Refractive Surgery Overview

The goal of refractive surgery is deceptively straightforward and simple: To render the pt less reliant upon refractive accoutrements (ie, contacts and glasses). Ideally, a pt s/p refractive surgery would have 20/20 vision at all distances, under any lighting conditions, with no dysphotopsias (visual experiences that degrade vision quality), and with no risk of future negative repercussions vis a vis the long-term health and/or optical performance of the eye. Also ideally, the above could be achieved irrespective of pre-op refractive status and/or pre-existing ocular conditions.
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Current technology is unable to meet this lofty ideal, and thus refractive surgery necessitates compromises and trade-offs; eg, If you had to pick one, would you rather be spectacle-free at distance, or near? Would it be acceptable if you only needed glasses in dimly-lit restaurants? How bothersome would haloes around lights at night be? Because some aspect of the pt’s post-op visual life will be less than ideal, key to successful refractive surgery is 1) developing a solid understanding of the pt’s visual preferences and requirements, and 2) communicating effectively with the pt regarding what her post-op visual life will be; ie, establishing expectations that are realistic and achievable.
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Before delving into specific surgical techniques, let’s touch briefly on the optics of refractive error, starting with an overview of vergence.
The term *vergence* describes what light rays are doing in relation to each other.
Refractive Surgery Overview

- The term *vergence* describes what light rays are doing in relation to each other.
- With respect to a given point, light rays can:
  - spread out (*diverge*)
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- spread out (*diverge*)
- come together (*converge*)
The term **vergence** describes what light rays are doing in relation to each other.

With respect to a given point, light rays can:

- spread out (**diverge**)
- come together (**converge**)
- run parallel (**vergence = zero**)


![Diagram](image-url)
Refractive Surgery Overview

- Two basic types of spherical lenses
  - Plus
  - Minus
In this example, a plus lens causes previously parallel rays to converge to a point.
Refractive Surgery Overview

- **Plus lens**: induces convergence

  Rays exiting this plus lens are diverging; however, they are **less** divergent than they were prior to encountering it (i.e., convergence has been added)
In this example, a minus lens causes previously parallel rays to diverge from a point
● *Minus* lens: induces divergence

*Rays exiting this minus lens are converging; however, they are less convergent than they were prior to encountering it (i.e., divergence has been added)*
The refractive state of an eye—that is, whether it is *emmetropic, myopic* or *hyperopic*—is determined by the location of its *far point*. 
The refractive state of an eye—that is, whether it is emmetropic, myopic or hyperopic—is determined by the location of its **far point**

The far point is *the location in space from which rays will be focused on the retina when the eye is not accommodating*

*Accommodation* refers to conformational changes in the ciliary body/lens to facilitate vision at near.
In the *emmetropic* eye, the parallel rays from a location at infinity are focused to a point located precisely on the retina.
In the emmetropic eye, the parallel rays from a location at infinity are focused to a point located precisely on the retina. In other words, the far point of the emmetropic eye is at infinity.

Far Point of the emmetropic eye: Infinity
The Emmetropic Eye

In the emmetropic eye, the parallel rays from a location at infinity are focused to a point located precisely on the retina. In other words, the far point of the emmetropic eye is at infinity. Thus, emmetropes see 20/20 (or better) at distance without correction.

*Far Point of the emmetropic eye: Infinity*
In contrast to the sharp uncorrected distance vision of the emmetrope, consider the plight of the myope.
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In the myopic eye, rays from infinity meet in the vitreous.
In contrast to the sharp uncorrected distance vision of the emmetrope, consider the plight of the myope. In the myopic eye, rays from infinity meet in the vitreous. By the time they reach the retina, the rays have diverged to form a blur circle, not a focal point.
In contrast to the sharp uncorrected distance vision of the emmetrope, consider the plight of the myope. In the myopic eye, rays from infinity meet in the vitreous. By the time they reach the retina, the rays have diverged to form a blur circle, not a focal point. You could say the myopic eye has too much converging power for its length.
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The Myopic Eye

The myopic eye has too much converging power for its length.

Note that if the retina was here, the rays from infinity would be focused to a point.
In contrast to the sharp uncorrected distance vision of the emmetrope, consider the plight of the myope. In the myopic eye, rays from infinity meet in the vitreous. By the time they reach the retina, the rays have diverged to form a blur circle, not a focal point. You could say the myopic eye has too much converging power for its length. To be focused on the retina, the Far Point of a myopic eye will have to offset its excess convergence with an equivalent amount of divergence. To accomplish this...
The Myopic Eye

...the Far Point of a myopic eye is just anterior to the corneal plane. Rays from this location are still quite divergent when they reach the eye, and this divergence offsets the excess convergence that is built into the myopic eye. Thus, rays originating from the far point end up sharply focused at the retina.
...the Far Point of a myopic eye is just anterior to the corneal plane. Rays from this location are still quite divergent when they reach the eye, and this divergence offsets the excess convergence that is built into the myopic eye. Thus, rays originating from the far point end up sharply focused at the retina. This is why nearsighted individuals can read without glasses—they’re able to put the material at or near their far point.
The Hyperopic Eye

Parallel rays from infinity (vergence = 0)

Parallel rays from infinity

Now consider the hyperope.
The Hyperopic Eye

Parallel rays from infinity (vergence = 0)

Parallel rays from infinity

Now consider the hyperope.
In the hyperopic eye, rays from infinity never meet—they run out of eyeball first. Thus, like the myopic eye, the rays form a **blur circle**, not a focal point, at the retina.

This is where the rays would meet if they hadn't run into the retina.
Now consider the **hyperope**.
In the hyperopic eye, rays from infinity never meet—they run out of eyeball first. Thus, like the myopic eye, the rays form a blur circle, not a focal point, at the retina. You could say **the hyperopic eye has too little converging power for its length**.
Now consider the hyperope. In the hyperopic eye, rays from infinity never meet—they run out of eyeball first. Thus, like the myopic eye, the rays form a blur circle, not a focal point, at the retina. You could say the hyperopic eye has too little converging power for its length.
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In order to be conjugate to the retina, the Far Point of a hyperopic eye must contribute convergence to compensate for this lack of converging power. To accomplish this…
...the far point of a hyperopic eye is *behind* the corneal plane. It contributes *convergence* to make up for the inadequate native convergence of the hyperopic eye.
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...the far point of a hyperopic eye is behind the corneal plane. It contributes convergence to make up for the inadequate native convergence of the hyperopic eye. Thus, rays associated with the far point end up sharply focused at the retina. Don’t get it twisted—hyperopes can’t actually see behind their heads. (Do I really have to say that?) Unlike myopes—who can see at their far point just out in front of their faces—a hyperope is out of focus at all distances (absent correction or accommodation.)
Refractive Surgery Overview

- The myopic eye has too much *converging* power for its length, as we said.
The myopic eye has too much converging power for its length, as we said. Think of it this way: The myopic eye refracts light as if an extra ‘plus’ lens was built into it. This so-called error lens contributes the excess convergence that produces a myopic refractive error.
Refractive Surgery Overview

- The myopic eye has too much converging power for its length, as we said.

Think of it this way: The **myopic eye refracts light as if an extra ‘plus’ lens was built into it.** This so-called **error lens** contributes the excess convergence that produces a myopic refractive error.

This explains why **myopes wear minus lenses** to correct their refractive error—minus lenses are needed to offset the excess convergence induced by the plus error lenses in their eyes.
The myopic eye has too much *converging* power for its length, as we said.

In contrast, the hyperopic eye has too much *diverging* power for its length.
The myopic eye has too much *converging* power for its length, as we said.

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Thus, the hyperopic eye acts as if it has a *minus* error lens within it, contributing the excess divergence resulting in a hyperopic refractive error.
The myopic eye has too much **converging** power for its length, as we said.

In contrast, the hyperopic eye has too much **diverging** power for its length.

This explains why **hyperopes** wear **plus lenses** to correct their refractive error—plus lenses are needed to offset the excess divergence induced by the minus error lenses in their eyes.

Thus, the **hyperopic eye acts as if it has a minus error lens within it**, contributing the excess divergence resulting in a hyperopic refractive error.
The goal of refractive surgery is to produce an error-lens offset that is incorporated into the eye itself, rather than worn on (CLs) or near (glasses) its anterior surface.
Refractive Surgery Overview

As mentioned previously, refractive surgical procedures come in two basic forms—*intraocular* and *corneal*. 
Refractive Surgery Overview

Likewise, *intraocular procedures* come in two forms—*pseudophakic*, and *phakic IOL* (PIOL).
Refractive Surgery Overview

A pseudophakic procedure involves removing the native lens and replacing it with an IOL powered to put parallel rays on the retina. The surgery is identical to that performed for cataracts. (Such procedures are referred to as ‘clear lens extraction.’)
Refractive Surgery Overview

Intraocular

Phakic IOL

Corneal

Pseudophakic

In a *phakic IOL procedure* the native lens is left in place, and a corrective lens is placed in front of it—an ‘intraocular contact lens’ if you will.

**Myopic Eye**
- **Plus** error lens
- **Minus** corrective implant

**Hyperopic Eye**
- **Minus** error lens
- **Plus** corrective implant
Refractive Surgery Overview

Phakic IOL
Refractive Surgery Overview

Phakic IOL
Refractive Surgery Overview

Phakic IOL vaulting over the native lens
Refractive Surgery Overview

Refractive Surgery

Intraocular

Pseudophakic

Phakic IOL

Corneal

Before we get into cornea-based refractive surgeries, let's take a look at corneal optics
The shape of the human cornea is prolate, which means the central portion is steeper (ie, has a shorter radius of curvature) than the peripheral portion. On average, the central cornea is 3-4D steeper than the periphery.
Power differential of central vs peripheral cornea
(don’t memorize the numbers)
Refractive Surgery Overview

The anterior corneal surface adds about 49D of convergence to incoming light (note how the air-cornea interface looks like a ‘plus’ lens)

Light rays

+49D
However, the posterior corneal surface adds about 6D of divergence as light passes through it into the AC (note how the cornea-aqueous interface looks like a minus lens)
The net result across the cornea is an overall power of about +43D
The human eye averages about 60D of total convergence, implying (correctly) that the cornea accounts for roughly 2/3 of its focusing power.

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The human eye averages about 60D of total convergence, implying (correctly) that the cornea accounts for roughly 2/3 of its focusing power.

Of course, these are only averages. In order to perform keratorefractive surgery, one must have accurate measurements of central corneal power—ideally, at both its anterior and posterior surfaces.

The net result across the cornea is an overall power of about +43D.
Two technologies are widely employed to determine central corneal power: Corneal **topography**, and corneal **tomography**.
Corneal topography works by reflecting a set of concentric rings (collectively called a Placido disk) from the anterior corneal surface, and a computer analyzes the distances between, and shapes of, the reflected rings.
Refractive Surgery Overview

**Corneal topography** works by reflecting a set of concentric rings (collectively called a *Placido disk*) from the anterior corneal surface, and a computer analyzes the distances between, and shapes of, the reflected rings. Based on this analysis, the topographer creates a color-coded ‘map’ depicting the curvature across the corneal surface.
Refractive Surgery Overview

**Corneal topography** works by reflecting a set of concentric rings (collectively called a *Placido disk*) from the anterior corneal surface, and a computer analyzes the distances between, and shapes of, the reflected rings. Based on this analysis, the topographer creates a color-coded ‘map’ depicting the curvature across the corneal surface.

Corneal Placido-disk topography: Color map demonstrating *with-the-rule astigmatism* (ie, the cornea is steeper in its vertical meridian)
Refractive Surgery Overview

**Corneal tomography** works by mapping the anterior and posterior corneal surfaces in relation to one another. It allows for 3-D modeling of the cornea, including both anterior and posterior surface curvature and corneal thickness.
Refractive Surgery Overview

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--- *Scanning-slit*: A series of overlapping scans are directed at the cornea. The light reflects off both the anterior and posterior surfaces. These reflections are acquired and analyzed to produce a model of the central cornea.
Refractive Surgery Overview

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--- **Scanning-slit**: A series of overlapping scans are directed at the cornea. The light reflects off both the anterior and posterior surfaces. These reflections are acquired and analyzed to produce a model of the central cornea.

--- **Scheimpflug imaging**: A series of Scheimpflug images are taken and analyzed with respect to anterior and posterior corneal curvature and corneal thickness. The data from each image are knitted together to produce a model of the cornea.
Refractive Surgery Overview

Pentacam corneal tomographer readout
Refractive Surgery Overview

A) Anterior corneal values
- $K_1, K_2, K_m$: The two major meridians ($K_1, K_2$). $K_m$ is the average of $K_1$ and $K_2$
- $R_f, R_s, R_m$: Radii corresponding with $K_1, K_2, and K_m$, respectively
- QS: Quality score (i.e. “OK,” “Data gaps,” “Fix,” “Model”)
- Axis: The meridian that requires no cylinder power to correct astigmatism
- Astig: The central corneal astigmatism

B) Posterior corneal values
The same variables described for the back of the cornea.

C), D) Fuggedaboudit (too much for this overview)
In addition to determining corneal power, pre-op corneal mapping is employed to determine whether a prospective keratorefractive pt has a *corneal ectasia*. 
In addition to determining corneal power, pre-op corneal mapping is employed to determine whether a prospective keratorefractive pt has a **corneal ectasia**. An ectasia is a noninflammatory condition characterized by progressive corneal thinning, the end result of which is corneal warpage. Pre-existing ectasia is a strong contraindication to many elective keratorefractive procedures, eg, LASIK.
In addition to determining corneal power, pre-op corneal mapping is employed to determine whether a prospective keratorefractive pt has a *corneal ectasia*. An ectasia is a noninflammatory condition characterized by progressive corneal thinning, the end result of which is corneal warpage. Pre-existing ectasia is a strong contraindication to many elective keratorefractive procedures, eg, LASIK. The two most common ectasias are *keratoconus* (KCN) and *pellucid marginal degeneration* (PMD).
Refractive Surgery Overview

KCN
Topography in KCN: Classic *inferior corneal steepening*
Refractive Surgery Overview

Topography in PMD: Classic *kissing doves*
Corneal Placido-disk topography: Mires typical of keratoconus
Most corneal refractive surgeries involve altering the shape of the cornea in a way that impacts the vergence it imparts to incoming light.
Most corneal refractive surgeries involve altering the shape of the cornea in a way that impacts the vergence it imparts to incoming light. These alterations can involve incising the cornea, lasering it, or some other means.
In a *keratoablative laser procedures* (eg, LASIK), the cornea is reshaped so as to offset the effect of the error lens.
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Refractive Surgery Overview

**Refractive Surgery**

- **Intraocular**
  - Pseudophakic
  - Phakic IOL

- **Corneal**
  - Incisional
  - Laser
  - Other

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**Think of it as shaving down the peak of a mountain in order to make the structure more mesa-like**

- **Myopic Eye**
  - Plus error lens
  - In myopic keratoablative surgery, the central cornea is flattened
In a keratoablative laser procedure (e.g., LASIK), the cornea is reshaped so as to offset the effect of the error lens. In myopic keratoablative surgery, the central cornea is flattened to reduce its converging power. Hyperopic keratoablative surgery is the opposite—the central cornea is steepened to increase its converging power.
Refractive Surgery Overview

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Note that, by definition, keratoablative refractive surgery involves reshaping the central cornea (and thereby altering its refractive power) via the removal (by annihilation) of corneal tissue.
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*One laser-based keratorefractive procedure does not involve tissue annihilation, rather, in it a section of corneal stroma is carved, then removed en bloc.*

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Refractive Surgery Overview

Refractive Surgery

Intraocular
- Pseudophakic
- Phakic IOL

Corneal
- Incisional
- Laser
  - PhotoRefractive Keratectomy (PRK)
- Other

These are the laser-based keratorefractive procedures covered in the BCSC book.
Refractive Surgery Overview

Refractive Surgery

Intraocular
- Pseudophakic
- Phakic IOL

Corneal
- Incisional
- Laser
- Other
  - PhotoRefractive Keratectomy (PRK)
  - LASer SubEpithelial Keratomileusis (LASEK)

These are the laser-based keratorefractive procedures covered in the BCSC book
Refractive Surgery Overview

Refractive Surgery

Intraocular
- Pseudophakic
- Phakic IOL

Corneal
- Incisional
- Laser
  - PhotoRefractive Keratectomy (PRK)
  - LASer SubEpithelial Keratomileusis (LASEK)
  - Epipolis LASer In-situ Keratomileusis (Epi-LASIK)

Other

These are the laser-based keratorefractive procedures covered in the BCSC book
Refractive Surgery Overview

Refractive Surgery

Intraocular
- Pseudophakic
- Phakic IOL

Corneal
- Incisional
- Laser
  - PhotoRefractive Keratectomy (PRK)
  - LASer SubEpithelial Keratomileusis (LASEK)
  - Epi-PLASer In-situ Keratomileusis (Epi-LASIK)
  - LASer In-situ Keratomileusis (LASIK)
- Other

These are the *laser-based keratorefractive procedures* covered in the BCSC book.
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Refractive Surgery Overview

Refractive Surgery

Intraocular
- Pseudophakic
- Phakic IOL

Corneal
- Incisional
- Laser
- Other

- PhotoRefractive Keratectomy (PRK)
- LASer SubEpithelial Keratomileusis (LASEK)
- Epipois LASer In-situ Keratomileusis (Epi-LASIK)
- LASer In-situ Keratomileusis (LASIK)
- SMall-Incision Lenticule Extraction (SMILE)

These are the laser-based keratorefractive procedures covered in the BCSC book. All are ablative except for SMILE, which is the nonablative one referred to on a recent slide.
Refractive Surgery Overview

Intraocular
- Pseudophakic
- Phakic IOL

Corneal
- Incisional
- Laser
- Other

In the SMILE procedure, the femtosecond laser, with its ability to be focused at very precise depths within the cornea, is used to carve a segment (called a lenticule) of very specific shape within the stroma without disturbing the overlying or underlying tissue.

**Small- Incision Lenticule Extraction** SMILE

These are the *laser-based keratorefractive procedures* covered in the BCSC book. All are ablative except for **SMILE**, which is the nonablative one referred to on a recent slide.
Refractive Surgery Overview

In the SMILE procedure, the femtosecond laser, with its ability to be focused at very precise depths within the cornea, is used to carve a segment (called a lenticule) of very specific shape within the stroma without disturbing the overlying or underlying tissue. The lenticule is then removed en bloc by being extracted through a very small incision (also created by the femto) that connects the femto-created intrastromal space and the corneal surface.

SMall-Incision Lenticule Extraction → SMILE

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Refractive Surgery Overview

Creation of lenticule and small access (< 4 mm)

Removal of the lenticule

Refractive error is corrected

SMILE
Refractive Surgery Overview

In the SMILE procedure, the femtosecond laser, with its ability to be focused at very precise depths within the cornea, is used to carve a segment (called a *lenticule*) of very specific shape within the stroma without disturbing the overlying or underlying tissue. The lenticule is then removed *en bloc* by being extracted through a very small incision (also created by the femto) that connects the femto-created intrastromal space and the corneal surface. The resulting loss of tissue reshapes the central corneal surface in a way that produces a desired change in its refractive power.

**SMall-**Incision **Lenticule** Extraction → **SMILE**

These are the laser-based keratorefractive procedures covered in the BCSC book. All are ablative except for **SMILE**, which is the nonablative one referred to on a recent slide.
In *keratoablative procedures*, remodeling of the central cornea occurs via annihilation of the corneal stroma with an excimer laser. But before the excimer can get to the stroma, the corneal epithelium has to get out of the way.
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In keratoablative procedures, remodeling of the central cornea occurs via annihilation of the corneal stroma with an excimer laser. But before the excimer can get to the stroma, the corneal epithelium has to get out of the way. The four keratoablative procedures differ solely in how the epithelium is handled.

In PRK, the handling of the epithelium couldn’t be more straightforward. It is simply cast aside—via scraping, chemical destruction, brushing, lasing, etc. This makes PRK the simplest of the laser keratorablative procedures: get the epithelium out of the way, then forget about it.
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In PRK, the handling of the epithelium couldn’t be more straightforward. It is simply cast aside—via scraping, chemical destruction, brushing, lasing, etc. This makes PRK the simplest of the laser keratorablative procedures: get the epithelium out of the way, then forget about it. However, PRK is associated with several post-operative complications that render it problematic, two of which are 1) it produces significant post-op pain, and 2) it is associated with an increased risk of post-op haze formation—a potentially sight-threatening development.
Post-PRK haze
Refractive Surgery Overview

In keratoablative procedures, remodeling of the central cornea occurs via annihilation of the corneal stroma with an excimer laser. But before the excimer can get to the stroma, the corneal epithelium has to get out of the way. The four keratoablative procedures differ solely in how the epithelium is handled.

In contrast, the well-known LASIK procedure deals with the epithelium by doing an end-run around it. A hinged flap is cut in the stroma and reflected, thereby moving the overlying epithelium out of the treatment area. The underlying stromal bed is then lased, and the flap (with its intact epithelium) is laid back in place.
Refractive Surgery Overview

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Refractive Surgery Overview

Step 1: Corneal flap is created with a microkeratome.

Step 2: The corneal flap is folded back.

Step 3: Excimer laser beam reshapes the cornea.

Step 4: The corneal flap is folded back in place.

LASIK
Ref refractive surgery overview

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Like PRK, LASEK is a ‘surface ablation’ procedure. However, it deals very differently with the corneal epithelium.
Refractive Surgery Overview

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Like PRK, LASEK is a ‘surface ablation’ procedure. However, it deals very differently with the corneal epithelium. In LASEK, the epithelium is chemically devitalized and loosened by bathing it in an alcohol solution. The loosened epithelium is then folded back, and the ablation is performed. Following the ablation, this ‘epithelial flap’ is smoothed back into place and covered with a bandage CL.
RefRACTIVE SURGERY OVERVIEW

1. 
2. 
3. 
4. 

LASEK
Ref refractive surgery overview

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Like LASEK, epi-LASIK is a surface-ablation variant designed to avoid the drawbacks of PRK. In it, a blunt keratome (an ‘epikeratome’) slides under the epithelium, separating it.

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Epi-LASIK

(For comparison)
Refractive Surgery Overview

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The four keratoablative procedures differ solely in how the epithelium is handled.

Like LASEK, epi-LASIK is a surface-ablation variant designed to avoid the drawbacks of PRK. In it, a blunt keratome (an ‘epikeratome’) slides under the epithelium, separating it. The epithelial flap thus created is folded back, then re-placed after the stroma has been ablated. (BTW, epipolis is a Greek word meaning ‘superficial.’)
Refractive Surgery Overview

Refractive Surgery

Intraocular
- Pseudophakic
- Phakic IOL

Corneal
- Incisional
  - Radial Keratotomy (RK)
- Laser
  - PRK
  - LASEK
  - Epi-LASIK
  - LASIK
  - SMILE
- Other

These are the incisional keratorefractive procedures covered in the BCSC book.
These are the *incisional keratorefractive procedures* covered in the *BCSC* book.
These are the *incisional keratorefractive procedures* covered in the *BCSC* book.
A set of incisions oriented radially (radial keratotomy, RK) will flatten the central cornea, and thereby reduce its converging power. Thus, RK can be used to treat myopia.
Refractive Surgery Overview

Figure 2: Incisions
Images A through E: Example of eye with 4, 8, 12, 16, and 20 incisions.

Radial keratotomy
A set of incisions oriented radially (radial keratotomy, RK) will flatten the central cornea, and thereby reduce its converging power. Thus, RK can be used to treat myopia. Note that because incisions cannot produce overall steepening of the central cornea, RK cannot be used to treat hyperopia.
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OTOH, peripheral incisional procedures to offset astigmatic refractive error are an important and oft-used surgical technique.
Refactive Surgery Overview

Refactive Surgery

Intraocular
- Pseudophakic
- Phakic IOL

Corneal
- Incisional
- Laser
  - PRK
  - LASEK
  - Epi-LASIK
  - LASIK
  - SMILE
- Other

Specifically, this refers to AK and LRI

OTOH, *peripheral* incisional procedures to offset *astigmatic* refractive error are an important and oft-used surgical technique
Both AK and LRI incisions are placed on the steep meridian of the cornea, in pairs located on opposite sides of the cornea. AK incisions are made in the paracentral cornea, whereas LRI are made at the limbus (as their name implies).
Refractive Surgery Overview

AK incisions

LR incisions

Limbal Relaxing Incisions
Both AK and LRI incisions are placed on the steep meridian of the cornea, in pairs located on opposite sides of the cornea. AK incisions are made in the paracentral cornea, whereas LRI are made at the limbus (as their name implies). Both techniques have the effect of flattening the meridian in which they're placed, but through a process called coupling, steepening the meridian 90 deg away.
Refractive Surgery Overview

Corneal Coupling Effect

Before Corneal Incisions

After Corneal Incisions

Coupling
Both AK and LRI incisions are placed on the steep meridian of the cornea, in pairs located on opposite sides of the cornea. AK incisions are made in the paracentral cornea, whereas LRI are made at the limbus (as their name implies). Both techniques have the effect of flattening the meridian in which they’re placed, but through a process called coupling, steepening the meridian 90 deg away. The most common indication for AK is correction of astigmatism in an eye that is s/p penetrating keratoplasty.
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Refractive Surgery Overview

- Intraocular
  - Pseudophakic
  - Phakic IOL

- Corneal
  - Incisional
  - Laser
    - RK
    - AK
    - LRI
    - PRK
    - LASEK
    - Epi-LASIK
    - LASIK
    - SMILE

- Other

 Conductive Keratoplasty (CK)

These are the ‘other’ procedures covered in the BCSC book.
Refractive Surgery Overview

Intraocular
- Pseudophakic
- Phakic IOL

Corneal
- Incisional
  - RK
  - AK
  - LRI
- Laser
  - PRK
  - LASEK
  - Epi-LASIK
  - LASIK
  - SMILE
- Other
  - Conductive Keratoplasty: CK
  - Small Aperture Inlay: SAI

These are the ‘other’ procedures covered in the BCSC book.
Refractive Surgery Overview

Refractive Surgery

Intraocular
- Pseudophakic
- Phakic IOL

Corneal
- Incisional
  - RK
  - AK
  - LRI
- Laser
  - PRK
  - LASEK
  - Epi-LASIK
  - LASIK
  - SMILE
- Other
  - Conductive Keratoplasty (CK)
  - Small Aperture Inlay (SAI)
  - Corneal Reshaping Inlay (CRI)

These are the ‘other’ procedures covered in the BCSC book
Refractive Surgery Overview

Refractive Surgery

Intraocular
- Pseudophakic
- Phakic IOL

Corneal
- Incisional
- Laser
  - RK
  - AK
  - LRI
  - PRK
  - LASEK
  - Epi-LASIK
  - LASIK
  - SMILE

Other
- Conductive Keratoplasty
- Small Aperture Inlay
- Corneal Reshaping Inlay
- Corneal CROSS Linking

These are the ‘other’ procedures covered in the BCSC book
Refractive Surgery Overview

Refractive Surgery

Intraocular
- Pseudophakic
- Phakic IOL

Corneal
- Incisional
  - RK
  - AK
  - LRI
- Laser
  - PRK
  - LASEK
  - Epi-LASIK
  - LASIK
  - SMILE
- Other
  - Conductive Keratoplasty (CK)
  - Small Aperture Inlay (SAI)
  - Corneal Reshaping Inlay (CRI)
  - Corneal CROSS Linking (CXL)
  - Intrastromal Corneal Ring Segments (ICRS)

These are the ‘other’ procedures covered in the BCSC book
Refractive Surgery Overview

Refractive Surgery

Intraocular
- Pseudophakic
- Phakic IOL

Corneal
- Incisional
  - RK
  - AK
  - LRI
- Laser
  - PRK
  - LASEK
  - Epi-LASIK
  - LASIK
  - SMILE
- Other

These three treat presbyopia
- Conductive Keratoplasty (CK)
- Small Aperture Inlay (SAI)
- Corneal Reshaping Inlay (CRI)
- Corneal CROSS Linking (CXL)
- Intrastromal Corneal Ring Segments (ICRS)
Refractive Surgery Overview

Refractive Surgery

Intraocular
- Pseudophakic
- Phakic IOL

Corneal
- Incisional
- Laser
  - RK
  - AK
  - LRI
  - PRK
  - LASEK
  - Epi-LASIK
  - LASIK
  - SMILE

Other

These three treat presbyopia
- Conductive Keratoplasty
- Small Aperture Inlay
- Corneal Reshaping Inlay

These two treat keratoconus
- Corneal CROSS Linking
- Intrastromal Corneal Ring Segments
In **CK**, a thermal probe is used to produce a set of focal corneal scars. The scars produce local corneal steepening, thereby increasing convergence and improving vision at near.
In CK, a thermal probe is used to produce a set of focal corneal scars. The scars produce local corneal steepening, thereby increasing convergence and improving vision at near.

The SAI is a tiny donut-shaped disc that is implanted in the central corneal stroma. Its central aperture produces a pinhole effect to improve near vision.
Refractive Surgery Overview

Made from Polyvinylidene Fluoride (PVDF)
Refractive Surgery Overview
In **CK**, a thermal probe is used to produce a set of focal corneal scars. The scars produce local corneal steepening, thereby increasing convergence and improving vision at near.

The **SAI** is a tiny donut-shaped disc that is implanted in the central corneal stroma. Its central aperture produces a pinhole effect to improve near vision.

Like the SAI, the **CRI** is a tiny device implanted in the central corneal stroma. However, its mechanism of action is different—it is disc-shaped, and its central ‘bump’ increases the curvature of the overlying corneal surface, increasing power and thus improving near vision.
Refractive Surgery Overview

CRI
CXL involves the induction of a chemical reaction that strengthens the bonds between corneal stroma fibrils. The result is a stabilization of the keratoconus process.
Refractive Surgery Overview

BEFORE CXL: LESS CROSSLINKING
= WEAKER CORNEA

AFTER CXL: MORE CROSSLINKING
= STRONGER CORNEA

CXL concept
Refractive Surgery Overview

1. We remove the Epithelium

2. Riboflavin (Vitamin B2) eye drops are applied onto the cornea

3. 1 minute later, the solution is irrigated or washed away by the surgeon

4. An ultra-violet light (UVA) illuminates the Riboflavin solution for the corneal cross-linking procedure

CXL: Process
Refractive Surgery Overview

CXL: Process
CXL involves the induction of a chemical reaction that strengthens the bonds between corneal stroma fibrils. The result is a stabilization of the keratoconus process.

ICRS employs semicircular segments of PMMA. These segments are placed in the peripheral corneal stroma, where they produce local flattening.
Refractive Surgery Overview

Intrastromal ring segments
Refractive Surgery Overview

Intrastromal ring segments *in situ*
Refractive Surgery Overview

Intrastromal ring segments placed for KCN
That’s it! Go through this slide-set a couple of times (at least) until you feel like you have a handle on it. When you’re ready, do slide-set RS1, which covers this material in a Q&A format (and more detail).