer

B. Anesthesia
   1. Topical tetracaine or proparacaine

C. Technique
   1. In seated position, the 180° meridian is marked with marking pen
   2. The patient is then prepped with Betadine solution
   3. Surgical sterile technique is utilized with surgical drape and gloves
   4. Lid speculum is inserted
   5. Proper axis and length of incision marked
6. Diamond blade set to 90% depth (central corneal thickness +50 microns often used) or femtosecond laser programmed

7. Arcuate incisions typically made 180° apart
   a. Incisions usually maintain an optical zone between 6 and 7 mm

8. Eye is patched or a bandage contact lens is applied for 12-24 hours over topical antibiotic

V. List the complications of the procedure, their prevention and management

A. Complications
   1. Anterior chamber perforation
   2. Regression or progression of effect
   3. Wound gape or dehiscence
   4. Infectious keratitis
   5. Irregular astigmatism
   6. Fibrous scarring
   7. Surgery performed at wrong axis

B. Prevention of complications
   1. Stay as far away from optical zone as possible
   2. Incisions never to exceed 90%
   3. Blade depth set with micrometer
   4. Avoid crossing radial incisions, when present
   5. Follow site and patient verification protocol
   6. Topographic map oriented to surgeon's view in OR

VI. Describe the follow-up care

A. The patient is seen for slit-lamp biomicroscopic examination in 24-48 hours followed by one week and then 3 months

B. Patient instructions for use of topical antibiotic until incisions reepithelialized

C. Visual rehabilitation takes 1-4 weeks

D. Driving restricted until light sensitivity reduces and visual acuity improves

Additional Resources

2. Faktorovich EG, Maloney RK, Price FW Jr. Effect of astigmatic keratotomy on spherical


Limbal relaxing incisions for astigmatism

I. List the indications/contraindications
   A. Definition: limbal relaxing incisions are similar to astigmatic keratotomy. The incisions are placed at the vascular limbal arcade in the hemi-meridians of steepest astigmatic power
   B. Indications
      1. Regular astigmatism up to 2.0 diopters (D)
         a. More central placement results in greater effect
      2. Normal limbal architecture
      3. Normal corneal thickness
      4. Combined with cataract surgery and intraocular lens (IOL) implantation to reduce corneal astigmatism
      5. Other, similar to astigmatic keratotomy (AK)
   C. Contraindications
      1. Similar to AK
      2. Limbal thinning disorders
         a. Keratoconus and pellucid marginal degeneration
         b. Terrien pellucid marginal thinning
         c. Rheumatoid arthritis melts
         d. Mooren ulcer

II. Describe the pre-procedure evaluation
   A. Complete comprehensive eye examination
   B. Tear film assessment
   C. Corneal pachymetry
   D. Keratometry
   E. Corneal topography

III. List the alternatives to the procedure
   A. Nonsurgical
      1. Eyeglasses or contact lenses
   B. Surgical
      1. Laser surface ablation
2. Laser in situ keratomileusis (LASIK)
3. Toric IOL’s: phakic (not FDA approved) and pseudophakic, including piggyback

IV. Describe the instrumentation, anesthesia and technique

A. Instrumentation (similar to AK)

B. Anesthesia
   1. Topical tetracaine or proparacaine

C. Technique
   1. Cornea marked while patient in sitting position at 180° meridian
   2. Hemi-meridians of the steepest astigmatic power identified and marked
   3. Corneal pachymetry measurements taken
   4. Guarded diamond blade set (about 600 microns
      a. Many base depth on central pachymetry plus additional factors such as patient age
   5. Incisions made near the vascular limbus
   6. Incision can be 45 degrees up to a maximum of 90 degrees

V. List the complications of the procedure, their prevention and management

A. Overcorrection
B. Undercorrection
C. Perforation
D. Infection
E. Surgery performed at the wrong axis

VI. Describe the follow-up care

A. Similar to AK

VII. Describe appropriate patient instructions

A. Similar to AK

Additional Resources

Epikeratophakia

I. List the indications
   A. Epikeratophakia was originally intended to treat aphakic patients unable to wear contact lenses
      1. Clinical trials were later expanded to include the treatment of hyperopia and myopia
   B. Epikeratophakia was also used to treat keratoconus as an alternative to penetrating keratoplasty (corneal transplant). This became the most common indication for epikeratophakia
   C. The introduction of safe and effective intraocular lenses (IOL), poor clinical results in epikeratophakia patients, and emergence of more effective refractive procedures led to a major decline in the popularity of the procedure
      1. Use of epikeratophakia is rare and is limited to centers which can harvest and lathe the donor lenticule

II. List the alternatives to this procedure
   A. Lamellar graft
   B. LASIK
   C. Laser surface ablation
   D. IOL (phakic and pseudophakic)
   E. Automated lamellar keratoplasty (currently out of favor)

III. Describe the instrumentation and technique
   A. A pre-shaped lenticule of human donor corneal tissue is sutured directly onto Bowman layer of the host cornea

IV. List the complications of this procedure, their prevention and management
   A. Delayed re-epithelialization
   B. Loss of best corrected visual acuity
   C. Irregular astigmatism
   D. Infection
   E. Scarring
   F. Graft dehiscence
   G. Graft failure

Additional Resources
Intrastromal corneal ring segments

I. List the indications

A. Intrastromal corneal ring segments are Food and Drug Administration (FDA) approved for the treatment of low levels of myopia (-1.00 to -3.00 diopter (D) spherical equivalent) Additional selection criteria are for patients:
   1. 21 years of age or older
   2. Documented stability of refraction as demonstrated by a change of less than or equal to 0.50D for at least 12 months prior to the preoperative examination
   3. Astigmatism of 1.0D or less

B. Intrastromal corneal ring segments are FDA approved under humanitarian device exemption program for a specific subset of keratoconus patients who meet the following criteria:
   1. Experienced progressive deterioration of their vision and can no longer achieve adequate functioning vision with contact lenses or eyeglasses
   2. 21 years of age or older
   3. Clear central corneas
   4. Corneal thickness of 450 microns or greater at proposed incision site
   5. Have corneal transplantation as only remaining option to improve their functional vision

C. Other promising uses
   1. Ectasia after laser in situ keratomileusis (LASIK)

II. List the surgical alternatives to this procedure

A. LASIK
B. Laser surface ablation
C. Penetrating keratoplasty

III. Describe the instrumentation and technique

A. The procedure involves the creation of a semi-circular lamellar channel or channels at approximately 2/3 stromal depth with a specialized mechanical dissector device or a femtosecond laser
B. This is followed by the insertion of the plastic ring segments.
C. The refractive correction is titrated by the thickness of the ring segment.

IV. List the complications of this procedure, their prevention and management
A. Loss of best corrected visual acuity
B. Intrastromal inflammation
C. Epithelial ingrowth
D. Tunnel deposits
E. Infection and infiltrates
F. Corneal thinning
G. Decentered segment placement
H. Anterior chamber perforation
I. Implant expulsion
J. Shallow ring placement
K. Reduced corneal sensitivity
L. Induced astigmatism
M. Visual disturbance from decentered rings or large pupils
N. Corneal erosion

Additional Resources

Excimer laser surface ablation for myopia and myopic astigmatism

I. List the indications/contraindications

A. Definition: in photo refractive keratectomy (PRK) for myopic astigmatism, spheroelliptical ablation is performed in the corneal stroma after the epithelium is removed and discarded, to correct spherical and astigmatic refractive error. The elliptical ablation is performed either sequentially or simultaneously with the spherical ablation. LASEK (laser subepithelial keratomileusis) and epi-LASIK are subtypes of surface ablation that attempt to preserve an epithelial flap.

B. Indications
1. Refractive error treatable by the excimer laser
2. Normal eye examination
3. Normal corneal topography
4. Good general health
5. Greater than 18 years of age (relative)
6. Realistic expectations

C. Contraindications
1. Unstable refraction
2. Abnormal corneal topography
3. Corneal warpage/irregular astigmatism
4. Insufficient corneal thickness
5. Corneal abnormalities
   a. Keratoconus (or form fruste keratoconus on topography)
   b. Other ectasias
      i. Pellucid marginal degeneration
   c. Edema
   d. Scarring
   e. Extensive vascularization
6. Less than 18 years of age (relative)
7. Abnormal eye exam
   a. Severe dry eye
   b. Cataract
c. Uncontrolled glaucoma

d. Uncontrolled connective tissue or autoimmune disease

8. Abnormal medical exam

a. Uncontrolled diabetes mellitus

b. Pregnancy

c. Uncontrolled connective tissue disease

9. Unrealistic patient expectations

D. **Relative contraindications**

1. Blepharitis

2. Atopy/allergy

3. Previous eye surgery

4. Amblyopia (best corrected visual acuity 20/40 or less in an amblyopic eye)

5. Monocular patient

6. Abnormal medical exam

   a. Connective tissue disease (controlled)

      i. Systemic lupus erythematosus (SLE)

      ii. Rheumatoid arthritis

      iii. Immunocompromised patients

         i) Human immunodeficiency virus (HIV) positive

         ii) Systemic immunosuppression medication

7. Pupil diameter in dim illumination greater than available ablation diameter

8. Overly steep or flat corneas (< 38.0; >48.0 diopters)

9. History of ocular herpes simplex virus (HSV) or varicella zoster virus (VZV) keratitis

II. **Describe the pre-procedure evaluation**

A. **Comprehensive medical eye examination that includes**

1. Vision with and without correction

2. Cycloplegic refraction for individuals expected to have accommodation

   a. Patients using contact lenses

      i. Soft lenses

         i) Discontinue at least 1 week prior to measurement

      ii. Rigid lenses
i) Discontinue for at least 3 weeks prior to measurement

iii. Keratometric and topography measurements need to stabilize

3. Measurement of pupil size in low-light conditions
4. Keratometry
5. Computerized corneal topography and tomography (scanning slit and Scheimpflug)
6. Wavefront assessment
7. Corneal pachymetry
8. Proper informed consent
9. Dry eye examination

III. List the alternatives to this procedure

A. Nonsurgical
   1. Eyeglasses
   2. Traditional contact lenses
   3. Specialty contact lenses
      a. Toric
      b. Bifocal
      c. Hybrid
      d. Orthokeratology (corneal refractive therapy)

B. Surgical
   1. Laser in situ keratomileusis (LASIK)
   2. Refractive lensectomy with/without IOL replacement
   3. Intrastromal corneal ring segments
   4. Phakic IOL
   5. Piggyback IOL

IV. Describe the instrumentation, anesthesia and technique

A. Surgical technique
   1. Preoperative
      a. Topical antibiotic or antiseptic
      b. Topical anesthetic such as tetracaine or proparacaine
      c. Maintenance of clean/sterile environment
i. Betadine scrub
ii. Sterile instruments

d. Preoperative check list
   i. Confirm identity of patient
   ii. Confirm operative eye
   iii. Confirm parameters are correctly entered into laser's computer
   iv. In surface ablation for myopic astigmatism, axis alignment is crucial
      i) To account for cyclotorsion, the horizontal axis should be marked with the patient in the seated position
      ii) Proper alignment intraoperatively of the axis marks with the laser alignment system
      iii) Position the head to ensure that the facial plane is at 90° to the laser beam

2. Stromal exposure methods
   a. PRK: Epithelium removed and discarded
      i. Chemical assistance sometimes used (alcohol)
      ii. Mechanical (brush, blade)
      iii. Laser removal
   b. LASEK: Epithelium removed and replaced
      i. Chemical assistance (alcohol)
      ii. Mechanical instruments to preserve epithelial flap
   c. Epi-LASIK: Epithelium removed and replaced
      i. Mechanical epithelial keratome attempts to cleave epithelial basement membrane/Bowman plane
   d. Excimer laser surface ablation
      i. Centered over entrance pupil
      ii. Maintain proper head position
         i) Facial/corneal planes parallel to the floor
         ii) Orthogonal to the laser beam
      iii. Laser activated
   e. Mitomycin C often used on stromal bed after ablation to reduce risk of haze

B. Postablation
   1. Topical antibiotic and corticosteroid/nonsteroidal anti-inflammatory drug (NSAID) used
   2. Bandage contact lens placed
V. List the complications of the procedure, their prevention and management

A. Optical complications
   1. Under correction/over correction/induced astigmatism
   2. Regression/progression of effect
   3. Loss of best eyeglass corrected visual acuity
   4. Visual aberrations
      a. Glare
      b. Star bursts
      c. Halos
   5. Decreased contrast sensitivity
   6. Premature presbyopic symptoms if overcorrected

B. Medical/surgical complications
   1. Corneal perforation
   2. Corneal melt
   3. Decentered ablations
   4. Central islands
   5. Corneal haze or scarring
   6. Corneal infiltrates and ulcers
   7. Progressive corneal steepening (keratectasia)
   8. Development or worsening of dry eye symptoms
   9. Decreased corneal sensitivity
   10. Reactivation of HSV keratitis
   11. Ptosis
   12. Recurrent erosions
   13. Undercorrection or overcorrection of astigmatism in PRK for myopic astigmatism
      a. Surgery performed at an incorrect axis
      b. Failure to account for cyclotorsion

C. Comparative studies of PRK, LASEK and epi-LASIK have not revealed any significant advantages to replacing the epithelium in terms of postoperative pain, risk of haze, or speed of visual recovery. Sloughing of non-viable epithelial flaps may delay healing and visual recovery.

VI. Describe the follow-up care
A. Slit-lamp biomicroscopic examination recommended on postop day #1 and every 2-3 days thereafter until the epithelium heals

B. Bandage contact lens to be discontinued once re-epithelization has occurred

C. Postoperative medications
   1. Antibiotics
   2. Corticosteroids
   3. NSAIDs
   4. Oral vitamin C sometimes recommended for reduced risk of haze

D. Follow-up visits
   1. Maintain until stable vision and refraction obtained
   2. Check for corticosteroid-related elevation of intraocular pressure
   3. Review appropriate patient instructions
   4. Visual expectations
      a. Vision may not improve for several weeks following surgery while epithelium is healing
   5. Postoperative pain
      a. Oral analgesics are usually used to aid discomfort
   6. Counsel regarding proper use of topical eye medications
      a. Antibiotics to avoid infection
      b. Corticosteroids to prevent haze formation
      c. NSAIDs to be used short term to decrease pain
   7. Emphasize need for maintenance of postoperative visits

Additional Resources

2. AAO, Focal Points: Choosing the Appropriate PRK Patient, Module #9, 1998.


Excimer laser in situ keratomileusis for myopia and myopia with astigmatism

I. List the indications/contraindications

A. Indications
   1. Laser in situ keratomileusis (LASIK) utilizes an excimer laser for the treatment of mild, moderate or high myopia, myopic astigmatism, hyperopia, hyperopic astigmatism, and mixed astigmatism beneath a lamellar corneal flap
   2. Similar to indications for laser surface ablation (See Excimer laser surface ablation for myopia and myopic astigmatism)

B. Contraindications
   1. Less than 18 years of age (relative)
   2. Unstable refraction
   3. Corneal abnormalities (similar to photorefractive keratectomy (PRK))
   4. Abnormal corneal topography
   5. Insufficient corneal thickness for proposed ablation depth
   6. Irregular astigmatism secondary to corneal warpage
   7. Ocular abnormalities
      a. Cataract
      b. Severe glaucoma
      c. Uncontrolled external disease (blepharitis, dry eye syndrome)
      d. Uncontrolled connective tissue or autoimmune disease
      e. Corneal epithelial basement membrane dystrophy, including recurrent erosion syndrome
      f. Orbital lid or ocular anatomy that does not allow proper placement and function of the microkeratome or femtosecond laser suction interface
      g. Unrealistic patient expectations

C. Relative contraindications
   1. Overly steep (>48D) or flat (<38D) corneas
   2. Corneal dystrophies
   3. History of corneal herpes simplex virus (HSV) or varicella zoster virus (VZV) keratitis
   4. Dry eye syndrome
   5. Poorly controlled diabetes mellitus
6. Pregnancy or lactation
7. Connective tissue or autoimmune diseases
8. Functional monocularity
9. Significant risk for occupational or recreational trauma

II. Describe pre-procedure evaluation
   A. Comprehensive medical eye evaluation
   B. Visual acuity with and without correction
      1. Computerized corneal topography and corneal tomography (scanning slit and Scheimpflug)
   C. Measurement of pupil size in low light conditions
   D. Corneal pachymetry
   E. Cycloplegic refraction
   F. In contact lens patients
      1. Soft lenses
         a. Discontinue at least 1 week prior (topography stable)
      2. Rigid lenses
         a. Discontinue at least 3 weeks prior (topography stable)
      3. 3. Keratometric and topography measurements need to stabilize
   G. Calculation of thinnest residual stromal bed
      1. Must be greater than 250 microns

III. List the alternatives to this procedure
   A. Nonsurgical
      1. Eyeglasses
      2. Contact lenses
         a. Soft
         b. Toric gas-permeable
         c. Hybrid types
         d. Orthokeratology (corneal refractive therapy)
   B. Surgical
      1. Laser surface ablation
      2. Refractive lensectomy
      3. Intrastromal corneal ring segments
4. Phakic IOL
5. Piggyback IOL

IV. Describe the instrumentation, anesthesia and technique

A. Instrumentation
   1. Microkeratome or Femtosecond Laser
   2. Excimer laser

B. Anesthesia
   1. Topical tetracaine or proparacaine

C. Technique
   1. Maintenance of clean environment (See Excimer laser surface ablation for myopia and myopic astigmatism)
   2. Microkeratome
      a. Check carefully prior to procedure
         i. For blade placement and movement
         ii. Proper depth plate selected and secured
         iii. Smooth transition across gear track
         iv. Check vacuum
         v. Femtosecond laser is an alternative to mechanical microkeratome
   3. Excimer laser
      a. Check patient's name
      b. Proper eye
      c. Appropriate measurements input into the laser
      d. Laser beam energy profile evaluated throughout the surgical day
      e. Close attention to preoperative marking of astigmatic axis
      f. Careful attention to proper axis alignment of laser to the patient's eye

V. List the complications of the procedure, their prevention and management

A. Flap complications
   1. Partial incomplete flaps
   2. Decentered flap
   3. Free flap requiring possible suturing
4. Buttonhole flap

5. Vertical gas breakthrough (femtosecond laser)

B. Optical side effects and complications (See Excimer laser surface ablation for myopia and myopic astigmatism)

C. Medical complications (See Excimer laser surface ablation for myopia and myopic astigmatism)

D. Additional LASIK complications

1. Micro striae and folds - typically asymptomatic

2. Macrostriae and folds - require intervention.

3. Post-LASIK epitheliopathy
   a. Secondary to aqueous tear deficiency
   b. Neurotrophic changes secondary to severing of corneal nerves

4. Interface complications
   a. Epithelial ingrowth
      i. May require lifting of flap, debridement, and irrigation of the interface
      ii. If that fails, may require flap sutures or fibrin glue
   b. Diffuse lamellar keratitis (DLK) (Sands of the Sahara)
      i. Noninfectious aggregation of inflammatory cells in the interface "stages 1-4"
      ii. Treated with topical corticosteroids
      iii. May require elevation of the flap plus irrigation

5. Postoperative infection
   a. May require scrapings for culture
   b. Intensive broad spectrum antibiotics utilized

6. Late flap complications
   a. Traumatic dislodged flap
   b. Late DLK
   c. Increased intraocular pressure (IOP) masked by fluid in the flap interface (Interface Fluid Syndrome)
   d. Epithelial defects

VI. Describe the follow-up care

A. Postoperative topical medications

1. Antibiotics

2. Short term use of corticosteroids
3. Routine ophthalmic follow-up  (See Excimer laser surface ablation for myopia and myopic astigmatism)

VII. Describe appropriate patient instructions

A. Postoperative care

1. Vision usually returns within the first week
2. Minimal postoperative discomfort
3. No eye rubbing for several weeks
4. No eye makeup for one week
5. Avoid hot tubs and swimming pools for 2 weeks

Additional Resources


Intraocular refractive surgery

I. Comparison with other types of refractive surgery

A. Advantages
   1. Avoids inherent limitations in corneal refractive surgery
      a. Flap issues
      b. Haze
      c. Ectasia
      d. Laser centration
      e. Appropriate laser application
      f. Irreversibility

B. Disadvantages
   1. Potential infection including endophthalmitis
   2. Potential for intraocular complications such as pupillary block, cataract, pigment dispersion and endothelial trauma
   3. Increased need for sterile technique
   4. Generally are required to be performed in a surgery center as opposed to an office setting

II. Phakic intraocular lenses (IOLs)

A. Food and Drug Administration (FDA) approval
   1. Many are under various stages of FDA approval

B. Fixation methods
   1. Iris fixated
   2. Angle-supported
   3. Posterior chamber angle supported

C. Long-term safety issues
   1. Vary depending upon the IOL type
   2. Make future cataract surgery somewhat more complicated
      a. The IOL needs to be removed prior to cataract surgery
      b. Prediction of pseudophakic IOL power is more complex

D. Anterior chamber IOLs
   1. Iris fixated IOLs
Complications

i. Inflammation/iritis

ii. Pseudo-pigment dispersion

iii. Polycoria

iv. Hyphema

v. Incorrect power

vi. Cataract

vii. Glaucoma

viii. Endothelial cell loss

b. These can be polymethylmethacrylate or silicone and are usually well-tolerated

2. Angle-supported anterior chamber IOLs

a. Complications

i. Same as Iris fixated IOLs

ii. Pupil distortion

iii. Rotation

b. Some are two-piece and are assembled inside the eye

c. Others are soft and can be injected (e.g., a collagen polymer) allowing small incision surgery

3. Require a peripheral iridotomy prior to or at the time of surgical implantation

E. Posterior chamber IOLs

1. Usually are soft and can be injected through a relatively small incision, and carefully placed in the posterior chamber

2. Generally vault anterior to the anterior lens capsule, but behind the iris

3. Complications

a. Anterior subcapsular cataract

b. Pigment dispersion

c. Incorrect IOL power

d. Angle-closure glaucoma

e. Traumatic dislocation of the phakic IOL

f. Endothelial cell loss

g. Inflammation/iritis

h. Hyphema

i. Spontaneous posterior dislocation into vitreous
III. Refractive lensectomy / refractive lens exchange

A. Concept of surgery
   1. Removing the natural lens due to incorrect refractive power, and replacing it with a more appropriate lens strength to allow good uncorrected distance or near acuity
   2. This is essentially modern-day cataract surgery (without the cataract)

B. Advantages
   1. Well-known technique/skill
   2. Low complication rate that most cataract surgeons enjoy

C. Disadvantages
   1. Same as with cataract surgery
      a. Loss of accommodation
      b. Potential complications with the IOL (decentration, incorrect IOL power, etc.)
      c. Posterior capsular opacification
      d. Increased risk for retinal detachment
      e. Night time visual symptoms and loss of contrast more common with multifocal lenses
      f. Cystoid macular edema (CME)

D. Newer-style IOLs may allow a certain degree of accommodation by utilizing hinged haptics, which allow some movement of the optic

E. Pseudoaccommodation is also achievable through the use of various styles of multifocal IOLs

F. Because of the increased visual expectations of patients having elective refractive surgery (as opposed to conventional cataract surgery), an even higher degree of accuracy is needed in predicting outcomes with surgery

G. Refractive outcomes should be monitored, and more accurate immersion a-scan or partial coherence interferometry measurements are recommended, using modern IOL calculation formulas

H. To minimize the duration of anisometropia symptoms, the time interval between left and right eyes should be limited

I. Because this is essentially the same procedure as cataract surgery, and lens opacities occur in a gradient from clear to densely opaque, the issue of when refractive lensectomy becomes cataract surgery must be addressed
   1. Should a patient with an early cataract with 20/20- acuity and some minimal cataract symptoms be scheduled for cataract removal, which is generally covered by most insurance policies, or refractive lensectomy, which is generally elective in nature?

Refractive surgery options for hyperopia

I. Excimer laser for hyperopia

A. The excimer laser is used to steepen the central cornea. Hyperopic ablation profile is a peripheral annular ablation around the central optic zone that results in steepening of the central cornea relative to the periphery. The procedure can be performed on the corneal surface (laser surface ablation) or beneath a flap (laser in situ keratomileusis (LASIK)). It may be combined with astigmatic correction.

B. List the indications/contraindications

1. Indications (similar to surface ablation and LASIK sections)
   a. Additionally, hyperopia up to 6 diopters (D) of correction

1. Contraindications (similar to surface ablation and LASIK sections)
   b. Additionally, corneal neovascularization is more likely to interfere with hyperopic ablation because larger flaps are required

C. Describe the preoperative evaluation

1. (See Excimer laser surface ablation for myopia and myopic astigmatism, and Excimer laser in situ keratomileusis for myopia and myopia with astigmatism)

II. Conductive keratoplasty

A. Contact technique delivery of radiofrequency energy

B. Indications

1. FDA approved for patients age 40 years or older for the reduction of 0.75D to 3.25D of hyperopia with ≤ 0.75D of astigmatism

2. FDA approved to recover near vision in the presbyopic patient

C. Contraindications

1. Similar to holmium laser thermokeratoplasty

III. Refractive lensectomy with intraocular lens (IOL)

A. Used for moderate to high degrees of hyperopia

IV. Phakic IOL (See Intraocular refractive surgery)

V. Describe the instrumentation and technique

A. Instrumentation and technique
1. **Excimer laser**
   a. Similar to laser surface ablation

2. **Conductive keratoplasty**
   a. The cornea is marked with a circular corneal marker with a diameter of 6, 7 or 8 mm
   b. A thin insulated tip is used to deliver radiofrequency energy to the peripheral cornea
   c. The number of spots and distance from the center of the pupil determine the amount of correction
   d. Care must be taken to apply the probe perpendicular to the cornea to avoid inducing astigmatism (regular/irregular)

**B. Anesthesia (similar to PRK/LASIK)**

**VI. List the complications of this procedure, their prevention and management**

**A. Excimer laser**

1. Similar to laser surface ablation

2. Additional complications
   a. Regression more common than treatment of myopia
   b. Steepening the cornea to keratometry readings greater than 50 diopters may interfere with best eyeglass-corrected visual acuity
   c. Induction of aberrations

**B. Conductive keratoplasty**

1. Initial overcorrection

2. Regression of effect

3. Induced astigmatism

4. Postoperative discomfort

5. Enhancements common

**VII. Describe the follow up care**

**A. Excimer laser**

1. Similar to LASIK and laser surface ablation

**B. Thermokeratoplasty and conductive keratoplasty**

1. Topical medicines
   a. Topical antibiotics
   b. Nonsteroidal anti-inflammatory drugs (NSAIDs)
c. Artificial tears

2. Under response, treated with additional spots

VIII. List the alternatives to this procedure

A. Eyeglasses
B. Contact lenses
C. Piggyback IOLs

Additional Resources


2. AAO, Preferred Practice Patterns Committee, Refractive Errors Panel. Refractive Errors and Refractive Surgery Preferred Practice Pattern, 2007.


Preoperative evaluation for refractive surgery

I. Patient expectations/reasons for refractive surgery

A. The informed consent process should confirm understanding of the following:

1. Refractive surgery procedures cannot promise perfect vision under all circumstances for all tasks
   a. Residual refractive error might necessitate correction for certain tasks (e.g. driving at night)
2. Keratorefractive surgery will not restore accommodative function
   a. Monovision represents a compromise acceptable to some but not all patients.
3. Correction of low myopia in the presbyopic patient introduces the need for reading correction
4. There is a risk of untoward symptoms that include recurrent erosion and dry eye
5. There is an inevitable risk of surgical complications that include
   a. Untoward visual symptoms (e.g. glare, halo, reduced night vision performance)
   b. Loss of best corrected visual acuity
6. For patients considering refractive lens exchange with multifocal IOL implantation, specific optical characteristics of different lens designs might include variable intermediate focus and the potential for glare and halo under low light conditions
7. Refractive lens exchange procedures bear the additional risks associated with cataract surgery, including retinal detachment and endophthalmitis

II. Medications

A. The preoperative evaluation of the refractive surgery candidate must include a review of systemic medications. Potential complications associated with the following medications must be considered

1. Isotretinoin (Accutane®) associated with corneal haze and night vision disturbance following photorefractive keratectomy (PRK)
2. Amiodarone (Cordarone®) associated with cornea verticillata
3. Sumatriptan (Imitrex®) associated with epithelial defects in patients where it causes anterior basement membrane dystrophy (ABMD) changes
4. Loratadine (Claritin™) associated with prolongation of time to re-epithelialization in PRK
5. Hormone replacement therapy associated with transient corneal edema and basal cell layer problems
6. For refractive lens exchange, tamsulosin (Flomax) has been associated with a floppy iris and increased risk for surgical complications in cataract surgery
7. Use of non steroidal anti-inflammatory medications (eg. aspirin, ibuprofen) or warfarin sodium (Coumadin) can increase risk of bleeding

III. Monocular patients
   A. Because of the unavoidable risk of sight-threatening complications associated with refractive surgery, monocular status should be considered a relative contraindication of surgery
      1. A detailed informed consent specific to the functional implications of vision loss is appropriate

IV. Contact lens issues prior to refractive surgery
   A. Contact lenses can be associated with reversible topographic changes that affect refraction
      1. This can lead to refractive instability before and after surgery
      2. In the case of both rigid and soft lenses, these topographic changes might be regular but yet induce significant refractive change, while rigid contact lenses can be associated with frank corneal warpage
      3. For this reason, contact lens use (soft and toric) should be discontinued at least one week prior to pre-operative exam
      4. Rigid contact lens wear should be discontinued for at least three weeks, and stability of topography and refraction confirmed before proceeding with refractive surgery
      5. After the preoperative exam, contact lenses should not be worn before surgery

V. Presbyopia and refractive surgery
   A. Presbyopic patients frequently do not understand that refractive surgery for myopia, hyperopia and astigmatism will not restore the ability to change focus from distance to near, and that the reduction of myopia reduces uncorrected near vision
   B. These issues must be addressed in detail in the informed consent
      1. Presbyopic and near-presbyopic patients with low myopia must demonstrate understanding that full correction of low myopia will cause them to lose the ability to perform near tasks without correction, and induce or increase the need for reading correction
      2. The option, advantages and disadvantages of monovision correction should be discussed
         a. If a monovision correction is considered, a contact lens trial that approximates the surgical goal may be conducted prior to surgery, since some do not tolerate monovision.
         b. It is not adequate to rely upon ocular dominance testing
      3. Where lens replacement surgery is appropriate, the relative merits and limitations of multifocal and presbyopia intraocular lenses (IOLs) should be discussed

VI. Pregnancy, lactation and refractive surgery
A. Because of concerns with regards to refractive stability, pregnancy and lactation is considered a relative contraindication to refractive surgery

VII. Medical conditions

A. The preoperative evaluation of the refractive surgery candidate must include a review of medical conditions

B. Potential complications associated with the following diseases must be considered:
   1. Diabetes mellitus
      a. Instability of the epithelium with poor healing rate
      b. Refractive instability
      c. Retinal diseases
      d. Increased risk of cystoid macular edema (CME) following refractive lens exchange
   2. Systemic lupus erythematosus
      a. Poor corneal wound healing
   3. Rheumatoid arthritis
      a. Poor corneal wound healing
   4. Atopy

VIII. Previous refractive surgery

A. Changes in corneal anatomy, topography and healing following prior refractive surgery should be considered when planning further surgical intervention

B. Radial keratotomy provokes the following considerations
   1. Refractive stability
      a. The 10 year prospective evaluation of radial keratotomy study indicated that 40% of patients experienced a hyperopic shift in refraction between 6 months and 10 years after surgery
      b. A recent history of refractive stability must be sought before consideration of a refractive procedure
   2. Scarring pattern with surface PRK ablation
      a. A risk for loss of best corrected acuity associated with visually significant haze and scarring has been reported associated with PRK ablation following radial keratotomy (RK)
   3. Corneal instability
      a. There is a risk of incision dehiscence during laser in situ keratomileusis (LASIK) following RK
      b. The cornea must be inspected carefully to confirm adequate wound healing
   4. Epithelial ingrowth
Incision separation or poor flap adherence following surgery can lead to epithelial ingrowth.

C. With a history of previous LASIK, flap depth and residual stromal thickness should be assessed by obtaining records of intraoperative pachymetry, prior operative report, or performing specialized exams (e.g. OCT, ultrasound) before considering a LASIK enhancement.

D. All keratorefractive procedures are associated with increased difficulty in performing accurate IOL power calculations for cataract and refractive lens exchange procedures.

IX. Pachymetry

A. Keratectasia following keratorefractive procedures is associated with topographic indicators of keratoconus or forme fruste keratoconus, and excessive thinning of the cornea.

B. Corneal pachymetry and calculation of anticipated central corneal thickness and residual bed thickness following PRK and LASIK respectively is mandatory.

C. The minimum accepted thickness is not definitively established, but 250 microns is the current standard.

D. Intraoperative pachymetry should be considered, as there is some discrepancy between expected and obtained flap thickness based on microkeratome or femtosecond laser performance.

X. Endothelial cell count and phakic intraocular lenses

A. The expected rate of endothelial cell loss in the unoperated eye is approximately 0.6% per year.

B. Higher rates are observed in eyes that have undergone phakic IOL implantation.

C. In order to reduce the risk of late endothelial decompensation and corneal edema, a minimum preoperative cell density may need to be established.

XI. Anterior chamber depth for phakic intraocular lenses

A. Current phakic IOL designs include

1. Anterior chamber angle fixation

2. Anterior chamber iris fixation

3. Posterior chamber placement immediately anterior to the crystalline lens

a. These space occupying devices pose a risk for trauma to the endothelium, angle, and crystalline lens.

b. To minimize these risks, adequate space must exist for these lenses.

c. A minimum anterior chamber depth is recommended for each lens

i. Implantable contact lens (Staar surgical) 2.8 mm minimum

ii. The lens length chosen is based on the anterior chamber depth and sulcus width with greater length used in deeper wider chambers in order to maximize anterior lens vault and minimize the risk of crystalline lens touch.
iii. Artisan iris fixated lens. 3.0 mm minimum AC depth is recommended by the manufacturer, but studies have suggested 3.5 mm to be safer

iv. Angle fixated anterior chamber phakic IOL: 3.5 mm

XII. Refractive lens exchange

A. History relevant to increased risk of complications associated with lens extraction and IOL placement should be solicited

1. Medication usage such as tamsulosin (Flomax) and warfarin sodium (Coumadin)
2. Risk factors for postoperative CME such as diabetes mellitus, epiretinal membrane, history of uveitis or trauma, retinitis pigmentosa, and cardiovascular disease

B. Anterior segment examination with special attention to risk factors for complications for cataract surgery

1. Corneal endothelium
2. Anterior chamber dimensions
3. Signs of capsular exfoliation syndrome
4. Phacodonesis and/or iridodonesis
5. Signs of active or past uveitis (e.g. synechia)
6. Poor dilation
7. Corneal thinning or scarring

C. Posterior segment examination with special attention for risk factors for complications of cataract surgery

1. Peripheral dilated fundus examination
2. Examination of the fovea

Additional Resources

2. AAO, Focal Points: Choosing the Appropriate PRK Patient, Module #9, 1998, p. 1, 2, 4-6.
3. AAO, Focal Points: LASIK, Module #3, 2000, p.3.

Informed consent issues with refractive surgery

I. Describe issues with informed consent with refractive surgery
   A. The informed consent is a critical step in the surgical process
   B. As with all surgery, the patient needs to have a clear understanding of the procedure in order to provide adequate consent
   C. While printed material, videos, and clinic personnel can provide adjuncts, it is incumbent on the surgeon to ascertain that the patient understands the ramifications of the procedure and can provide informed consent to proceed
   D. This should not occur when the patient is medicated immediately prior to surgery
   E. Important topics to be covered in the consent process are
      1. Alternatives
         a. Eyeglasses
         b. Contact lenses
         c. Laser in situ keratomileusis (LASIK)
         d. Laser surface ablation
         e. Refractive lens exchange
         f. Phakic intraocular lens (IOL)
         g. Intrastromal corneal ring segments
      2. Risks/possible complications
         a. Infection
         b. Bleeding
         c. Under/overcorrection
         d. Decentered ablation
         e. Central island
         f. Flap complications
         g. Corneal scarring
         h. Decreased quality of vision
         i. Haze
         j. Glare
         k. Starbursts
         l. Monocular diplopia
m. Night vision problems
n. Loss of best corrected visual acuity (BCVA)
o. Difficulties in management of glaucoma
p. Worsening or inducement of dry eye disease
q. Possible loss of the eye

3. Irreversible nature of the procedure
4. Implications in managing other ocular disorders such as
   a. Cataracts
      i. More difficult to estimate IOL power
      ii. Eventual cataract formation will alter effect of surgery in phakic patients
   b. Glaucoma
      i. More difficulty following intraocular pressure (IOP)

5. Reduces but does not eliminate the need for corrective lenses in most patients
   a. Surgery does not reduce the need for reading glasses in presbyopic patients and may make reading glasses necessary when they were not needed prior to surgery
   b. Monovision should be discussed in presbyopic and near presbyopic patients, and patients interested in this should have a monovision trial prior to surgery

6. Stability issues
   a. Vision can fluctuate following refractive surgery
   b. Possible ectasia

7. Adjusting to monovision

F. Informed consent must obtain documentation that all questions were answered, and that the patient understands or appears to understand

Additional Resources

2. AAO, Focal Points: LASIK, Module #3, 2000, p. 3.
4. Samples of informed consent documents for all refractive surgery procedures can be downloaded from the Ophthalmic Mutual Insurance Company at www.omic.com (http://www.omic.com/)
Issues of unilateral vs. bilateral refractive surgery

I. Describe when unilateral surgery might be preferable to bilateral

   A. Surgeon inexperience or high patient anxiety
   
   B. Higher risk patients such as
      
      1. Patients with dry eye syndrome or epithelial basement membrane dystrophy
      
      2. Patients with previous corneal surgery such as corneal graft
      
      3. High myopes with large pupils
      
      4. Patients with relative contraindications such as collagen vascular diseases
      
   C. Treatment for monovision or monovision trial (although a contact lens trial is preferable to a surgical trial)

   D. Only one eye is ametropic

   E. Complication occurs on the first eye of planned bilateral simultaneous surgery

   F. Treatment in the other eye is contraindicated or will not improve vision

   G. Desire to avoid possible risk of bilateral complications such as bilateral bacterial keratitis

   H. Intend to use postoperative course/refractive measurements from first eye to guide treatment for second eye

Additional Resources


Pupil measurements prior to refractive surgery

I. Describe different methods of measuring low light pupil size
   A. Infrared or low light camera devices
      1. Some of these devices are automated, others rely on the observer to make the measurement
   B. Manual measurement with pupil chart in darkened room
      1. This can be difficult to perform in patients with darkly pigmented iris
   C. Ask patient to focus on a distant target or look off into the distance so as to prevent miosis from focusing on the light or a near target

II. Describe implications in counseling patients pre-operatively
   A. It remains controversial if patients with large pupils are at an increased risk for post-surgical glare/haloes
      1. It is prudent to mention the potential increased risk of night vision complaints in all patients with large scotopic pupils

III. List options to treat symptomatic patients who have quality of vision symptoms
   A. Enlargement of treatment zone/use of blend zone
   B. Medical treatment with brimonidine (Alphagan®) or dilute pilocarpine
   C. Eyeglasses, contact lenses
   D. Custom (wavefront) ablation may benefit patients who have had previous conventional laser vision correction and are experiencing subjective complaints

Additional Resources
Ocular dominance testing prior to refractive surgery

I. Many techniques have been described to test ocular dominance, but can be broadly divided into ones involving history versus testing

A. Historical
   1. Based on questions such as "Which eye do you look with to take a picture? Use a camcorder? Telescope?"

B. Testing
   1. Ask patient to point directly at examiner using index finger, and noting which eye patient is fixating with
   2. Ask patient to look at a distant object through a paper with a single hole in it, noting with which eye patient is fixating
   3. Ask patient to look at a distant target through a hole created with both outstretched hands, noting with which eye the patient is fixating

C. Fogging techniques
   1. Non-dominant eye tolerates fogging better

II. Ocular dominance is established in order to determine which eye is to be corrected for distance (typically dominant eye) and which is to be corrected for near (typically non dominant eye) in patients wanting monovision

A. Studies have been conducted which cast doubt on the importance of ocular dominance, ocular dominance testing, and any difference in success rates in monovision treatments in which one eye is corrected for distance

Additional Resources

Tonometry prior to refractive surgery

I. Describe common methods to measure tonometry
   A. Goldmann
   B. Tono-Pen
   C. Puff tonometry
   D. Pneumotonometry

II. List implications of abnormally high pressure pre-operatively
   A. Uncontrolled glaucoma needs to be controlled and stable prior to refractive surgery
      1. Risk of potential worsening of glaucomatous field loss due to brief increase in intraocular pressure (IOP) during laser in situ keratomileusis (LASIK) procedure
      2. Risk of increased IOP and potential field loss due to corticosteroid-induced glaucoma
   B. Functioning trabeculectomy is a relative contraindication to LASIK due to potential for bleb failure, as well as failure to increase IOP sufficiently during flap creation
   C. Topical glaucoma medications may affect flap healing/adherence and corneal epithelium
   D. Increased complexity in following IOP in patients post myopic laser vision correction due to iatrogenic corneal thinning and true IOP that is higher than measured IOP

III. Accuracy of intraocular pressure measurements
   A. Office measurement of IOP using applanation or indentation-based devices is artificially low following a procedure which removes tissue from the central cornea (i.e., LASIK to treat myopia)
      1. This has implications when IOP is used as a screening method to detect glaucoma patients or when following patients with ocular hypertension or glaucoma who have previously undergone refractive surgery
   B. Fluid in the LASIK flap interface may result in a measured IOP significantly lower than the true IOP

Additional Resources
   1. AAO, Basic and Clinical Science Course. Section 14, Refractive Surgery, 2013-2014.
   2. AAO, Focal Points: Choosing the Appropriate PRK Patient, Module #9, 1998, p. 5.
Understanding issues of ablation diameter vs. depth

I. The formula to calculate the residual stromal bed after myopic laser in situ keratomileusis is (all measurements in microns)
   A. Residual stromal bed thickness = central corneal pachymetry - central flap thickness - central cornea tissue removed

II. The current minimum safe residual bed thickness is 250 microns

III. The Munnerlyn formula can be used as an approximation for the conventional treatment of myopia. It is based on the degree of myopia and optical zone size. The simplified version of the formula is:
   A. Ablation depth in microns = (optical zone diameter in millimeters) 2 X (myopia in diopters) / 3
   B. Another way to state this is that the ablation depth in microns = the square of the optical zone diameter in millimeters multiplied by the diopters of myopia, and divided by 3
   C. For a 6mm optical zone diameter, a 1D myopia treatment would remove 12 microns of tissue
   D. Increasing the optical zone increases the ablation depth by a square function
   E. However, the formula does not account for transition zones, astigmatism correction, or wavefront guided surgery
   F. The best method of estimating the ablation depth is to use the laser company derived software, typically integral to the laser device
   G. It is important that ablation depth be based on the amount of intended refractive correction not on a nomogram adjusted ablation depth

IV. There is a risk/benefit balance between increased laser treatment diameter and increased tissue removal
   A. Large optical zone treatments are less likely to induce quality of vision symptoms but more tissue removed by the laser increases the risk of corneal thinning and ectasia
   B. Better refractive surgery options for patients with thinner corneas that may result in 250 microns or less of residual bed thickness are laser surface ablation or an intraocular procedure

Additional Resources
1. AAO, Basic and Clinical Science Course, Section 14, Refractive Surgery, 2013-2014.
Visual axis alignment and angle kappa issues

I. List indications and contraindications
   A. Indications
      1. Axis alignment and angle kappa should be considered in all patients planning to undergo refractive surgery particularly since cyclotorsion occurs going from sitting to supine position
      2. Visual axis alignment is also an important consideration in toric lens use
   B. Contraindications
      1. No specific contraindications

II. Describe the preprocedure evaluation
   A. During surgical evaluation attention to corneal light reflex test, awareness of importance of correct axis alignment in patients with astigmatism or in wavefront guided treatments

III. List the alternatives to this procedure
   A. Using ocular landmarks (e.g., large vessels, pigment spots)
   B. Relying solely on laser tracking systems for alignment

IV. Describe the instrumentation and technique
   A. Instillation of topical anesthetic prior to marking
   B. Patient placed at slit lamp and asked to focus on distant target to facilitate visualization
   C. Limbus marked at vertical and or horizontal axis with surgical marking pen or radial marker
   D. Prior to laser treatment head aligned with reticle axis lines

V. List the complications of the procedure, their prevention and management
   A. Possible complications include
      1. Misalignment errors from poor technique i.e. 30 degree error in axis leads to no change in the magnitude of the cylinder
      2. Corneal abrasion
      3. Disappearance of marks by the time of treatment
VI. Describe the considerations in interpretation of this diagnostic procedure

A. Because no laser registration system is 100% successful, visual axis marking as a second line of defense against misaligned treatments is an important consideration.

B. In patients who show a large angle kappa the visual line of sight does not correspond to the center of the pupil.

C. Centering the laser over the line of sight as opposed to the pupil may result in a better outcome in some patients (higher hyperopes).

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 3: Optics, Refraction, and Contact Lenses, 2013-2014.
Sources of error in delivering laser correction

I. Describe the approach to establishing the diagnosis

A. Describe the etiology of this disease
   1. Wrong patient name entered
   2. Wrong eye entered
   3. Wrong numbers entered for sphere and cylinder
   4. Plus and minus axis of astigmatism confused
   5. Wrong patient's wavefront data used
   6. Wrong patient is treated

B. Define the relevant aspects of epidemiology of the disease
   1. May occur with novice or experienced surgeons and/or staff
   2. May occur in a surgical environment where there is insufficient crosschecking, or where "surgical time-out" is not implemented

C. List the pertinent elements of the history
   1. Patient may be confused with name or surgical eye after receiving sedative medication
   2. Patients with similar names may be present
   3. Error may have occurred in transcribing surgical plan from medical record
   4. Wrong medical record may have inadvertently been used to enter identification
   5. Technician may have entered wrong data due to reading or hearing the information incorrectly
   6. Typographic errors may have occurred
   7. Computer software error may rarely occur in two patients with same name

D. Describe pertinent clinical features
   1. Wrong treatment is delivered
   2. Patient may have either residual or induced refractive error

II. Define the risk factors

A. Surgeon or operating team in a rush or distracted
B. Delay in the progress of surgery
C. Standard procedure to double check information entered into computer is not followed
D. Standard procedure to double check surgical site and patient identification is not followed
E. Multiple charts or operating plans present in laser suite
F. Humidity and temperature in the room

III. List the differential diagnosis

A. Over- or under-response to laser treatment, or rapid regression of effect
B. Induced astigmatism due to individual patient factors, independent of laser treatment
C. Error in initial refraction (e.g., over-minus in manifest refraction due to patient with excessive accommodation, inconsistent patient responses)
D. Unstable refractive error from contact lens wear, diabetes, etc.

IV. Describe patient management in terms of treatment and follow-up

A. Prevention
   1. Patients wear identification bands and operative eye is marked
   2. Only one surgical plan and medical record should be present in the room with the patient
   3. Surgeon is required to check input into computer software and confirm proper refractions
   4. An appropriate system of double checks and surgical time out should be routine procedure

B. Describe medical therapy options
   1. Eyeglasses
   2. Contact lenses

C. Describe surgical therapy options
   1. Retreatment when stable

V. List the complications of treatment, their prevention and management

A. Medical therapy
   1. Anisometropia or aniseikonia - may cause difficulty wearing glasses
   2. Standard complications of contact lenses

B. Surgical therapy
   1. Potential for removal of excessive stromal tissue and subsequent ectasia
   2. May induce corneal haze if repeat surface ablation is necessary
   3. Results of second treatment may be less predictable if large overcorrection occurred with first procedure

VI. Describe appropriate patient instructions
A. Patient should be instructed on proper use of contact lenses if necessary
B. If anisometropia is present, prepare patient for potential difficulties such as driving at night
C. If error has occurred, be honest with patient and discuss options for fixing the problem

Additional Resources

1. AAO, Basic and Clinical Science Course. , Section 14, Refractive Surgery, 2013-2014.
Incomplete or irregular laser in situ keratomileusis flap

I. Describe the approach to establishing the diagnosis

A. Describe the etiology of the disease
   1. Failure to complete a satisfactory laser in situ keratomileusis (LASIK) flap due to microkeratome or femtosecond laser problems

B. List the pertinent elements of the history
   1. History of a LASIK flap complication
   2. History of suction loss during flap creation
   3. History of aborted femtosecond laser treatment

C. Describe pertinent clinical features
   1. Slit-lamp biomicroscopic exam
      a. Incomplete flap
         i. Slit-lamp biomicroscopy reveals a partial flap that does not extend to the intended length or width.
      b. Irregular flap
         i. If flap is placed back appropriately at time of surgery, may only see a relatively thin flap
   2. Corneal imaging devices (OCT, ultrasound, etc.) can improve ability to detect abnormal flap dimensions in perioperative period or when evaluating patients with a history of prior refractive surgery

II. Define the risk factors

A. Mechanical interference which can block the pass of the microkeratome
   1. Eyelids (narrow interpalpebral fissures)
   2. Eyelashes
   3. Drapes
   4. Lid speculum

B. Loss of or inadequate vacuum in the suction ring during microkeratome or femtosecond laser pass
   1. Deep orbits, which may make suction loss more likely
   2. Conjunctival chemosis, which can make maintaining suction more difficult
3. Patient movement or lid squeezing during the microkeratome pass
4. Ensure adequate suction before pass is made (techniques may include use of tonometer, confirming dilation of pupil or dimming of vision)

C. Electrical failure during the treatment

III. List the differential diagnosis (from the view of a second opinion doctor examining a patient at the slit-lamp biomicroscope)

A. Buttonhole flap
B. Torn flap
C. Incomplete flap creation step
D. Stromal haze from excessively thin flap

IV. Describe patient management in terms of treatment and follow-up

A. Describe medical therapy options
   1. Immediate
      a. Topical antibiotics and steroids
      b. Bandage contact lens to protect flap
   2. Later options
      a. Contact lens/eyeglasses (patient may decide not to have further surgery)

B. Describe surgical options
   1. Immediate surgical treatment
      a. Replace flap
      b. Laser surface ablation such as immediate transepithelial PRK
         i. Obtain consent for this option prior to LASIK
      c. Consider aborting treatment of contralateral eye or using new blade if thin flap in first eye
   2. Later options
      a. Recut a new flap months after the initial surgery
         i. Consider using a femtosecond laser
      b. Perform surface ablation (possibly with mitomycin C)
      c. Consider excimer PTK (possibly with mitomycin C) to smooth surface alone or in combination with PRK

V. List the complications of treatment, their prevention and management
A. Laser surface ablation

1. Risk of haze formation
   a. Reduce this risk with
      i. Avoid ultraviolet exposure
      ii. Oral vitamin C 1000mg/day
      iii. Intraoperative mitomycin C 0.02%

2. Risk of flap interface inflammation (DLK)
   a. Reduce this risk with
      i. Frequent topical corticosteroids

3. Any of the other risks of PRK/LASEK

B. Recut a new flap

1. Creating a new flap is considered a risky treatment option with microkeratome
   a. Risk of transection of the first cut, resulting in a sliver of tissue that can be difficult to reposition
   b. Consider a larger, deeper cut if corneal thickness allows

2. Creating a new flap with a femtosecond laser may allow better control of second flap dimensions

3. Any of the other risks of LASIK, including ectasia with very deep flaps

VI. Describe appropriate patient instructions

A. All of the instructions with regular LASIK (See Excimer laser in situ keratomileusis for myopia and myopic astigmatism)

Additional Resources


Free cap after laser in situ keratomileusis

I. Describe the approach to establishing the diagnosis
   A. Describe the etiology of the disease
      1. Patient squeezing during microkeratome pass
      2. Excessively flat cornea
   B. Define the relevant aspects of epidemiology of the disease
      1. Less likely to occur with more surgeon experience
      2. Less likely to occur with flaps created by femtosecond laser.
   C. List the pertinent elements of the history
      1. A free cap in one eye increases the risk of a free cap in the fellow eye
   D. Describe pertinent clinical features
      1. Intraoperative, following the microkeratome pass
         a. Free cap can remain inside the microkeratome, and can gently be removed and later replaced
      2. Postoperative: blurred vision
         a. Due to wrong orientation of the laser in situ keratomileusis (LASIK) flap when replaced
         b. Due to loss of free cap during the early postoperative period
         c. Due to macrostriae resulting from difficulty replacing flap or use of sutures
         d. Due to astigmatism from use of sutures
         e. Due to increased corneal edema from complicated surgery

II. Define the risk factors
    A. Flat corneas
    B. Loss of suction near the end of the flap creation process
    C. Thin planned flap

III. List the differential diagnosis
     A. Irregular, thin cap, partial in size
     B. Epithelial cap

IV. Describe patient management in terms of treatment and follow-up
A. Describe medical therapy options
   1. Place bandage contact lens and pressure patch eye to prevent accidental loss of free cap
      a. If poor adherence, flap sutures may be required
   2. Use typical LASIK postoperative drops
   3. May require longer treatment with corticosteroids if the cap cannot be located
   4. Follow closely for development of diffuse lamellar keratitis (DLK), macrostriae and epithelial ingrowth

B. Describe surgical therapy options
   1. Careful preoperative marking of the cornea allows a free cap to be replaced in the proper orientation
   2. Locate the cap
      a. Typically it remains in the microkeratome housing
      b. Ensure the epithelial surface of the cap is correctly identified before repositioning
   3. Correctly align the flap into the proper orientation
   4. The cap may require flap sutures, if the cap fails to adhere properly

V. List the complications of treatment, their prevention and management
   A. Loss of cap during the early postoperative period
      1. May require homoplastic lamellar keratoplasty
   B. High postoperative astigmatism and induction of higher order aberrations if the flap is incorrectly repositioned.
      1. Marking the cornea at the estimated flap edge before the microkeratome pass helps in the re-alignment if a free cap occurs
   C. Sutures might induce astigmatism and striae
   D. Increased risk for other complications such as DLK, macrostriae, epithelial ingrowth

VI. Describe disease-related complications
   A. A lost cap can result in
      1. Corneal scarring
      2. Irregular astigmatism
      3. Decreased vision
   B. A poorly positioned flap can result in
      1. Decreased vision
      2. Irregular astigmatism
3. Epithelial ingrowth

C. Inversion of the flap can result in sloughing of the flap, scarring, irregular astigmatism and a hyperopic shift

VII. Describe appropriate patient instructions

A. All of the instructions with regular LASIK (See Excimer laser in situ keratomileusis for myopia and myopic astigmatism)

Additional Resources

Epithelial sloughing during laser in situ keratomileusis procedure

I. Describe the approach to establishing the diagnosis

A. Describe the etiology of this disorder
   1. Microkeratome plate defects
   2. Femtosecond laser applanation irregularity
   3. Dryness of the patient's cornea during the microkeratome pass
   4. Preexisting corneal epithelial basement membrane dystrophy

B. Define the relevant aspects of epidemiology of the disease
   1. More common in patients with dry eye syndrome and older patients
   2. More common in patients with long standing, insulin-dependant diabetes mellitus
   3. May be less likely with femtosecond flaps

C. List the pertinent elements of the history
   1. Dry eye syndrome
   2. Recurrent erosions
   3. Insulin-dependant diabetes mellitus

D. Describe pertinent clinical features
   1. Epithelial detachment noticed immediately after the microkeratome pass
   2. Epithelial slough may be partial or involve the entire flap surface

E. Describe appropriate laboratory testing for establishing the diagnosis
   1. Look for negative staining of the corneal surface pre-operatively
   2. "Q-tip" test: gently push epithelium to see if it is loose

II. Define the risk factors

A. Corneal epithelial basement membrane dystrophy
B. Allowing the cornea to dry out during the preparation for surgery
C. Failure to maintain a polished head/plate on the microkeratome
D. Increased age of patient
E. Excessive use of anesthetic eye drops prior to surgery
F. Second eyes have higher risk than first eyes
G. Type of microkeratome
H. Dry eye syndrome
I. Diabetes mellitus

III. List the differential diagnosis
A. Free flap
B. Irregular flap

IV. Describe patient management in terms of treatment and follow-up
A. Describe medical therapy options
   1. Postoperative antibiotics to prevent infection
   2. Lubricating drops to help with epithelial healing
   3. Bandage contact lens to promote epithelial healing
   4. Increased topical corticosteroids to prevent diffuse lamellar keratitis (DLK)
   5. Close follow up, as patient is at increased risk for infection, DLK and epithelial ingrowth
   6. Consider using systemic doxycycline for several weeks to reduce the risk of recurrent erosions
B. Describe surgical therapy options
   1. Finish ablating under the flap, place a contact lens
   2. Abort planned LASIK on second eye
   3. Convert to surface ablation on second eye if discussed preoperatively
   4. Punctal occlusion
   5. Temporary tarsorrhaphy

V. List the complications of treatment, their prevention and management
A. Complications
   1. Intolerance to bandage contact lens
   2. Intolerance to patching
   3. Contact lens related infection
   4. Contact lens induced sterile infiltrates
B. Prevention
   1. Remove bandage contact lens carefully
C. Management
   1. Discontinue bandage contact lens
2. Discontinue patching

VI. Describe disease related complications

A. Persistent epithelial defect
B. Scarring
C. Diffuse lamellar keratitis
D. Infection
E. Recurrent erosions
F. Epithelial ingrowth
G. Loss of BCVA

VII. Describe appropriate patient instructions

A. Important to protect the affected eye
B. Maintain lubrication
   1. Preservative-free artificial tears
   2. Viscous lubricant during sleep
   3. Cyclosporine drops

Additional Resources

2. AAO, Focal Points: LASIK, Module #3, 2000, p.6.
I. Describe the approach to establishing the diagnosis
   A. Describe the etiology of this disorder
      1. Inadequate suction
      2. Dislodged suction ring during the microkeratome pass
      3. Poor exposure
      4. Poor blade quality
      5. Mechanical failure
   B. Define the relevant aspects of epidemiology of the disorder
      1. Steep corneas
      2. Irregular corneas (e.g. after penetrating keratoplasty)
      3. Tight eyelids
      4. May be less likely with the use of a femtosecond laser
   C. Describe pertinent clinical features
      1. Flap with a central, uncut area
      2. Epithelium may/may not remain intact

II. Define the risk factors
   A. Steep corneas
   B. Irregular corneas (e.g., after penetrating keratoplasty)
   C. Tight eyelids
   D. Thinner planned flap
   E. Thinner pachymetry
   F. Second eye in a bilateral procedure using the same blade
   G. Use of a larger suction ring

III. Describe patient management in terms of treatment and follow-up
   A. Describe medical therapy options
      1. Protection with a bandage soft contact lens postoperatively
   B. Describe surgical therapy options
      1. Immediate surgical treatment
a. Replace flap
b. Laser surface ablation such as immediate transepithelial PRK
   i. Obtain consent for this option prior to LASIK
c. Consider aborting treatment of contralateral eye or using new blade if thin flap in first eye

2. Later options
   a. Recut a new flap months after the initial surgery
      i. Consider using a femtosecond laser
   b. Perform surface ablation (possibly with mitomycin C)
   c. Consider excimer PTK (possibly with mitomycin C) to smooth surface alone or in combination with PRK

IV. List the complications of treatment, their prevention and management

A. Corrected vision usually returns to its pre-operative level when healing is complete
B. Do not perform the laser treatment if a buttonhole flap is produced
C. Irregular astigmatism may require a rigid contact lens for restoration of vision

V. Describe disease-related complications

A. Irregular astigmatism
B. Loss of best corrected visual acuity
C. Epithelial ingrowth
D. Scarring

VI. Describe appropriate patient instructions

A. Explain the complication
B. Describe future therapy

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 8: External Disease and Cornea. 2013-2014.
Haze or scarring after photorefractive keratectomy

I. Describe the approach to establishing the diagnosis

A. Describe the etiology of this disorder
   1. An abnormal healing response to photorefractive keratectomy (PRK)
   2. Deposition of type III collagen
   3. Disorderly array of collagen fibers
   4. Activated keratocytes

B. Define the relevant aspects of epidemiology of this disorder
   1. Influence of ultraviolet light exposure
   2. More prevalent in temperate regions
   3. Keloid formers are not at higher risk for developing haze

C. List the pertinent elements of the history
   1. Loss of best eyeglass corrected visual acuity (BSCVA)
   2. Regression of effect
   3. May induce glare or other visual symptoms

D. Describe pertinent clinical features
   1. Reticular anterior stromal haze / grading scale
   2. Haze typically peaks 6 to 12 weeks postoperatively
   3. Relates to depth of ablation, amount of correction

E. Describe appropriate testing and evaluation for establishing the diagnosis
   1. Slit-lamp biomicroscopic examination
   2. Contrast sensitivity testing
   3. Glare testing

II. Define the risk factors

A. Use of nitrogen blowing intraoperatively
B. Smoking tobacco
C. Exposure to sunlight postoperatively
D. Trauma
E. Haze in the first eye
III. List the differential diagnosis
   A. Scarring secondary to trauma
   B. Scarring secondary to infection

IV. Describe patient management in terms of treatment and follow-up
   A. Prevention of haze
      1. Antioxidants i.e. Vitamin C
      2. Decrease optical zone of treatment to decrease depth of treatment
      3. Use of mitomycin C prophylactically (link to other mito section)
      4. Use of UV blocking sunglasses postoperatively
   B. Describe medical therapy options
      1. Wait until the haze fades spontaneously
      2. Topical corticosteroids
      3. Topical mitomycin C
   C. Describe surgical therapy options
      1. Retreatment with PRK for residual refractive error
      2. Phototherapeutic keratectomy +/- mitomycin C
      3. Diamond burr/ mitomycin C
      4. Lamellar or full thickness keratoplasty in severe cases

V. List the complications of treatment, their prevention and management
   A. Long-term corticosteroid use may induce
      1. Cataracts
      2. Glaucoma
      3. Limit the length of time used to three or four months
   B. Mitomycin C may lead to corneal melting if used incorrectly
      1. Apply no more than 2 minutes intraoperatively
      2. Concentration 0.02% or less applied intraoperatively
C. Additional excimer treatment may not eliminate the haze

VI. Describe disease-related complications

A. Permanent, sight-threatening corneal scarring
B. Loss of BSCVA
C. Regression of refractive results

VII. Describe appropriate patient instructions

A. Include a discussion of haze development in preoperative counseling
B. Confirm patient compliance with postoperative regimen

Additional Resources

Decentered ablation after refractive surgery

I. Describe the approach to establishing the diagnosis

A. Describe the etiology of this disorder
   1. Patient inability to fixate on target during procedure
   2. Patient fixation wandering during procedure
   3. Strong Bells phenomenon causing drifting of gaze
   4. Patient gazing at wrong target
   5. Decentration due to surgeon error in placement of ablation
   6. Improper tracking (flying spot/tracking lasers)
   7. Improper alignment when using an eye holding device

B. List the pertinent elements of the history
   1. Loss of best corrected visual acuity (BCVA)
   2. Patient visual complaints
      a. Glare
      b. Night halos
      c. Monocular polyopia

C. Describe pertinent clinical features
   1. Irregular astigmatism
   2. Topographical eccentricity
   3. Loss of BCVA
   4. Undercorrection
   5. Decreased contrast sensitivity

D. Describe appropriate testing and evaluation for establishing the diagnosis
   1. Corneal topography will delineate extent of decentration of ablation in comparison to center of pupil
   2. Wavefront analysis with high levels of coma

II. Define the risk factors

A. Patient unable to fixate
1. Nervous or overmedicated patient
2. High refractive error causing inability to see target
3. High angle kappa
4. Eccentric pupils
5. Nystagmus
6. Cross fixation

B. Poor comprehension of operative instructions

III. List the differential diagnosis

A. Pseudo-decentration due to abnormal wound healing (e.g., asymmetric haze after photorefractive keratectomy (PRK), epithelial ingrowth lifting edge of laser in situ keratomileusis (LASIK) flap)
B. Asymmetric ablation due to flap hinge position near center of pupil
C. Asymmetric ablation due to performing the excimer treatment with an incomplete or partial flap
D. Irregular astigmatism from other causes
E. Poor microkeratome blade quality creating a flap with irregular thickness

IV. Describe patient management in terms of treatment and follow-up

A. Describe medical therapy options
   1. Rigid contact lens
   2. Hybrid contact lens
   3. Miotic agents to reduce pupil size (pilocarpine, brimonidine)
   4. Polarized lenses

B. Describe surgical therapy options
   1. Perform customized wavefront-guided ablation
   2. Perform complementary ablation to balance the asymmetry
   3. Perform topography guided ablation (not currently approved in the US)
   4. Place arcuate keratotomy incisions on the opposite side of the decentration
   5. Penetrating keratoplasty

V. List the complications of treatment, their prevention and management

A. Complications
   1. Discomfort or inability to wear rigid gas permeable lens
   2. Redness or brow ache with miotic agents
3. Residual night vision difficulties, monocular diplopia, or ghost images
4. Overcorrection
   a. May need repeat enhancement
5. Induced astigmatism
   a. May need repeat enhancement
6. Excessive removal of stromal tissue
   a. Need to measure stromal bed to ensure adequate stromal tissue will remain after enhancement
7. Residual decentration or patient symptoms
   a. May need further medical or surgical therapy

B. Prevention
1. Try rigid contact lenses first
2. Make certain retreatment is possible

C. Management
1. Same as for primary LASIK

VI. Describe disease related complications
   A. Permanent loss of vision
   B. Requirement for additional surgery, i.e., keratoplasty

VII. Describe appropriate patient instructions
   A. Prevention
      1. Instruct patient how to fixate on target light and practice prior to actual ablation
      2. Surgical vigilance during the procedure to ensure proper patient fixation
   B. If decentration occurs, instruct patient on
      1. Proper use and care of contact lens
      2. Side effects of miotic medication
      3. Appropriate LASIK postoperative instructions if retreatment is performed

Additional Resources
Delayed re-epithelialization after laser surface ablation

I. Describe the approach to establishing the diagnosis
   A. Describe the etiology of the disease
      1. Delay in epithelial healing due to local factors such as
         a. Dry eye
         b. Toxic medications
         c. Excessive eye rubbing
      2. Inappropriate use or overuse of topical medications, e.g., topical non-steroidal anti-inflammatory drugs (NSAIDs)
   B. List the pertinent elements of the history
      1. Persistent eye discomfort for extra days following laser surface ablation
      2. Persistent blurred vision for extra days following laser surface ablation
   C. Describe pertinent clinical features
      1. Persistent epithelial defect
   D. Describe appropriate testing for establishing the diagnosis
      1. Sequential slit-lamp biomicroscopic examination
      2. May require contact lens removal and fluorescein staining to establish diagnosis

II. Define the risk factors
   A. Preoperative dry eye
   B. Excessive use of topical medications with preservatives
   C. Tight fitting contact lens
   D. Preoperative neurotrophic cornea (e.g. previous herpes simplex virus or diabetes mellitus)
   E. Autoimmune disorders
   F. Exposure keratopathy

III. List the differential diagnosis
   A. Sterile corneal ulceration
   B. Anesthetic abuse
   C. Medicamentosa/overuse of topical NSAIDs
D. Neurotrophic cornea
E. Tight contact lens syndrome
F. Infectious keratitis (bacterial, herpetic, fungal, and others)

IV. Describe patient management in terms of treatment and follow-up

A. Describe medical therapy options
   1. Reduce the amount of eye drops that contain preservatives
   2. Increase preservative-free tears
   3. Increase lubricating gels
   4. Continue bandage contact lens; adjust bandage contact lens if needed or consider patching
   5. Attention to corticosteroid use
   6. Matrix metalloproteinase inhibitor treatment (oral doxycycline)
   7. Autologous serum drops
   8. Educate patient on risks of topical anesthetic abuse

B. Describe surgical therapy options
   1. Punctal plugs or cautery to increase lubrication
   2. Debride loose epithelium
   3. Tarsorrhaphy
   4. Amniotic membrane graft

C. The epithelium typically heals over a number of days
   1. The smaller the initial defect, the more rapid the completion of healing
   2. For an 8 mm ablation, the epithelial defect heals in 4-6 days

V. Describe disease-related complications

A. Corneal ulcer
B. Scarring
C. Surface irregularity

VI. Describe appropriate patient instructions

A. All of the instructions with regular laser surface ablation (pain, blurred vision, photophobia, redness)
Issues of intraocular pressure measurements after laser in situ keratomileusis and laser surface ablation

I. Describe the approach to establishing the diagnosis

A. Describe the etiology of the situation
   1. Laser eye surgery removes corneal tissue, resulting in a thinner cornea
   2. The devices used to measure intraocular pressure (IOP) (Goldmann tonometer/Tono-Pen, etc) measure IOP with the assumption of a normal corneal thickness
   3. Corneas that have become thinner following laser eye surgery will seem to have a lower measured IOP, although their actual IOP should be unchanged following surgery (most studies suggest approximately 15-20 microns of thinning leads to a one millimeter of mercury (mmHg) reduction in measured IOP)
   4. The peripherally cut collagen fibers in the flap may also contribute to a lower corneal elasticity which further alters the IOP measurement
   5. Interface fluid may lead to falsely low measurement (i.e., the true IOP is actually elevated)

B. Describe pertinent clinical features
   1. IOP measures lower than prior to surgery
   2. IOP measurement may be in the low or normal range when it is actually elevated
   3. Visual field loss and/or progressive optic disc cupping

C. Describe appropriate testing and evaluation for establishing the diagnosis
   1. Pachymetry
      a. Measure the corneal thickness
   2. Slit-lamp biomicroscopic exam
      a. May reveal a pocket of fluid in the flap interface
   3. Confocal microscopy
      a. May reveal a pocket of fluid in the flap interface

II. Define the risk factors

A. Patients with a family history of glaucoma or preoperative glaucoma are at risk for having seemingly low IOP that are, in actuality, still too high for their own optic nerves

B. Frequent use of topical corticosteroids
III. List the differential diagnosis
   A. Unrelated IOP reduction
   B. Postoperative optic neuropathy
   C. Flap interface fluid

IV. Describe appropriate patient instructions
   A. Alert all doctors who measure IOP of previous laser eye surgery
   B. Educate patient on effects of laser vision correction on IOP measurement

Additional Resources

Corticosteroid-induced glaucoma (steroid glaucoma) after refractive surgery

I. Describe the approach to establishing the diagnosis

A. Describe the etiology of the disease
   1. Gradual or rapid rise in intraocular pressure (IOP), often without other symptoms in surface ablation patients
   2. Gradual blurring of vision with falsely low IOP measurement in laser in situ keratomileusis (LASIK) patients

B. Define the relevant aspects of epidemiology of the disease
   1. Typically on corticosteroids for several weeks

C. Describe pertinent clinical features
   1. Elevated IOP on exam
   2. Falsely low IOP in LASIK patient
   3. Pseudo diffuse lamellar keratitis picture in LASIK patient, with presence of interface fluid

D. Describe appropriate testing and evaluation for establishing the diagnosis
   1. In LASIK patients
      a. IOP must be measured in the peripheral cornea as well as over the LASIK flap, because interface fluid can develop with elevated IOP following LASIK
   2. Careful examination to rule out flap interface fluid
   3. Gonioscopy to rule out angle closure
   4. Visual field test may show visual field defects characteristic of glaucomatous changes, although serial testing may be necessary to establish the repeatability of findings
   5. Nerve fiber layer analysis may demonstrate the extent of optic neuropathy

II. Define the risk factors

A. Patients with a family history of glaucoma
B. Patients with active glaucoma
C. Patients with a history of corticosteroid-induced glaucoma or corticosteroid responsive glaucoma patients

III. List the differential diagnosis

A. Primary open angle glaucoma
B. Incorrect measurement of IOP after refractive surgery

IV. Describe patient management in terms of treatment and follow-up

A. Describe medical therapy options
   1. Stop the use of corticosteroids
   2. Switch to lower potency corticosteroids
   3. Start IOP-lowering medications

B. Describe surgical therapy options (for cases that do not respond to medical therapy)
   1. Glaucoma laser surgery
      a. Argon laser trabeculoplasty
      b. Selective laser trabeculoplasty
   2. Trabeculectomy
   3. Glaucoma implant surgery

V. List the complications of treatment, their prevention and management

A. For corticosteroid-induced glaucoma with surface ablation
   1. Rapid cessation of corticosteroids may increase the risk of corneal haze
      a. Instead, may need to switch to a mild corticosteroid and/or add ocular antihypertensives

VI. Describe appropriate patient instructions

A. Follow up exams for IOP checks are important
B. Use corticosteroid medications as indicated
C. Visual field testing should be done to assess visual function

Additional Resources

1. AAO, Basic and Clinical Science Course. , Section 14, Refractive Surgery, 2013-2014.
Decentered flap with laser in situ keratomileusis

I. Describe the approach to establishing the diagnosis

A. Describe the etiology of the disease
   1. Abnormal anatomy which precludes proper suction ring placement
   2. Patient squeezing during microkeratome pass
   3. Incorrect initial positioning of the suction ring

B. Define the relevant aspects of epidemiology of the disease
   1. Less likely to occur with more surgeon experience

C. Describe pertinent clinical features
   1. A flap decentered over the pupillary axis which results in the ablation not being able to be contained within the bed

II. Define the risk factors

A. Abnormally small palpebral fissures

B. Excessive squeezing

III. Describe patient management in terms of treatment and follow-up

A. Describe medical therapy options
   1. After replacement and healing of (severely) decentered flap, soft or rigid gas permeable contact lens may be utilized if no treatment was performed, or eyeglasses if no irregular astigmatism was induced
   2. Free caps generally cause no problem if it is properly repositioned, but a shield can be placed over the eye to prevent the patient from rubbing their eye and displacing the cap

B. Describe surgical therapy options
   1. In a mildly decentered flap which covers the ablation zone, excimer ablation may be performed. However, attention toward and guarding of the hinge is essential to avoid excimer ablation of the back surface of the flap, which can lead to irregular astigmatism
   2. If the flap is severely decentered, it is replaced, allowed to heal, and is later either recut or surface ablation is performed over the flap
   3. If a femtosecond laser created flap is severely decentered, the laser should be stopped prior to the side cut and suction reapplied with better centration with a repeat laser pass at the same programmed depth
4. If a free cap occurs, ablation is performed as usual, while the lenticule is protected in a clean chamber
   a. The cap is then replaced, with or without sutures, and a Fox shield and bandage contact lens may be utilized to prevent loss

IV. List the complications of treatment, their prevention and management

   A. Irregular astigmatism
   B. Corneal scarring
   C. Optical aberrations
   D. Prevention
      1. Pick appropriate candidates with reasonable anatomy and normally shaped corneas
      2. Consider marking the corneal intercept of the line of sight to maintain a centration reference when aligning suction ring and/or applanation plate (i.e. femtosecond laser LASIK)
      3. Confirm good centration with ring prior to initiating suction

V. Describe appropriate patient instructions

   A. Wear contact lens and shield as directed
   B. Avoid eye rubbing and squeezing

Additional Resources

   2. AAO, Focal Points: LASIK, Module #3, 2000, p.6-8.
Recurrent corneal erosion after refractive surgery

I. Describe the approach to establishing the diagnosis

A. Describe the etiology of this disease
   1. Loose corneal epithelium after refractive surgery creates symptoms of tearing, sharp pain or discomfort, usually upon awakening

B. Define the relevant aspects of epidemiology of the disease
   1. Uncommon side effect after refractive surgery
   2. More common in patients predisposed to recurrent erosions, such as corneal epithelial basement membrane dystrophy

C. List the pertinent elements of the history
   1. Underlying history of anterior basement membrane dystrophy (ABMD)
   2. Underlying history of recurrent erosions secondary to trauma
   3. Loose epithelium undiagnosed until time of surgery
   4. Diabetes mellitus

D. Describe pertinent clinical features
   1. Loose epithelium may be present at time of surgery, causing intraoperative epithelial sloughing, possible flap complications, and postoperative epithelial defect over laser in situ keratomileusis (LASIK) flap
   2. If photorefractive keratectomy (PRK) is performed, loose epithelium may develop tighter adhesions over laser-treated area
      a. May continue to slough in the peripheral corneal areas originally denuded of epithelium but untreated by laser
   3. Patients typically experience recurrent erosion symptoms as listed above, but slit-lamp biomicroscopic examination may reveal no obvious abnormality

E. Describe appropriate testing and evaluation for establishing the diagnosis
   1. Epithelial adhesion may be tested with the edge of a surgical sponge
   2. Slit-lamp biomicroscopic examination may reveal basement membrane dystrophy changes

II. Define the risk factors

A. History of ABMD
B. History of recurrent erosions
C. Loose epithelium discovered at time of surgery
D. Underlying history of dry eyes

III. List the differential diagnosis
   A. Severe dry eye syndrome
   B. Epithelial defect secondary to other etiology (trauma, foreign body, etc.)

IV. Describe patient management in terms of treatment and follow-up
   A. Describe medical therapy options
      1. Treat underlying dry eye syndrome
         a. Tear supplements
         b. Punctal plugs
         c. Ointments
         d. Low dose cyclosporine
         e. MMP inhibitors (doxycycline)
         f. Autologous serum
      2. Hypertonic saline drops and ointments
      3. Bandage contact lens if severe
   B. Describe surgical therapy options
      1. Debride loose epithelium
      2. Stromal puncture or diamond burr if localized to one area (outside LASIK flap or after PRK)
      3. Phototherapeutic keratectomy (PTK)

V. List the complications of treatment, their prevention and management
   A. Prevention
      1. Avoid LASIK with a mechanical keratome in patients with ABMD or known loose epithelium; surface ablation or femtosecond flap may be preferable. In femtosecond LASIK, care must be taken not to disrupt epithelium
      2. Treat underlying dry eye and surface disease prior to doing LASIK or PRK
      3. Consider PTK for recurrent erosions prior to doing refractive surgery, especially before LASIK with a mechanical keratome
   B. Medical therapy
      1. Symptoms may persist despite treatment
      2. Bandage contact lens may cause infection if worn for extended periods
3. Side effects of low dose cyclosporin (increased burning sensation)

4. Side effects of doxycycline (sunburn, gastric symptoms, vaginal yeast infections, interference with other medications)

C. Surgical therapy

1. Stromal puncture may not work, or epithelium may be loose in multiple other areas that are not readily visible on slit-lamp biomicroscopic examination

2. Symptoms may persist after PTK

VI. Describe appropriate patient instructions

A. Advise patients that they may be at increased risk for erosions if ABMD or recurrent erosions are present preoperatively

B. Consider advising patients to have laser surface ablation if known risk factors are present

C. Treat dry eye and recurrent erosion prior to doing refractive surgery, if possible

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 14: Refractive Surgery, Section 8: External Disease and Cornea, 2013-2014

Laser in situ keratomileusis flap striae

I. Describe the approach to establishing the diagnosis

A. Definition of the complication
   1. Macrostriae
      a. Gross misalignment of the flap
      b. Visible at slit-lamp biomicroscope as undulating flap folds
      c. Easily detected with negative fluorescein staining, with an asymmetric gutter; or upon retinoscopy (dark shadow streaked parallel to striae)
   2. Microstriae
      a. Fine random "cracks" in the flap without linear or radiating orientation
      b. The gutter is symmetric

B. Describe the etiology of this complication
   1. Macrostriae are due to poor alignment at time of flap positioning, or flap movement post-operatively
   2. Microstriae are due to flap fitting poorly in stromal bed, such as in cases of high myopia
   3. Thick flap

C. Define the relevant aspects of epidemiology of this complication (macrostriae)
   1. History of trauma or eye rubbing. The flap may be displaced by trauma years after the surgery
   2. Epithelial defect at the time of surgery
   3. Inadequate adhesion at time of surgery
   4. Excessive irrigation of stromal bed or corneal flap edema may predispose to flap slippage
   5. High myopia
   6. Brimonidine (Alphagan®) use

D. List the pertinent elements of the history
   1. Reduced visual acuity
   2. Foreign body sensation
   3. Pain

E. Describe pertinent clinical features
   1. Slit-lamp biomicroscopic findings
   2. Negative fluorescein staining of the flap folds
II. Describe patient management in terms of treatment and follow-up

A. Almost all cases of macrostriae require surgical intervention
   1. Same sterile technique as a primary laser in situ keratomileusis (LASIK) procedure
      a. Flap lift and refloat with possible stretching maneuvers
      b. If folds are fixed, the overlying epithelium can be removed - note folds will appear to stay even in early refloats and thus removal of epithelium is not necessary
      c. This technique also used for significant microstriae
      d. Check for epithelial ingrowth and treat by removal or observation
      e. May require bandage contact lens
   2. Flap suturing
   3. Phototherapeutic keratectomy

B. Recurrent flap slippage
   1. The repair may require suturing the flap
   2. The patient should be followed closely for signs of infection or epithelial ingrowth

C. Complications of treatment include epithelial ingrowth, infection, loss of vision (See Epithelial ingrowth after laser in situ keratomileusis)

III. Describe appropriate patient instructions

A. Avoid trauma

B. Eye protection, especially during the perioperative time period

Additional Resources

Traumatic laser in situ keratomileusis flap dislocation

I. Describe the approach to establishing the diagnosis

A. Describe the etiology of this disorder
   1. Trauma to an eye which has had laser in situ keratomileusis (LASIK)
   2. Disruption may occur years after LASIK

B. Define the relevant aspects of epidemiology of the disease
   1. More common in patients who engage in contact sports or activities that could introduce ocular trauma
   2. Patients handling infants or small children

C. List the pertinent elements of the history
   1. History of injury to an eye which has had LASIK
   2. Blunt or sharp trauma
   3. Contaminated material involved
   4. Photophobia
   5. Tearing
   6. Usually decreased vision

D. Describe pertinent clinical features
   1. Flap disruption partial or total
   2. Staining at the flap margin
   3. Interface debris

E. Describe appropriate testing and evaluation for establishing the diagnosis
   1. Culture for microorganisms

F. Define the risk factors

G. Failure to wear eye protection

H. Engaging in high risk activities
   1. Patients whose lifestyles place them at higher risk for these situations may be better undergoing surface ablation procedures

II. List the differential diagnosis

A. Trauma
B. Infection
C. Self-induced

III. Describe patient management in terms of treatment and follow-up

A. Describe medical therapy options
   1. Topical antibiotics
   2. Withholding surgery if vision is uninterrupted
   3. Bandage soft contact lens
   4. Patching

B. Describe surgical therapy options
   1. Repositioning the flap
   2. Use of hypotonic solutions to remove flap folds
   3. Irrigate the interface
   4. Suture the flap
   5. Lamellar keratoplasty

IV. List the complications of treatment, their prevention and management

A. Complications
   1. Hypersensitivity to topical antibiotics
   2. Re-injury to flap when removing bandage soft contact lens
   3. Surgical trauma

B. Prevention
   1. Clinical judgment of best course of treatment
   2. Modification of course of treatment based on patient's history, type of trauma, etc.

C. Management
   1. Discontinue topical agents suspected of causing a hypersensitivity reaction
   2. Reposition flap if it should move again; consider sutures

V. Describe disease-related complications

A. Loss of vision
B. Need for additional surgery, e.g. keratoplasty
C. Diffuse lamellar keratitis
VI. Describe appropriate patient instructions

A. Protect eyes with goggles, eyeglasses or safety glasses
B. Be cautious when holding infants
C. Seek immediate medical attention if ocular trauma occurs
D. Traumatic flap dislocations have been reported many years after LASIK

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 14, Refractive Surgery, 2013-2014.
2. AAO, Focal Points: LASIK, Module #3, 2000, p.6-7,14.
Dry eye after laser in situ keratomileusis

I. Describe the approach to establishing the diagnosis
   A. Describe the etiology of this disorder
      1. Denervation of a large portion of the cornea
      2. Interruption of feedback to the lacrimal secretory apparatus
      3. Decreased tear production
      4. Lacrimal gland inflammation
   B. Define the relevant aspects of epidemiology of the disease
      1. Can occur in any laser in situ keratomileusis (LASIK) patient
      2. More common in patients with dry eyes preoperatively
      3. More common in menopausal or post menopausal women
      4. More common in patients who are middle aged or beyond
      5. More common with certain systemic diseases (e.g., connective tissue disease)
   C. List the pertinent elements of the history
      1. Foreign body sensation, dryness, irritation, blurred vision
      2. Medications (antihistamines/decongestants, diuretics, antipsychotics)
   D. Describe pertinent clinical features
      1. Low tear film assessment or other tests for dry eyes
      2. Stippling of the ocular surface with fluorescein, Rose Bengal, or lissamine green stains
      3. Punctate epithelial erosions most pronounced in the inferior portion of cornea
   E. Describe appropriate testing and evaluation for establishing the diagnosis
      1. Staining of the ocular surface with fluorescein, rose Bengal, or lissamine green
      2. Decreased tear break up time
      3. Decreased tear production with tear film assessment

II. Define the risk factors
   A. Middle age or greater
   B. Menopausal or post menopausal
   C. Preexisting history of dry eye
   D. Sjögren syndrome
   E. Rheumatoid arthritis
F. Thyroid dysfunction
G. Taking medications known to exacerbate ocular dryness
H. Decreased blink response, as in Parkinsons disease or prior herpes keratitis
I. Blepharoplasty
J. More common if prior herpes simplex virus (HSV) keratitis

III. List the differential diagnosis
A. Exposure keratoconjunctivitis
B. Medicamentosa
C. Intraoperative epithelial defect
D. Infection

IV. Describe patient management in terms of treatment and follow-up
A. Describe medical therapy options
   1. Frequent preservative-free artificial tear use
   2. Lubricating gel or ointment at bedtime
   3. Cyclosporine/other anti-inflammatory medications
   4. Systemic alpha omega-3 fatty acid dietary supplements
   5. Systemic lacrimal secretory stimulating drugs
   6. Treatment of concomitant lid disease (e.g., oral tetracyclines, warm compresses/lid hygiene measures)
   7. Bandage soft contact lens
   8. Moisture chambers/side shields for eyeglasses
   9. Smoking cessation
  10. Topical corticosteroids
  11. Autologous serum
B. Describe surgical therapy options
   1. Occlusion of lacrimal puncta
   2. Tarsorrhaphy

V. List the complications of treatment, their prevention and management
A. Complications
   1. Inconvenience of having to use frequent preservative-free artificial tears
2. Epithelial disruption if preserved lubricants are used
3. Intolerance to punctual plugs
4. Retained punctal plug/abscess
5. Lost plugs
6. Epiphora
7. Intolerance to systemic drugs or dietary supplements

B. Prevention
1. Use preservative-free lubricants
2. Punctal cautery
3. Non-LASIK alternatives (e.g., laser surface ablation, refractive lens exchange, etc.)

C. Management
1. Change brand of preservative-free lubricants
2. Use a different type of punctal plug
3. Discontinue systemic agents that are not tolerated
4. Avoid antihistamines and other medications known to exacerbate dry eye syndrome
5. Good hydration
6. Consider surgical alternatives

VI. Describe disease-related complications
A. Decreased vision
B. Discomfort
C. Exacerbation following retreatment
D. Risk of infection
E. Corneal scarring

VII. Describe appropriate patient instructions
A. Emphasize the need for regular, frequent use of preservative-free artificial tears and lubricants
B. Explain that the dry eye symptoms improve over time
C. Avoid medications known to exacerbate dry eye syndrome
D. Good hydration
E. Consider surgical alternatives
3. AAO, Basic and Clinical Science Course. Section 14: Refractive Surgery, Section 8: External Disease and Cornea, 2013-2014.


Immediate postoperative diffuse lamellar keratitis

I. Describe the approach to establishing the diagnosis

A. Describe the etiology of this disorder
   1. Controversial
   2. Many possible causes
      a. Debris
      b. Meibomian gland secretions
      c. Toxic substances
      d. Endotoxins
      e. Atopy
      f. Blood
      g. Inflammation
      h. Intraoperative or postoperative epithelial defects
      i. Excessive femtosecond laser energy during flap creation

B. Define the relevant aspects of epidemiology of the disease
   1. More common in patients with blepharitis
   2. Retention of endotoxins in the instrument sterilizer

C. List the pertinent elements of the history
   1. Increased pain
   2. Increased photophobia

D. Onset 1 to 6 days postoperatively

E. Describe pertinent clinical features
   1. Little or no ciliary flush or conjunctival inflammation
   2. Diffuse infiltrates limited to the interface
   3. Infiltrates over a large area
   4. Multiple foci of infiltrates may be present
   5. Little or no anterior chamber reaction
   6. Infiltrates may coalesce

F. Describe appropriate testing and evaluation for establishing the diagnosis
1. If the flap is refloated, a culture of the interface surface is occasionally advisable

II. Define the risk factors

A. Blepharitis
B. Meibomitis
C. Atopy
D. Peripheral corneal vascularization
E. Recent similar cases in the same operating suite
F. Epithelial defects
G. Excessive femtosecond laser energy

III. List the differential diagnosis

A. Infection
B. Interface flap debris
C. Epithelial cell implantation
D. Epithelial ingrowth
E. Pressure induced stromal keratitis (PISK)

IV. Describe patient management in terms of treatment and follow-up

A. Describe medical therapy options
   1. Frequent (hourly) topical corticosteroids drops
   2. Oral corticosteroids
   3. Close observation

B. Describe surgical therapy options
   1. Irrigate the interface
   2. Lift the flap; apply corticosteroids
   3. Culture the interface

V. List the complications of treatment, their prevention and management

A. Infection could be masked
B. Infection could develop while corticosteroid drops are used frequently
C. Elevated intraocular pressure (IOP)
   1. Interface cleft may develop
2. Measurement of IOP must be done peripheral to the flap

D. Flap striae after flap lift

E. Flap edema after flap lift (temporary visual decline)

F. Epithelial ingrowth

VI. Describe disease-related complications

A. Flap necrosis

B. Flap wrinkling and scarring (fixed flap folds)

C. Induced refractive change

D. Pressure-induced loss of visual field

E. Blindness

VII. Describe appropriate patient instructions

A. Notify ophthalmologist if

1. Pain increases

2. Photophobia increases

3. Vision decreases

Additional Resources


Late diffuse lamellar keratitis related to flap trauma (epithelial defects)

I. Describe the approach to establishing the diagnosis

A. Describe the etiology of this disorder
   1. Trauma
   2. Disruption of the corneal surface stimulates a stromal inflammatory response
   3. Recurrent erosion syndrome might be precipitated by epithelial defect during surgery

B. Define the relevant aspects of epidemiology of the disease
   1. More common in patients who engage in contact sports or activities that could introduce ocular trauma
   2. Parents with infants or small children

C. List the pertinent elements of the history
   1. Pain
   2. Photophobia
   3. Tearing
   4. Decreased vision

D. Describe pertinent clinical features
   1. Epithelial defect, stains with fluorescein
   2. Shift of flap position (+/-)
   3. Interface haze, often in a "shifting sands" pattern is graded clinically on a scale of I - IV
   4. Absence of anterior chamber reaction

E. Describe appropriate testing and evaluation for establishing the diagnosis
   1. Culture the corneal surface
   2. If the flap is repositioned surgically, culture the interface

II. Define the risk factors

A. Contact sports
B. Infants held by patients
C. Lack of eye protection in high risk activities
D. Epithelial defect at the time of surgery followed by recurrent erosion
III. List the differential diagnosis

A. Infection
B. Toxic keratitis
C. Preexisting haze or scarring
D. Epithelial ingrowth
E. Pressure induced stromal keratitis (PISK)

IV. Describe patient management in terms of treatment and follow-up

A. Describe medical therapy options
   1. Observation without treatment or lubrication only
   2. Frequent topical corticosteroids
   3. Topical antibiotic prophylaxis
   4. Bandage soft contact lens
   5. Oral corticosteroids

B. Describe surgical therapy options
   1. Flap lift and irrigation and reposition if flap is displaced by trauma
   2. Epithelial debridement
   3. Stromal micropuncture

V. List the complications of treatment, their prevention and management

A. Complications of treatment
   1. Frequent topical corticosteroid use could promote the growth of microorganisms
   2. Benzalkonium chloride toxicity to the corneal epithelium

B. Prevention
   1. Observe; withhold therapy
   2. Use custom formulated preservative-free topical corticosteroids

C. Management
   1. Minimize topical corticosteroids; taper as quickly as possible
   2. Remove bandage contact lens as soon as the epithelium has healed
   3. Treat infection appropriately

VI. Describe disease-related complications
A. Loss of vision
B. Corneal scarring
A. Irregular astigmatism

VII. Describe appropriate patient instructions

A. Protect eyes whenever engaged in high risk activities
B. Be cautious when holding infants
C. Seek immediate medical attention if trauma to eyes occurs

Additional Resources


Microbial keratitis after refractive surgery

I. Describe the approach to establishing the diagnosis

A. Describe the etiology of the disease
   1. Invasion of the cornea by microorganisms introduced during surgery
   2. Infection in the immediate postoperative period
   3. Late infection

B. Define the relevant aspects of epidemiology of the disease
   1. Epidemic pattern from contaminants from the surgical suite
   2. Poor patient compliance/hygiene
   3. Bandage contact lens
   4. Contaminated eyedrops/water
   5. Trauma

C. List the pertinent elements of the history
   1. Increased pain
   2. Increased photophobia
   3. Discharge
   4. Decreased vision

D. Describe pertinent clinical features
   1. Corneal haze
   2. Infiltrate
   3. Cell and flare in the anterior chamber

E. Describe testing and evaluation for establishing the diagnosis
   1. Lift flap / culture infiltrates
   2. Culture bandage contact lens
   3. Culture eyedrops

II. Define the risk factors

A. Recent previous case of infection in a given surgical center
B. Poor patient compliance
C. Persistent epithelial defect
D. Prolonged corticosteroid use
E. Gram positive cocci and atypical mycobacteria

III. List the differential diagnosis
   A. Diffuse lamellar keratitis
   B. Sterile infiltrates
   C. Interface debris
   D. Epithelial cell implantation
   E. Epithelial ingrowth

IV. Describe patient management in terms of treatment and follow-up
   A. Describe medical therapy options
      1. Broad spectrum antibiotics given topically until the microorganism is identified
      2. Specific fortified antimicrobial agent(s) when the culture and sensitivity reports are obtained
      3. Microbiology laboratory should be aware of potential anaerobic or saprophytic organisms
   B. Describe surgical therapy options
      1. In laser in situ keratomileusis (LASIK) cases, lift the flap, then culture and irrigate the interface
      2. Amputation of the flap

V. List the complications of treatment, their prevention and management
   A. Hypersensitivity or extreme irritation to antimicrobial agents
      1. Prevention
         a. Selection of an appropriate agent based on patient history of drug allergy
   B. Management
      1. Selection of an alternate agent

VI. Describe disease-related complications
   A. Corneal necrosis
   B. Corneal scarring
   C. Corneal perforation
   D. Permanent loss of vision
   E. Need for additional corneal surgery

VII. Describe appropriate patient instructions
A. **Instruct patient to notify the doctor if he/she develops:**

1. Increased pain
2. Decreased vision
3. Increased photophobia
4. Ocular redness
5. Discharge

**Additional Resources**

1. AAO, Basic and Clinical Science Course. Section 14: 2013-2014.
Herpes simplex virus keratitis after refractive surgery

I. Describe the approach to establishing the diagnosis
   
   A. Describe the etiology of this disease
      1. Herpes simplex virus (HSV) reactivated from latency
      2. Newly acquired viral infection
   
   B. Define the relevant aspects of epidemiology of the disease
      1. History of previous ocular HSV is a relative contraindication for laser vision correction
      2. Acquired viral keratitis, e.g., epidemic keratoconjunctivitis
   
   C. List the pertinent elements of the history
      1. Sudden onset of photophobia, pain, decreased vision
      2. Patient may not have been aware of previous HSV infections
      3. Recent systemic illness
      4. Recent trauma
      5. Recent exposure to ultraviolet light, sunburn, etc.
   
   D. List the pertinent clinical features
      1. Dendritic epithelial lesion
      2. Infiltrate(s)
      3. Anterior chamber cell and flare
      4. Vesicles on eyelid
      5. Follicular reaction in conjunctiva
      6. Palpable pre-auricular nodes
      7. Interface lamellar keratitis (laser in situ keratomileusis)
      8. Old anterior stromal scars from preexisting HSV
   
   E. Describe appropriate testing and evaluation for establishing the diagnosis
      1. Culture for virus
      2. Culture for other microorganisms

II. Define the risk factors
   
   A. Previous history of recurrent monocular infection
B. Exposure to infected individuals post operatively

III. List the differential diagnosis

A. Microbial keratitis
   1. Acanthamoeba
   2. Atypical mycobacteria
   3. Fungal keratitis
   4. Bacterial keratitis

B. Collagen vascular disease

IV. Describe patient management in terms of treatment and follow-up

A. Describe medical therapy options
   1. Topical trifluridine, vidarabine, acyclovir, or ganciclovir gel
   2. Oral acyclovir, famciclovir or valacyclovir
   3. Topical steroids for stromal keratitis

B. Describe surgical therapy options
   1. Debridement

V. List the complications of treatment, their prevention and management

A. Complications
   1. Irritation or hypersensitivity to the antiviral agent

B. Prevention
   1. Long term oral antivirals are of use in prevention of recurrences
   2. Recognition of allergic response to the drug
   3. Avoiding drugs to which the patient is hypersensitive

C. Management: switching drugs when appropriate

VI. Describe disease-related complications

A. Progression of infection
B. Loss of corneal tissue
C. Permanent scarring
D. Loss of vision
E. Need for additional surgery
F. Irregular astigmatism

VII. Describe appropriate patient instructions

A. Question the patient specifically about previous HSV ocular infection

B. Instruct patient to notify the ophthalmologist if he/she develops:

1. Increased pain
2. Decreased vision
3. Increased photophobia
4. Ocular redness
5. Discharge

Additional Resources

Epithelial ingrowth after laser in situ keratomileusis

I. Describe the approach to establishing the diagnosis

A. Describe the etiology of this disorder
   1. Epithelium implanted during surgery by microkeratome or irrigating cannula
   2. Fistula formation at the flap margin
   3. Following diffuse lamellar keratitis
   4. Loss of epithelium over flap edge, leading to poor adherence at edge and to epithelial ingrowth, and may be associated with re lift and enhancement procedures
      a. Loss of epithelium anywhere can lead to fistula formation at the flap edge

B. List the pertinent elements of the history
   1. Patient is usually asymptomatic but may have a chronic foreign body sensation (with positive or negative fluorescein staining of the flap edge at the site of the fistula)
   2. Age
   3. Recurrent erosion symptoms
   4. Decreased vision and irregular astigmatism

C. Describe pertinent clinical features
   1. Appearance of interface debris noted post operatively
   2. Debris may clear or later appear as epithelial rests in the interface
   3. A plaque ("putty-like") may develop weeks after surgery
   4. Necrosis of flap can occur over ingrown epithelium
   5. Many epithelial nests become encysted and are translucent
   6. There may be no vision effects if the epithelium is not in the entrance pupil

D. Describe appropriate testing and evaluation for establishing the diagnosis
   1. Observation
   2. Photographs
   3. Corneal topography
   4. Slit-lamp biomicroscopic examination
   5. Fluorescein
      a. Tracks under flap in region of epithelial ingrowth
   6. Refraction
II. Define the risk factors
   A. Elevation of the flap margin postoperatively
   B. Epithelial defect, particularly near the flap margin
   C. Diffuse lamellar keratitis
   D. Prior corneal surgery (especially radial keratotomy)
   E. Corneal epithelial basement membrane dystrophy (map-dot-fingerprint dystrophy)
   F. Laser in situ keratomileusis (LASIK) enhancement

III. List the differential diagnosis
   A. Infectious infiltrate
   B. Interface debris

IV. Describe patient management in terms of treatment and follow-up
   A. Describe medical therapy options
      1. Observation
      2. Treat epithelial defects (bandage soft contact lens; patching)
      3. Topical corticosteroids for interface inflammation
   B. Describe surgical therapy options
      1. Lift flap, scrape cells off stromal surface and the underside of the flap
      2. Use of fibrin glue may be helpful
      3. Chemical cauterization (such as diluted alcohol)
      4. Suturing of the flap in cases of recurring epithelial ingrowth

V. List the complications of treatment, their prevention and management
   A. Complications
      1. Treatment is not always successful in eliminating epithelial ingrowth
      2. Damage to the flap
      3. Introduction of striae in flap
      4. Infection
   B. Prevention of complications
      1. Avoid intervening surgery if the epithelium does not interfere with vision or is not causing flap melt
2. Avoid chemical cauterization, as it is risky
3. Focal laser treatment to the stromal surface will potentially cause topographical abnormalities and should be avoided

C. Management of complications of treatment
   1. Induced surface irregularities may require rigid contact lens wear for best vision
   2. Flap damage may require flap amputation or keratoplasty
   3. Suturing of the flap

VI. Describe disease related complications
   A. Flap necrosis
   B. Growth of epithelium into the visual axis causing visual disturbances

Additional Resources
   1. AAO, Basic and Clinical Science Course. Section 14: Refractive Surgery, Section 8: External Disease and Cornea, 2013-2014.
   2. AAO, Focal Points: LASIK, Module #3, 2000, p.6-7,14.
Ectasia after laser in situ keratomileusis

I. Describe the approach to establishing the diagnosis
   A. Describe the etiology of this disease
      1. Unstable refractions or keratometry readings/topography maps
      2. Irregular contour or corneal thinning at slit-lamp biomicroscope
      3. Thin pachymetry readings
   B. List the pertinent elements of the history
      1. History of forme fruste keratoconus
      2. History of repeated enhancement surgery
   C. Describe pertinent clinical features
      1. Increasing steep keratometry readings
      2. Increasing steepness and irregularity of cornea on corneal topography

II. Define the risk factors
   A. Keratoconus or forme fruste keratoconus, (abnormal topography)
   B. Thin residual stromal bed
   C. Thin preoperative central corneal thickness
   D. Repeated enhancement surgery
   E. High myopia
   F. Young patient age

III. List the differential diagnosis
   A. True keratoconus with progression
   B. Central island or decentered ablation
   C. Previous laser vision correction of high hyperopia

IV. Describe patient management in terms of treatment and follow-up
   A. Define medical therapy options
      1. Rigid gas permeable contact lens
      2. Eyeglasses until they no longer adequately correct vision
   B. Define surgical therapy options
1. Additive procedures: Intacs with/without collagen crosslinking (not FDA approved)/epikeratophakia/penetrating keratoplasty (PK)

2. Lamellar keratoplasty

V. List the complications of treatment, their prevention and management

A. Contact lens-associated complications

B. Complications associated with PK

VI. Describe appropriate patient instructions

A. Appropriate contact lens care

B. Postoperative Intacs/PK instructions

C. No eye rubbing

Additional Resources

1. AAO, Basic and Clinical Science Course. Section 14: Refractive Surgery, Section 8: External Disease and Cornea, 2013-2014.


Mitomycin C for haze prophylaxis (risks vs. benefits)

I. List the indications/contraindications

A. Indications
   1. Patients who have developed haze after previous photorefractive keratectomy (PRK)
   2. Phototherapeutic keratectomy (PTK) patients in whom the underlying disease process could lead to haze formation
   3. High correction
   4. Patients undergoing laser surface ablation who are at increased risk for haze
      a. High myopia
      b. Previous corneal surgery (laser in situ keratomileusis (LASIK), radial keratotomy, corneal transplant)

B. Contraindications
   1. Lack of an indication (topical application of Mitomycin C to the eye is considered by the FDA as an off-label use of the drug)
   2. History of healing disorder
   3. Suspicion of poor patient compliance

II. Describe the pre-procedure/therapy evaluation

A. History of keloid formation
B. Biomicroscopy
C. Glare testing
D. Contrast sensitivity testing

III. List the alternatives to this procedure/therapy

A. Repeat PTK or PRK without using mitomycin C
   2. Manual superficial keratectomy without application of excimer laser treatment with using mitomycin

B. Aggressive use of topical corticosteroids
C. Topical application of antimetabolites after treatment.
1. Prescribe one drop of 0.02% mitomycin C 4 times a day for 2 weeks (patient should be warned that eye often becomes red with this dosage)

D. Observation without intervention

IV. Describe the instrumentation, anesthesia and technique

A. Apply a sponge soaked in very low dose (0.01 or 0.02%) mitomycin C to the operative site for 12-120 seconds after ablation (be aware of concentration mistakes)
B. Remove the sponge, irrigate well with balanced salt solution
C. Bandage contact lens
D. Prescribe one drop of 0.02% mitomycin C 4 times a day for 2 weeks (patient should be warned that eye often becomes red with this dosage)

V. List the complications of the procedure/therapy, their prevention and management

A. Complications
   1. Retardation of healing
   2. Persistent epithelial defect
   3. Corneal scarring
   4. Corneal melt
B. Prevention
   1. Limit exposure intraoperatively to 2 minutes or less
C. Management
   1. Discontinue the drug
   2. Bandage soft contact lens
   3. Patching
   4. Botulinum toxin-induced ptosis
   5. Tarsorrhaphy

VI. Describe the follow up care

A. Frequent examinations
B. One day postoperatively
C. Repeat assessment within one week postoperatively
D. Discontinue the drug at the earliest sign of complication

VII. Describe appropriate patient instructions
A. Tell the patient why you are using mitomycin C and the risks
B. Instruct the patient to notify the ophthalmologist if side effects occur
C. Stress the importance of limiting mitomycin C use to the prescribed period of time

Additional Resources

Quality of vision problems after laser in situ keratomileusis

I. Describe the approach to establishing the diagnosis
   A. Describe the etiology of the disease
      1. Irregular astigmatism, such as central island
      2. Decentered ablation
      3. Small optical zone
      4. Overly steep or flat corneas
      5. Dry eyes
      6. Corneal haze
      7. Interface haze/debris
      8. Flap striae
      9. Residual refractive error
     10. Epithelial ingrowth
   B. List the pertinent elements of the history
      1. Decreased best spectacle corrected visual acuity
      2. Decreased quality of vision
         a. Typically worse at night
         b. Glare
         c. Halos
         d. Starbursts
   C. Describe pertinent clinical features
      1. Irregular astigmatism on topography and/or inferior steepening (ectasia)
      2. Decentered ablation on topography
      3. Small optical zone from operative report or on topography
      4. Overly steep or flat corneas
      5. Dry eyes on slit-lamp biomicroscopic exam
      6. Corneal haze on slit-lamp biomicroscopic exam
      7. Interface haze/debris on slit-lamp biomicroscopic exam
      8. Flap striae on slit-lamp biomicroscopic exam
9. Residual refractive error
10. Epithelial ingrowth visible on slit-lamp biomicroscopic exam

D. Describe appropriate testing and evaluation for establishing the diagnosis
1. Evaluate higher order aberrations using wavefront aberrometer
2. Retinoscopy
3. Refraction to determine residual refractive error
4. Corneal topography
5. Slit-lamp biomicroscopic exam

II. Define the risk factors
A. Patients treated with small optical zones/ablation diameters
B. Higher levels of corrections (myopia/astigmatism/hyperopia)
   1. Effective optical zone becomes smaller with higher preop myopia
C. The role of pupil size remains controversial
   1. Some peer reviewed literature does not support the notion that large pupils affect the quality of vision after LASIK

III. Describe patient management in terms of treatment and follow-up
A. Describe medical therapy options
   1. Trial of pupillary constriction
      a. Low dose pilocarpine
      b. Brimonidine (Alphagan ®)
   2. For dry eyes: cyclosporine/lubrication/autologous serum
   3. Eyeglass prescription for any residual refractive error
   4. Rigid contact lenses - for treatment of irregular astigmatism
B. Describe surgical therapy options
   1. Laser in situ keratomileusis (LASIK) enhancement to treat residual refractive error
   2. LASIK enhancement to widen treatment zone (for large pupil patients)
   3. Flap lift/stretch for striae
   4. Flap suture for striae
   5. Punctal plugs for dry eyes
   6. Removal of epithelial ingrowth
   7. Wavefront based enhancement for patients with increased higher order aberrations
IV. List the complications of treatment, their prevention and management

A. Pilocarpine
   1. Slight increased risk of retinal detachment
   2. Headache or brow ache
   3. Decreased night vision

B. LASIK enhancement
   1. All of the usual risks with enhancements

C. Flap lift/stretch
   1. Infection
   2. Inflammation
   3. Epithelial ingrowth

D. Flap sutures
   1. Irregular astigmatism

E. Punctal plugs
   1. Canalicular infections/inflammation (pyogenic granuloma)

F. Epithelial ingrowth
   1. Recurrence of epithelial ingrowth

V. Describe appropriate patient instructions

A. All of the instructions with regular LASIK

Additional Resources


Intolerance to monovision after refractive surgery

I. Describe the approach to establishing the diagnosis
   
   A. Describe the etiology of this disease
      1. Difficulty seeing well at both distance and near after monovision correction
   
   B. Define the relevant aspects of epidemiology of the disease
      1. Patients with strong sighting preferences have reduced interocular blur suppression and binocular depth, with higher failure rate
      2. Although women may be more likely to pick monovision as a surgical alternative, success is not related to age or gender
      3. Patients who have occupations requiring fine work may be less satisfied
   
   C. List the pertinent elements of the history
      1. Monovision contact lens trial prior to refractive surgery may be instituted, but success is not necessarily dependent on trial
      2. Crossed monovision may be successful, but generally dominant eye is corrected for distance
   
   D. Describe pertinent clinical features
      1. Reduced acuity
      2. Reduced stereopsis
      3. Decompensated strabismus or induced phoria
      4. More significant loss of acuity in low illumination settings (night driving problems)
      5. Residual astigmatism causes greater loss of acuity
      6. Anisometropic blur suppression is required for success, is more common when the dominant eye is corrected for distance, and improves with adaptation
   
   E. Describe appropriate testing and evaluation for establishing the diagnosis
      1. Stereoacuity testing
         a. Randot
         b. Worth 4-dot
      2. Cover-uncover testing
      3. Manifest refraction
      4. Contrast sensitivity testing
      5. Ocular dominance testing
II. Define the risk factors
   A. Inability to suppress image between two eyes
   B. Significantly reduced stereoacuity with monovision trial
   C. Large esophoric shifts with monovision
   D. Anisometropic blur greater than 1.75 diopters (D)
   E. Occupations requiring fine work

III. List the differential diagnosis
   A. Residual refractive error in dominant eye may cause significant drop in low illumination visual acuity, but if corrected, monovision may be successful

IV. Describe patient management in terms of treatment and follow-up
   A. Prevention
      1. Attempt monovision contact lens trial to distinguish candidates who are intolerant
      2. Caution when attempting more than 1.5-1.75 D of anisometropia
      3. Allow at least several weeks for adaptation
   B. Medical treatment
      1. Eyeglasses or contact lens
         a. Either for dominant and/or non-dominant eye
      2. Prisms
         a. For decompensated strabismus after monovision laser in situ keratomileusis (LASIK)
   C. Surgical treatment
      1. Correction of residual refractive error in dominant eye
      2. Full correction of anisometropia in monovision eye to reverse monovision
      3. Partial correction of excessive anisometropia in monovision eye
      4. Surgical correction of decompensated strabismus, if present

V. List the complications of treatment, their prevention and management
   A. Standard risks from contact lenses
   B. Standard risks from enhancement of LASIK surgery
   C. Standard risk of strabismus surgery, if performed

VI. Describe appropriate patient instructions
A. Discuss pros and cons of monovision with patient prior to surgery
B. Discuss routine contact lens care in patients requiring contact lenses

Additional Resources

Enhancements

I. Describe the approach to establish the timing of enhancements
   A. Define the relevant aspects of epidemiology of the disorder
      1. Hyperopia tends to progress over a patient's lifetime until the onset of cataract formation
      2. Myopia usually stabilizes by the mid-twenties
      3. Cataract formation usually results in a myopic shift in refraction
   B. List the pertinent elements of the history
      1. Any type of refractive surgery
      2. Overcorrections usually regress in weeks to months
      3. Under corrections usually stabilize in several weeks to three months
      4. In middle-aged adults, hyperopia tends to slowly progress with time, so hyperopic drift after refractive surgery is common
      5. After myopic laser in situ keratomileusis (LASIK), especially for higher myopia, mild regression may occur over several years' time
   C. Describe pertinent clinical features
      1. Change in refractive error over time
      2. Change in corneal steepness as detected by topography and keratometry over time
      3. After laser surface ablation, subepithelial haze may increase and cause progressive myopic regression after myopic procedure, or hyperopic regression after hyperopic procedure
      4. Epithelial hyperplasia may occur after both LASIK and photorefractive keratectomy (PRK) and may be responsible for slow regression over time
      5. Cataracts may eventually ensue, causing myopic shift
   D. Describe appropriate testing and evaluation for establishing the diagnosis
      1. Manifest refraction
      2. Keratometry
      3. Corneal topography
      4. Slit-lamp biomicroscopic examination

II. Define the risk factors
   A. Higher levels of preoperative hyperopia or myopia lead to more pronounced regression over time
   B. Preexisting cataract may progress after refractive surgery, leading to myopic shift
   C. Larger optical zone ablations for myopia tend toward longer postoperative stabilization, and may
predispose toward overcorrections
D. Excessively small ablations will result in more marked regression over time

III. List the differential diagnosis
A. Progressive ectasia, or bowing forward of the cornea, may cause a myopic shift
B. Excessive haze formation in the cornea after PRK, or epithelial ingrowth under the flap after LASIK, may produce refractive shifts, depending on the location of the corneal elevation

IV. Describe patient management in terms of treatment and follow-up
A. Prevention
1. Consider avoiding corneal surgery in patients with excessive hyperopia or myopia
2. Prevention of haze in surface ablation by intraoperative use of mitomycin C and/or limiting postoperative ultraviolet exposure.
3. Avoid surgery in patients with visually significant cataracts
B. Describe medical therapy options
1. Eyeglasses or contact lenses
2. Observation and repeat manifest refractions until stability is achieved
C. Describe surgical therapy options
1. Enhancement procedure if patient desires
   a. Mark and undermine flap edge with hook via slit lamp biomicroscopy or visualize flap by indentation under operating microscope.

V. List the complications of treatment, their prevention and management
A. Medical therapy
1. Patient may require months for stabilization after myopic LASIK or PRK overcorrection
B. Surgical therapy
1. Because of tendency for regression and epithelial hyperplasia after hyperopic surgery, care must be taken to assess true residual stromal thickness accurately and avoid over ablation of stroma with multiple enhancements
2. If multiple myopic enhancements are performed, the cornea may become weakened and progressive ectasia may result; care must be taken to assess residual stromal bed thickness accurately
3. If enhancements are undertaken prior to refractive stabilization, the results may be unpredictable
4. Consider treating consecutive hyperopia (i.e., hyperopic overcorrection after myopic LASIK) more conservatively due to tendency toward overcorrections (i.e., repeat myopia after enhancement)
after enhancements of this subset of patients

5. Progressive myopia due to cataracts should be treated with cataract surgery, not with repeat corneal surgery
6. It may be difficult to lift LASIK flaps many months to years later, making enhancement surgery technically more difficult
7. The rate of epithelial ingrowth is higher after LASIK enhancements, and the risk of haze after PRK enhancements is higher and might require use of topical mitomycin C

VI. Describe appropriate patient instructions

A. Encourage patience to wait for refractive stability before undertaking enhancement procedure
B. Routine postoperative instructions if enhancement is performed
C. Routine contact lens care instructions if required
D. Patients should be informed that regression of effect may occur over the years and that an enhancement for long-term regression (or progression of underlying myopia or hyperopia) may be required several years later

Additional Resources

Intraocular lens calculation following refractive surgery

I. List the indications/contraindications
   A. Indications
      1. Any candidate for cataract surgery with intraocular lens (IOL) implantation or refractive lens exchange who has undergone prior keratorefractive surgery

II. Describe the pre-procedure evaluation
   A. History of refractive surgery and review of old records, if available
   B. Complete ophthalmic examination
      1. Visual acuity
      2. Refraction
      3. Tonometry
      4. Keratometry
      5. Slit-lamp biomicroscopic and dilated ophthalmoscopic examination
      6. Corneal topography

III. List the alternatives to this procedure
   A. No intraocular lens (IOL) implantation
   B. IOL implantation with standard calculation techniques and likely post-operative ametropia

IV. Describe the instrumentation and technique
   A. Instrumentation
      1. Keratometer
      2. A scan (ultrasonic) or partial coherence interferometer (optical)
      3. Computerized corneal topographer
      4. IOL calculation software and compatible computer hardware
   B. Techniques
      1. Clinical history method
         a. Change in manifest refractive spherical equivalent due to keratorefractive surgery is subtracted from pre-operative mean keratometry value
i. The difference is used as the K value in the IOL calculation formula of choice

ii. Selection of a K value slightly flatter and/or calculated IOL power slightly greater, can help to offset a tendency for hyperopic outcomes

iii. Prefer most recent manifest refraction after keratorefractive surgery prior to development of cataract

2. Corneal topography method
   a. The effective refractive power of the cornea may be calculated from topographically obtained values, over central cornea
      i. May be used effectively in post-radial keratotomy (RK) eyes
      ii. Requires adjustment in post-PRK or LASIK eyes

3. Weighted averages of results of above methods

4. Use of late generation IOL calculation formulae

5. Intraoperative refraction of the eye in the aphakic state

V. **List the complications of the procedure, their prevention and management**

   A. **Post-operative ametropia**
      1. Hyperopic surprise is most frequently encountered
         a. In general, IOL implantation in eyes with prior RK results in early post-operative hyperopia
         b. The eye may require 3 months for the refraction to stabilize
         c. Therefore, early IOL exchange or placement of a piggyback IOL should not be undertaken until refractive stability has been achieved

   B. **Post-operative Increase in Aberrations**
      1. The increase in higher order aberrations after LASIK may be further increased with improper IOL selection (i.e. multifocal IOL)
      2. Selection of an Aspheric IOL may lessen the spherical aberration of myopic refractive surgery

VI. **Describe the considerations in interpretation of this diagnostic procedure**

   A. **Standard keratometry inaccurately reflects corneal refractive power after keratorefractive surgery**
      1. Careful measurement and calculation, including the use of an optimized IOL constant and advanced formula will add to the accuracy of IOL power selection

Additional Resources


