What are the three incisional procedures covered in the Refractive Surgery book?
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Incisional Corneal Refractive Surgery

Refractive Surgery

Intraocular

Pseudophakic

Phakic IOL

Iris-fixated

Sulcus-fixated

Corneal

Incisional

Laser

RK?

AK

LRI

Other

PRK

LASEK

Epi-LASIK

LASIK

SMILE

CK

SAI

CRI

CXL

ICRS

What does RK stand for?
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What does RK stand for?
Radial Keratotomy
Refractive Surgery

Intraocular
- Pseudophakic
  - Refractive lens exchange (RLE)
- Phakic IOL
  - Iris-fixated
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Corneal
- Incisional
  - RK
  - AK?
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What does **RK** stand for?  
Radial **K**eratotomy

What does **AK** stand for?  
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Incisional Corneal Refractive Surgery

Refractive Surgery

Intraocular
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- Phakic IOL
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  - Iris-fixated
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Corneal
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Limbal Relaxing Incisions
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Figure 2: Incisions
Images A through E: Example of eye with 4, 8, 12, 16, and 20 incisions.

Radial keratotomy
Radial keratotomy: 78 incisions!
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Schematic diagrams of the effect of radial incisions. A, 8-incision radial keratotomy (RK) with circular central optical zone (*dashed circle*), which shows the limit of the inner incision length.
Incisional Corneal Refractive Surgery

Schematic diagrams of the effect of radial incisions. A, 8-incision radial keratotomy (RK) with circular central optical zone (dashed circle), which shows the limit of the inner incision length. B, Cross-sectional view of the cornea, pre-RK. C, Post-RK the corneal periphery steepens, thereby inducing flattening in the central cornea.
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Recall that hyperopes need additional plus-power to offset their hyperopia. Thus, to correct hyperopia, keratorefractive surgery has to steepen the central cornea to create the needed additional plus-power. But incising the cornea (ie, RK) can only flatten the central cornea—it cannot steepen it. So no RK for hyperopes.
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Refractive Surgery

Intraocular

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The radial cuts gape, causing the peripheral cornea to bulge and steepen. This steepening of the peripheral cornea leads inevitably to an increase in which higher-order aberration?

**Spherical aberration**

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**This steepens the peripheral cornea**

Steepening of the peripheral cornea leads inevitably to an increase in which higher-order aberration?
**Incisional Corneal Refractive Surgery**

**Refractive Surgery**
- **Intraocular**
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How much steeper (in diopters) is the typical central cornea than the typical peripheral cornea?
3-4
Incisional Corneal Refractive Surgery

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What is the term for this shape? Prolate

How much steeper (in diopters) is the typical central cornea than the typical peripheral cornea? 3-4
Power differential of central vs peripheral virgin cornea
Incisional Corneal Refractive Surgery

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- Pseudophakic
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For more, see the slide-set Corneal Optics (RS3).
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In two words, what is the main short-term problem with RK?

'Diurnal fluctuation'

What does this refer to?
To the fact that a significant proportion of RK eyes are more hyperopic upon awakening in the morning.

Is this hyperopic shift permanent?
No. As the day proceeds, the extra hyperopia 'wears off,' and the eye reverts to its previous state.

What accounts for diurnal fluctuation?
Hypoxic edema. Closed eyelids during sleep deprive the cornea of O2, and the resulting hypoxia causes the incisions to swell a little. This swelling in turn induces increased flattening of the central cornea, resulting in more hyperopia. After several hours of O2 exposure while the eyes are open, the edema dissipates, and the excess hyperopia resolves.
Refractive Surgery

Incisional Corneal Refractive Surgery

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No. As the day proceeds, the extra hyperopia ‘wears off,’ and the eye reverts to its previous state

What accounts for diurnal fluctuation?
Hypoxic edema. Closed eyelids during sleep deprive the cornea of O2, and the resulting hypoxia causes the incisions to swell a little. This swelling in turn induces increased flattening of the central cornea, resulting in more hyperopia. After several hours of O2 exposure while the eyes are open, the edema dissipates, and the excess hyperopia resolves.
In two words, what is the main short-term problem with RK?
‘Diurnal fluctuation’

What does this refer to?
To the fact that a significant proportion of RK eyes are more hyperopic upon awakening in the morning

Is this hyperopic shift permanent?
No. As the day proceeds, the extra hyperopia ‘wears off,’ and the eye reverts to its previous state

What accounts for diurnal fluctuation?
**Hypoxic edema.** Closed eyelids during sleep deprive the cornea of O₂, and the resulting hypoxia causes the incisions to swell a little. This swelling in turn induces increased flattening of the central cornea, resulting in more hyperopia.
Incisional Corneal Refractive Surgery

Briefly, how is RK performed?
Radial incisions are made that extend from the peripheral cornea to the edge of the 'optical zone' (central portion of the cornea bounded by a 3-4 mm diameter ring).

How deep are these cuts made?
Quite deep—about 85-90% corneal thickness.

How many cuts are made?
Usually 4 or 8, occasionally 16, hopefully not 32 (although it's been done, unfortunately).

How do radial cuts correct myopia?
The radial cuts gape, causing the peripheral cornea to bulge. This steepens the peripheral cornea, which in turn flattens the central cornea. Essentially, RK works by redistributing corneal power from the central cornea to the peripheral cornea.

In two words, what is the main short-term problem with RK?
'Diurnal fluctuation'

What does this refer to?
To the fact that a significant proportion of RK eyes are more hyperopic upon awakening in the morning.

Is this hyperopic shift permanent?
No. As the day proceeds, the extra hyperopia 'wears off,' and the eye reverts to its previous state.

What accounts for diurnal fluctuation?
Hypoxic edema. Closed eyelids during sleep deprive the cornea of $O_2$, and the resulting hypoxia causes the incisions to swell a little. This swelling in turn induces increased flattening of the central cornea, resulting in more hyperopia. After several hours of $O_2$ exposure while the eyes are open, the edema dissipates, and the excess hyperopia resolves.
**Incisional Corneal Refractive Surgery**

**Refractive Surgery**

- **Intraocular**
  - Pseudophakic
  - Phakic IOL (Intraocular Pseudophakic Phakic IOL)

- **Corneal**
  - Incisional
    - RK
  - Laser
    - PRK
  - Other
    - CK

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**Briefly, how is RK performed?**
Radial incisions are made that extend from the peripheral cornea to the edge of the ‘optical zone’ (central portion of the cornea) to the edge of the sclera.

**How deep are these cuts made?**
Quite deep—about 85-90% corneal thickness.

**How many cuts are made?**
Usually 4 or 8, occasionally 16, hopefully not 32 (although it’s been done, unfortunately).

**How do radial cuts correct myopia?**
The radial cuts gape, causing the peripheral cornea to bulge. This steepens the peripheral cornea, which in turn flattens the central cornea. Essentially, RK works by redistributing corneal power from the central cornea to the peripheral cornea.

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**In two words, what is the main long-term problem with RK?**
'Hyperopic drift'
To the fact that a significant proportion of RK eyes gradually become more and more hyperopic over time.

According to the Prospective Evaluation of Radial Keratotomy (PERK) study, what percentage of RK eyes will manifest a diopter or more of hyperopic drift after 10 years?
Just over 40!
**Incisional Corneal Refractive Surgery**

Briefly, how is RK performed?
Radial incisions are made that extend from the peripheral cornea to the edge of the ‘optical zone’ (central portion of the cornea bounded by a 3-4 mm diameter ring). The cuts are quite deep—about 85-90% of corneal thickness. Usually, 4 or 8 cuts are made, occasionally 16, but not 32 (although it’s been done, unfortunately).

How deep are these cuts made?
Quite deep—about 85-90% corneal thickness.

How many cuts are made?
Usually 4 or 8, occasionally 16, hopefully not 32 (although it’s been done, unfortunately).

How do radial cuts correct myopia?
The radial cuts gape, causing the peripheral cornea to bulge. This steepens the peripheral cornea, which in turn flattens the central cornea. Essentially, RK works by redistributing corneal power from the central cornea to the peripheral cornea.

In two words, what is the main long-term problem with RK?
‘Hyperopic drift’

(Note: ‘Hyperopic drift’ is AKA progressive flattening effect of surgery)
Briefly, how is RK performed?
Radial incisions are made that extend from the peripheral cornea to the edge of the ‘optical zone’ (central portion of the cornea that is bounded by a 3-4 mm diameter ring).

In two words, what is the main long-term problem with RK?
‘Hyperopic drift’

What does this refer to?

The radial cuts gape, causing the peripheral cornea to bulge. This steepens the peripheral cornea, which in turn flattens the central cornea. Essentially, RK works by redistributing corneal power from the central cornea to the peripheral cornea.
Incisional Corneal Refractive Surgery

Refractive Surgery

Intraocular

Pseudophakic

Phakic IOL

Corneal

Refractive lens exchange (RLE)

Incisional

Laser

Other

RK

PRK

CK

Briefly, how is RK performed?
Radial incisions are made that extend from the peripheral cornea to the edge of the ‘optical zone’ (central portion of the cornea) to the edge of the cornea. So far, the incisions are:

- How deep are these cuts made?
  Quite deep—about 85–90% corneal thickness

- How many cuts are made?
  Usually 4 or 8, occasionally 16, hopefully not 32 (although it’s been done, unfortunately)

- How do radial cuts correct myopia?
  The radial cuts gape, causing the peripheral cornea to bulge. This steepens the peripheral cornea, which in turn flattens the central cornea. Essentially, RK works by redistributing corneal power from the central cornea to the peripheral cornea.

In two words, what is the main long-term problem with RK?
‘Hyperopic drift’

What does this refer to?
To the fact that a significant proportion of RK eyes gradually become more and more hyperopic over time.
Briefly, how is RK performed?
Radial incisions are made that extend from the peripheral cornea to the edge of the ‘optical zone’ (central portion of the cornea, excluding the rim). The incisions are usually 4 or 8, occasionally 16, but not 32, although it has been done in some cases.

How deep are these cuts made?
Quite deep—about 85-90% of corneal thickness.

How many cuts are made?
Usually 4 or 8, occasionally 16, not 32.

How do radial cuts correct myopia?
The radial cuts gape, causing the peripheral cornea to bulge. This steepens the peripheral cornea, which in turn flattens the central cornea. Essentially, RK works by redistributing corneal power from the central cornea to the peripheral cornea.

In two words, what is the main long-term problem with RK?
‘Hyperopic drift’

What does this refer to?
To the fact that a significant proportion of RK eyes gradually become more and more hyperopic over time.

According to the Prospective Evaluation of Radial Keratotomy (PERK) study, what percentage of RK eyes will manifest a diopter or more of hyperopic drift after 10 years?
Just over 40%.
In two words, what is the main long-term problem with RK?
‘Hyperopic drift’

What does this refer to?
To the fact that a significant proportion of RK eyes gradually become more and more hyperopic over time

According to the Prospective Evaluation of Radial Keratotomy (PERK) study, what percentage of RK eyes will manifest a diopter or more of hyperopic drift after 10 years?
Over 40!

The radial cuts gape, causing the peripheral cornea to bulge. This steepens the peripheral cornea, which in turn flattens the central cornea. Essentially, RK works by redistributing corneal power from the central cornea to the peripheral cornea.
Refractive Surgery

Incisional Corneal Refractive Surgery

Intraocular

Pseudophakic

Phakic IOL

Incisional

Laser

Other

RK

PRK

CK

Briefly, how is RK performed?
Radial incisions are made that extend from the peripheral cornea to the edge of the ‘optical zone’ (central portion of the cornea with good vision).

How deep are these cuts made?
Quite deep—about 85-90% corneal thickness.

How many cuts are made?
Usually 4 or 8, occasionally 16, hopefully not 32 (although it's been done, unfortunately).

How do radial cuts correct myopia?
The radial cuts gape, causing the peripheral cornea to bulge. This steepens the peripheral cornea, which in turn flattens the central cornea. Essentially, RK works by redistributing corneal power from the central cornea to the peripheral cornea.

In two words, what is the main long-term problem with RK?
‘Hyperopic drift’

What does this refer to?
To the fact that a significant proportion of RK eyes gradually become more and more hyperopic over time. According to the Prospective Evaluation of Radial Keratotomy (PERK) study, what percentage of RK eyes will manifest a diopter or more of hyperopic drift after 10 years?
Over 40!

For those pts with visually significant hyperopic drift, are they candidates for corrective keratorefractive surgery?
Yes, they can be treated with a keratoablativelaser procedure (eg LASIK; PRK). Which is preferable in a post-RK eye: a flap-based procedure (eg, LASIK), or a surface-based procedure (eg, PRK)? While either is acceptable, surface-based procedures are probably preferable, as trying to create a flap in a post-RK cornea can lead to incision-related complications.
Briefly, how is RK performed?
Radial incisions are made that extend from the peripheral cornea to the edge of the ‘optical zone’ (central portion of the cornea). These cuts affect the peripheral cornea.

In two words, what is the main long-term problem with RK?
‘Hyperopic drift’

For those pts with visually significant hyperopic drift, are they candidates for corrective keratorefractive surgery?
Yes, they can be treated with a keratoablative laser procedure (eg LASIK; PRK).
Briefly, how is RK performed?
Radial incisions are made that extend from the peripheral cornea to the edge of the ‘optical zone’ (central portion of the cornea) and beyond. The incisions are typically 85-90% of corneal thickness.

How deep are these cuts made?
Quite deep—about 85-90% corneal thickness.

How many cuts are made?
Usually 4 or 8, occasionally 16, hopefully not 32 (although it’s been done, unfortunately).

How do radial cuts correct myopia?
The radial cuts gape, causing the peripheral cornea to bulge. This steepens the peripheral cornea, which in turn flattens the central cornea. Essentially, RK works by redistributing corneal power from the central cornea to the peripheral cornea.

In two words, what is the main long-term problem with RK? ‘Hyperopic drift’

For those pts with visually significant hyperopic drift, are they candidates for corrective keratorefractive surgery? Yes, they can be treated with a keratoablative laser procedure (eg LASIK; PRK).

Which is preferable in a post-RK eye: a flap-based procedure (eg, LASIK), or a surface-based procedure (eg, PRK)? While either is acceptable, surface-based procedures are probably preferable, as trying to create a flap in a post-RK cornea can lead to incision-related complications.
Briefly, how is RK performed?
Radial incisions are made that extend from the peripheral cornea to the edge of the ‘optical zone’ (central portion of the cornea enclosed by a 3-4 mm diameter ring).

In two words, what is the main long-term problem with RK?
‘Hyperopic drift’

For those pts with visually significant hyperopic drift, are they candidates for corrective keratorefractive surgery?
Yes, they can be treated with a keratoablatative laser procedure (eg LASIK; PRK)

Which is preferable in a post-RK eye: a flap-based procedure (eg, LASIK), or a surface-based procedure (eg, PRK)?
While either is acceptable, surface-based procedures are probably preferable, as trying to create a flap in a post-RK cornea can lead to incision-related complications.

The Prospective Evaluation of Radial Keratotomy (PERK) study found that over 40% of RK eyes will manifest a diopter or more of hyperopic drift after 10 years.
Incisional Corneal Refractive Surgery

What is the other main problem associated with RK? (Hint: It’s not usually encountered until the pt is 60+ years old.)

Briefly, how is RK performed?
Radial incisions are made that extend from the peripheral cornea to the edge of the ‘optical zone’ (central portion of the cornea bounded by a 3-4 mm diameter ring).

How deep are these cuts made?
Quite deep—about 85-90% corneal thickness.

How many cuts are made?
Usually 4 or 8, occasionally 16, hopefully not 32 (although it’s been done, unfortunately.

How do radial cuts correct myopia?
The radial cuts gape, causing the peripheral cornea to bulge. This steepens the peripheral cornea, which in turn flattens the central cornea.

Essentially, RK works by redistributing corneal power from the central cornea to the peripheral cornea.

In two words, what is the main long-term problem with RK?
Hyperopic drift

What does this refer to?
To the fact that a significant proportion of RK eyes gradually become more and more hyperopic over time.

According to the Prospective Evaluation of Radial Keratotomy (PERK) study, what percentage of RK eyes will manifest a diopter or more of hyperopic drift after 10 years?
Over 40!
Incisional Corneal Refractive Surgery

Briefly, how is RK performed?
Radial incisions are made that extend from the peripheral cornea to the edge of the ‘optical zone’ (central portion of the cornea) and can be made in a variety of patterns.

In two words, what is the main long-term problem with RK?
Hyperopic drift

What does this refer to?
To the fact that a significant proportion of RK eyes gradually become more and more hyperopic over time.

According to the Prospective Evaluation of Radial Keratotomy (PERK) study, what percentage of RK eyes will manifest a diopter or more of hyperopic drift after 10 years?
Over 40!

The radial cuts gape, causing the peripheral cornea to bulge. This steepens the peripheral cornea, which in turn flattens the central cornea. Essentially, RK works by redistributing corneal power from the central cornea to the peripheral cornea.

What is the other main problem associated with RK? (Hint: It's not usually encountered until the pt is 60+ years old.)
Imprecision in IOL calculations for cataract surgery

How deep are these cuts made?
Quite deep--about 85-90% corneal thickness

How many cuts are made?
Usually 4 or 8, occasionally 16, hopefully not 32 (although it's been done, unfortunately)
Incisional Corneal Refractive Surgery

What is the other main problem associated with RK? (Hint: It’s not usually encountered until the pt is 60+ years old.)
Imprecision in IOL calculations for cataract surgery

Why does RK lead to imprecise IOL calcs?

Briefly, how is RK performed?
Radial incisions are made that extend from the peripheral cornea to the edge of the ‘optical zone’ (central portion of the cornea bounded by a 3-4 mm diameter ring)

In two words, what is the main long-term problem with RK?
‘Hyperopic drift’

What does this refer to?
To the fact that a significant proportion of RK eyes gradually become more and more hyperopic over time

According to the Prospective Evaluation of Radial Keratotomy (PERK) study, what percentage of RK eyes will manifest a diopter or more of hyperopic drift after 10 years?
Over 40!

The radial cuts gape, causing the peripheral cornea to bulge. This steepens the peripheral cornea, which in turn flattens the central cornea. Essentially, RK works by redistributing corneal power from the central cornea to the peripheral cornea.
Incisional Corneal Refractive Surgery

What is the other main problem associated with RK? (Hint: It's not usually encountered until the pt is 60+ years old.)
Imprecision in IOL calculations for cataract surgery

Why does RK lead to imprecise IOL calcs?
This is discussed in greater depth in the slide-set entitled IOL Calculations. But briefly, the problem lies in the way central corneal power is determined. Standard techniques (keratometry; Placido-disc topography) don't measure central power directly; rather, they measure power at about the 3-4 mm optical zone, then infer central power based on assumptions concerning the relationship between corneal curvature at these two areas.

Briefly, how is RK performed?
Radial incisions are made that extend from the peripheral cornea to the edge of the ‘optical zone’ (central portion of the cornea, typically 3-4 mm in diameter). These cuts are usually 4 or 8, occasionally 16, hopefully not 32 (although it's been done, unfortunately).

In two words, what is the main long-term problem with RK?
Hyperopic drift

What does this refer to?
To the fact that a significant proportion of RK eyes gradually become more and more hyperopic over time.

According to the Prospective Evaluation of Radial Keratotomy (PERK) study, what percentage of RK eyes will manifest a diopter or more of hyperopic drift after 10 years?
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Briefly, how is RK performed?
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How deep are these cuts made?
Quite deep—about 85-90% corneal thickness.

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What is the other main problem associated with RK? (Hint: It’s not usually encountered until the pt is 60+ years old.)
Imprecision in IOL calculations for cataract surgery.

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In two words, what is the main long-term problem with RK?
‘Hyperopic drift.’

What does this refer to?
To the fact that a significant proportion of RK eyes gradually become more and more hyperopic over time.

According to the Prospective Evaluation of Radial Keratotomy (PERK) study, what percentage of RK eyes will manifest a diopter or more of hyperopic drift after 10 years?
Over 40!
Refractive Surgery

Incisional Corneal Refractive Surgery

Briefly, how is RK performed?
Radial incisions are made that extend from the peripheral cornea to the edge of the ‘optical zone’ (central portion of the cornea bounded by a 3-4 mm diameter ring).

How deep are these cuts made?
Quite deep—about 85–90% corneal thickness.

How many cuts are made?
Usually 4 or 8, occasionally 16, hopefully not 32 (although it’s been done, unfortunately).

How do radial cuts correct myopia?
The radial cuts gape, causing the peripheral cornea to bulge. This steepens the peripheral cornea, which in turn flattens the central cornea. Essentially, RK works by redistributing corneal power from the central cornea to the peripheral cornea.

What is the other main problem associated with RK? (Hint: It’s not usually encountered until the pt is 60+ years old.)
Imprecision in IOL calculations for cataract surgery.

Why does RK lead to imprecise IOL calcs?
This is discussed in greater depth in the slide-set entitled IOL Calculations. But briefly, the problem lies in the way central corneal power is determined. Standard techniques (keratometry; Placido-disc topography) don’t measure central power directly; rather, they measure power at about the 3-4 mm optical zone, then infer central power based on assumptions concerning the relationship between corneal curvature at these two areas. The trouble is, these assumptions were developed with virgin corneas. By inducing central corneal flattening, RK radically alters the relationship between central power and power at the 3-4 mm optical zone; thus, the assumptions simply no longer apply.

If standard IOL calc techniques are applied to an RK eye, will the resulting ‘refractive surprise’ be myopic, or hyperopic?
Hyperopic.

In two words, what is the main long-term problem with RK?
‘Hyperopic drift’

What does this refer to?
To the fact that a significant proportion of RK eyes gradually become more and more hyperopic over time.

According to the Prospective Evaluation of Radial Keratotomy (PERK) study, what percentage of RK eyes will manifest a diopter or more of hyperopic drift after 10 years?
Over 40!

^other

A
**Incisional Corneal Refractive Surgery**

**What is the other main problem associated with RK?** (Hint: It’s not usually encountered until the pt is 60+ years old.)

Imprecision in IOL calculations for cataract surgery

**Why does RK lead to imprecise IOL calcs?**

This is discussed in greater depth in the slide-set entitled *IOL Calculations*. But briefly, the problem lies in the way central corneal power is determined. Standard techniques (keratometry; Placido-disc topography) don't measure central power directly; rather, they measure power at about the 3-4 mm optical zone, then infer central power based on assumptions concerning the relationship between corneal curvature at these two areas. The trouble is, these assumptions were developed with virgin corneas. By inducing central corneal flattening, RK radically alters the relationship between central power and power at the 3-4 mm optical zone; thus, the assumptions simply no longer apply.

**If standard IOL calc techniques are applied to an RK eye, will the resulting ‘refractive surprise’ be myopic, or hyperopic?** Hyperopic

**Briefly, how is RK performed?**

Radial incisions are made that extend from the peripheral cornea to the edge of the ‘optical zone’ (central portion of the cornea bounded by a 3-4 mm diameter ring).

**In two words, what is the main long-term problem with RK?** "Hyperopic drift"

**What does this refer to?**

To the fact that a significant proportion of RK eyes gradually become more and more hyperopic over time.

**According to the Prospective Evaluation of Radial Keratotomy (PERK) study, what percentage of RK eyes will manifest a diopter or more of hyperopic drift after 10 years?**

Over 40!

The radial cuts gape, causing the peripheral cornea to bulge. This *steepens* the peripheral cornea, which in turn *flattens* the central cornea. Essentially, RK works by redistributing corneal power from the central cornea to the peripheral cornea.
Incisional Corneal Refractive Surgery

What is the other main problem associated with RK? (Hint: It’s not usually encountered until the pt is 60+ years old.)

Imprecision in IOL calculations for cataract surgery

Why does RK lead to imprecise IOL calcs?

This is discussed in greater depth in the slide-set entitled IOL Calculations. But briefly, the problem lies in the way central corneal power is determined. Standard techniques (keratometry; Placido-disc topography) don’t measure central power directly; rather, they measure power at about the 3-4 mm optical zone, then infer central power based on assumptions concerning the relationship between corneal curvature at these two areas. The trouble is, these assumptions were developed with virgin corneas. By inducing central corneal flattening, RK radically alters the relationship between central power and power at the 3-4 mm optical zone.

If standard IOL calc techniques are applied to an RK eye, will the resulting ‘refractive surprise’ be myopic, or hyperopic?

Hyperopic

In two words, what is the main long-term problem with RK?

‘Hyperopic drift’

What does this refer to?

To the fact that a significant proportion of RK eyes gradually become more and more hyperopic over time.

According to the Prospective Evaluation of Radial Keratotomy (PERK) study, what percentage of RK eyes will manifest a diopter or more of hyperopic drift after 10 years?

Over 40!

The radial cuts gape, causing the peripheral cornea to bulge. This steepens the peripheral cornea, which in turn flattens the central cornea. Essentially, RK works by redistributing corneal power from the central cornea to the peripheral cornea.

Is there anything that can be done to reduce the likelihood of a hyperopic refractive surprise?

Yes. A number of alternative IOL power calculation techniques have been developed (see the IOL Calculations slide-set for details). The short version is as follows:

First, determine corneal power by either 1) measuring it directly (via a technology capable of doing so in a post-RK eye); 2) using keratometric measurements obtained pre-RK (usually difficult or impossible to obtain); or 3) performing a hard contact-lens overrefraction; then

Second, performing the calcs via several of the 3rd or 4th generation calc formula, then using the highest IOL power that pops out of those calcs.
Briefly, how is RK performed?
Radial incisions are made that extend from the peripheral cornea to the edge of the 'optical zone' (central portion of the cornea bounded by a 3-4 mm diameter ring)

How deep are these cuts made?
Quite deep—about 85-90% corneal thickness

How many cuts are made?
Usually 4 or 8, occasionally 16, hopefully not 32 (although it’s been done, unfortunately)

How do radial cuts correct myopia?
The radial cuts gape, causing the peripheral cornea to bulge. This steepens the peripheral cornea, which in turn flattens the central cornea. Essentially, RK works by redistributing corneal power from the central cornea to the peripheral cornea.

What is the other main problem associated with RK? (Hint: It’s not usually encountered until the pt is 60+ years old.)
Imprecision in IOL calculations for cataract surgery

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This is discussed in greater depth in the slide-set entitled IOL Calculations. But briefly, the problem lies in the way central corneal power is determined. Standard techniques (keratometry; Placido-disc topography) don’t measure central power directly; rather, they measure power at about the 3-4 mm optical zone, then infer central power based on assumptions concerning the relationship between corneal curvature at these two areas. The trouble is, these assumptions were developed with virgin corneas. By inducing central corneal flattening, RK radically alters the relationship between central power and power at the 3-4 mm optical zone; thus, the assumptions simply no longer apply.

If standard IOL calc techniques are applied to an RK eye, will the resulting ‘refractive surprise’ be myopic, or hyperopic?
Hyperopic

In two words, what is the main long-term problem with RK?
‘Hyperopic drift’

What does this refer to?
To the fact that a significant proportion of RK eyes gradually become more and more hyperopic over time

According to the Prospective Evaluation of Radial Keratotomy (PERK) study, what percentage of RK eyes will manifest a diopter or more of hyperopic drift after 10 years?
Over 40!

Is there anything that can be done to reduce the likelihood of a hyperopic refractive surprise?
Yes. A number of alternative IOL power calculation techniques have been developed (see the IOL Calculations slide-set for details).

Other Incisional Corneal Refractive Surgery
- PRK
- LASEK
- CK
- ICRS
- CXL
- LASIK
- SMILE
- Epi-LASIK
- RK
- AK
- LRI
Incisional Corneal Refractive Surgery

What is the other main problem associated with RK? (Hint: It’s not usually encountered until the pt is 60+ years old.)
Imprecision in IOL calculations for cataract surgery

Why does RK lead to imprecise IOL calcs?
This is discussed in greater depth in the slide-set entitled IOL Calculations. But briefly, the problem lies in the way central corneal power is determined. Standard techniques (keratometry; Placido-disc topography) don’t measure central power directly; rather, they measure power at about the 3-4 mm optical zone, then infer central power based on assumptions concerning the relationship between corneal curvature at these two areas. The trouble is, these assumptions were developed with virgin corneas. By inducing central corneal flattening, RK radically alters the relationship between central power and power at the 3-4 mm optical zone; thus, the assumptions simply no longer apply.

If standard IOL calc techniques are applied to an RK eye, will the resulting ‘refractive surprise’ be myopic, or hyperopic?
Hyperopic

In two words, what is the main long-term problem with RK?
‘Hyperopic drift’

What does this refer to?
To the fact that a significant proportion of RK eyes gradually become more and more hyperopic over time

According to the Prospective Evaluation of Radial Keratotomy (PERK) study, what percentage of RK eyes will manifest a diopter or more of hyperopic drift after 10 years?
Over 40!

Is there anything that can be done to reduce the likelihood of a hyperopic refractive surprise? Yes. A number of alternative IOL power calculation techniques have been developed (see the IOL Calculations slide-set for details). The short version is as follows:

First, determine corneal power by either 1) measuring it directly (via a technology capable of doing so in a post-RK eye); 2) using keratometric measurements obtained pre-RK (usually difficult or impossible to obtain); or 3) performing a hard contact-lens overrefraction.
Incisional Corneal Refractive Surgery

What is the other main problem associated with RK? (Hint: It’s not usually encountered until the pt is 60+ years old.)

Imprecision in IOL calculations for cataract surgery

Why does RK lead to imprecise IOL calcs?
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Second, performing the calcs via several of the 3rd or 4th generation calc formula, then using the highest IOL power that pops out of those calcs

What does this refer to?
To the fact that a significant proportion of RK eyes gradually become more and more hyperopic over time

According to the Prospective Evaluation of Radial Keratotomy (PERK) study, what percentage of RK eyes will manifest a diopter or more of hyperopic drift after 10 years?
Over 40!

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Refractive Surgery

Incisional Corneal Refractive Surgery

What is the other main problem associated with RK? (Hint: It’s not usually encountered until the pt is 60+ years old.)

Imprecision in IOL calculations for cataract surgery

Why does RK lead to imprecise IOL calcs?

This is discussed in greater depth in the slide-set entitled IOL Calculations. But briefly, the problem lies in the way central corneal power is determined. Standard techniques (keratometry; Placido-disc topography) don’t measure central power directly; rather, they measure power at about the 3-4 mm optical zone, then infer central power based on assumptions concerning the relationship between corneal curvature at these two areas. The trouble is, these assumptions were developed with virgin corneas. By inducing central corneal flattening, RK radically alters the relationship between central power and power at the 3-4 mm optical zone; thus, the assumptions simply no longer apply.

If standard IOL calc techniques are applied to an RK eye, will the resulting ‘refractive surprise’ be myopic, or hyperopic?

Hyperopic

In two words, what is the main long-term problem with RK?

‘Hyperopic drift’

What does this refer to?

To the fact that a significant proportion of RK eyes gradually become more and more hyperopic over time

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Over 40!

Is there anything that can be done to reduce the likelihood of a hyperopic refractive surprise?

Yes. A number of alternative IOL power calculation techniques have been developed (see the IOL Calculations slide-set for details). The short version is as follows:

First, determine corneal power by either 1) measuring it directly (via a technology capable of doing so in a post-RK eye); 2) using keratometric measurements obtained pre-RK (usually difficult or impossible to obtain); or 3) performing a hard contact-lens overrefraction; then

Second, performing the calcs via several of the 3rd or 4th generation calc formula, then using the highest IOL power that pops out of those calcs
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With regard to the IOL itself, can a toric and/or a multifocal lens be used in a post RK eye?
A toric lens can be considered, but multifocals should be avoided in these eyes.
Incisional Corneal Refractive Surgery

Refractive

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Briefly, how is RK performed?
Radial incisions are made that extend from the peripheral cornea to the edge of the ‘optical zone’ (central portion of the cornea bounded by a 3-4 mm diameter ring).

How deep are these cuts made?
Quite deep—about 85-90% corneal thickness.

How many cuts are made?
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What about the cataract surgery itself—are there any adjustments in technique that should be considered?
Yes. The surgeon should give consideration to employing a scleral-tunnel incision, in order to avoid ‘crossing’ the RK incisions.

If feasible, on the steep meridian.

In two words, what is the main long-term problem with RK?
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Incisional Corneal Refractive Surgery

Refractive

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If so, is the patient absolutely sure that he wants the incision to be placed on the steep meridian?
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Incisional Corneal Refractive Surgery

Refractive

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In two words, what is the main short-term problem with RK? 'Diurnal fluctuation'.

What does this refer to? To the fact that a significant proportion of RK eyes are more hyperopic upon awakening in the morning.

Is this hyperopic shift permanent? No. As the day proceeds, the extra hyperopia 'wears off', and the eye reverts to its previous state.

What accounts for diurnal fluctuation? Hypoxic edema. Closed eyelids during sleep deprive the cornea of O₂, and the resulting hypoxia causes the incisions to swell a little. This swelling in turn induces increased flattening of the central cornea, resulting in more hyperopia. After several hours of increased O₂ exposure while the eyes are open, the edema dissipates, and the excess hyperopia resolves.

In two words, what is the main long-term problem with RK? 'Hyperopic drift'.

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If standard IOL calc techniques are applied to an RK eye, will the resulting 'refractive surprise' be myopic, or hyperopic? Hyperopic.

Because of these and other issues, RK is considered 'obsolete,' and thus is no longer performed in the US.
There is another procedure, similar to AK and LRI, that was at one time commonly used to correct astigmatism, but is rarely used today. What is it?

Transverse keratotomy differs from AK and LRI in that AK/LRI incisions are curved, whereas transverse keratotomy incisions are straight.
There is another procedure, similar to AK and LRI, that was at one time commonly used to correct astigmatism, but is rarely used today. What is it? **Transverse keratotomy**

(Note: ‘Transverse keratotomy’ is aka **tangential keratotomy**)

**Incisional Corneal Refractive Surgery**

- **Corneal**
  - Incisional
    - RK
    - AK
    - LRI
    - **Transverse keratotomy**
  - Laser
    - PRK
    - LASEK
    - Epi-LASIK
    - LASIK
    - SMILE
  - Other
    - CK
    - SAI
    - CRI
    - CXL
    - ICRS

- **Intraocular**
  - Pseudophakic
  - Phakic IOL
Refractive Surgery

Incisional Corneal Refractive Surgery

Intraocular

Pseudophakic

Phakic IOL

Corneal

Incisional

Laser

Other

RK

PRK

CK

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In what fundamental way does transverse keratotomy differ from AK and LRI?
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Transverse keratotomy

In what fundamental way does transverse keratotomy differ from AK and LRI?
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Incisional Corneal Refractive Surgery

Schematic diagrams of incisions used in astigmatic keratotomy. Flattening is induced in the axis of the incisions (at 90° in this case), and steepening is induced 90° away from the incisions (at 180° in this case).
In what fundamental way does AK differ from LRI?

Incisional Corneal Refractive Surgery

Refractive Surgery

Intraocular

Pseudophakic

Phakic IOL

Corneal

Incisional

Laser

Other

Incisional

RK

AK

LRI

PRK

LASEK

Epi-LASIK

LASIK

SMILE

CXL

ICRS

Other

CK

SAI

CRI
In what fundamental way does AK differ from LRI? In terms of the location of the incision.
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In terms of the location of the incision—AK incisions are made # to # mm from the center of the cornea, whereas LRI incisions are made at the duh
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Incisional Corneal Refractive Surgery

AK incisions

LR incisions
In what fundamental way does AK differ from LRI? In terms of the location of the incision—AK incisions are made 3.5-4.5 mm from the center of the cornea, whereas LRI incisions are made at the limbus.

(Note that this results in an optical zone of 7 to 9 mm)
Incisional Corneal Refractive Surgery

Are AK and LRI incisions placed on the steep, or the flat meridian of the cornea?

Incisional
  RK
  AK
  LRI

Laser
  PRK
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  Epi-LASIK
  LASIK
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The steep
Incisional Corneal Refractive Surgery

Refractive Surgery

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Laser

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Are AK and LRI incisions placed on the steep, or the flat meridian of the cornea?
The steep

Are they performed singularly, or in pairs?
In pairs, on opposite sides of the cornea
Which is more commonly used today?
LRIs, by a mile
What is the typical context in which LRIs are used?
They are usually performed at the time of cataract surgery, or shortly thereafter
What is the typical context in which AKs are used?
To correct post-penetrating keratoplasty astigmatism
Incisional Corneal Refractive Surgery

Refractive Surgery

Corneal

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Refractive Surgery

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    - LASIK
    - SMILE
  - Other
    - CK
    - SAI
    - CRI
    - CXL
    - ICRS

*Are AK and LRI incisions placed on the steep, or the flat meridian of the cornea?*
The steep

*Are they performed singularly, or in pairs?*
Usually pairs, on opposite sides of the cornea

*Which is more commonly used today?*
LRIs, by a mile

*What is the typical context in which LRIs are used?*
They are usually performed at the time of cataract surgery, or shortly thereafter

*What is the typical context in which AKs are used?*
To correct post-penetrating keratoplasty astigmatism
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Incisional Corneal Refractive Surgery

- RK
- AK
- LRI

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Incisional Corneal Refractive Surgery

Refractive Surgery

Corneal

Incisional

Laser

Other

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In treating post-PK astigmatism, where are the AK incisions placed?
Incisional Corneal Refractive Surgery

Refractive Surgery

Corneal

Incisional
- RK
- AK
- LRI

Laser
- PRK
- LASEK
- Epi-LASIK
- LASIK

Other
- CK
- SAI
- CRI
- CXL
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To correct post-penetrating keratoplasty astigmatism

In treating post-PK astigmatism, where are the AK incisions placed?
Either in the host vs donor cornea, or the PK incision itself
Incisional Corneal Refractive Surgery

Refractive Surgery

Corneal

Incisional
- RK
- AK
- LRI

Laser
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Refractive Surgery

Incisional Corneal Refractive Surgery

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Why not place the incisions in the host bed?
Are AK and LRI incisions placed on the steep, or the flat meridian of the cornea? The steep.

Are they performed singularly, or in pairs? Usually pairs, on opposite sides of the cornea.

Which is more commonly used today? LRIs, by a mile.

What is the typical context in which LRIs are used? They are usually performed at the time of cataract surgery, or shortly thereafter.

What is the typical context in which AKs are used? To correct post-penetrating keratoplasty astigmatism.

In treating post-PK astigmatism, where are the AK incisions placed? Either in the donor cornea, or the PK incision itself.

Why not place the incisions in the host bed? Because doing so produces only a negligible effect on the astigmatism.
What was the typical context in which transverse keratotomy was used?

Transverse keratotomy
What was the typical context in which transverse keratotomy was used?
It was used in conjunction with RK to correct the astigmatic portion of the RK pt's refractive error. As RK fell out of favor, transverse keratotomy fell with it.
When AK and LRI incisions placed on the steep meridian of the cornea, what effect do they have on that meridian’s steepness?

- When AK and LRI incisions are placed on the steep meridian of the cornea, they flatten it.
- What effect (if any) does placement of AK or LRI incisions have on the steepness of the meridian 90 degrees away (i.e., the opposite meridian)? They steepen it.
- What is the name for the phenomenon of incisions producing steepening in the opposite meridian? Coupling
- In this context, what is the coupling ratio? It is an index of the relative flattening and steepening caused by the incisions. It is defined as the amount of flattening (in diopters) divided by the amount of steepening (again, in diopters).
- What is the effect of the incisions on the spherical equivalent (SE) of the eye if the coupling ratio is... greater than 1? There is a hyperopic shift.
- Less than 1? There is a myopic shift.
- Equal to 1? The SE is unchanged.

Other
- CK
- SAI
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**Coupling**
Corneal Coupling Effect

Before Corneal Incisions

MRx -3.00 + 2.00 x 090
Spherical Equivalent -1.50
K 45.00x090 / 43.00x180

Coupling
Corneal Coupling Effect

Before Corneal Incisions

MRx -3.00 + 2.00 x 090
Spherical Equivalent -1.50
K 45.00x090 / 43.00x180

After Corneal Incisions

MRx -1.50 spherical
Spherical Equivalent -1.50
K 44.00x090 / 44.00x180

Coupling
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In this context, what is the coupling ratio?
Incisional Corneal Refractive Surgery

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**Incisional Corneal Refractive Surgery**

- **Incisional Laser Surgery**
  - RK
  - AK
  - LRI

- **Incisional Refractive Surgery**
  - PRK
  - LASEK
  - Epi-LASIK
  - LASIK
  - SMILE

- **Other**
  - CK
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- <1? There is a **myopic** shift
- =1? The SE is **unchanged**

**How do LRIs and AKs fair with respect to coupling ratio?**

**Refractive surgery**

- **Incisional**
  - RK
  - AK
  - LRI

- **Laser**
  - PRK
  - LASEK
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How do LRIs and AKs fair with respect to coupling ratio? Both reliably produce ratios of 1.0.
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Transverse keratotomy

As an aside: How does the rarely-performed transverse keratotomy incision fair vis a vis coupling ratio? It tends to result in ratios greater than 1, thereby producing a hyperopic shift.
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Incisional Corneal Refractive Surgery

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Incisional Corneal Refractive Surgery

Coupling effect of astigmatic incisions. A, A limbal relaxing incision has a coupling ratio of 1.0, and the spherical equivalent and average corneal power are not changed.

Preoperative $K$: 43.00 @ 90°
                 45.00 @ 180°

Postoperative $K$: 44.00 @ 90°
                   44.00 @ 180°
Coupling effect of astigmatic incisions. **A**, A limbal relaxing incision has a coupling ratio of 1.0, and the spherical equivalent and average corneal power are not changed. **B**, A transverse incision has a coupling ratio greater than 1.0, which causes a hyperopic change in refraction by making the average corneal power flatter.
With regard to AKs and LRIs, what factors influence their effectiveness?

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--Pt age
--The number of incisions
--The length of the incisions
--The depth of the incisions

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--The number of incisions
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--The depth of the incisions

Should incisional correction of astigmatism be based on a manifest refraction, or corneal topography?
It depends. AKs performed as a stand-alone procedure should be based on the manifest refraction, so as to offset both corneal and lenticular astigmatism. In contrast, LRIs performed at the time of cataract surgery should be based on corneal topography, because any astigmatism owing to the lens will be dealt with by the CE surgery.

When marking the pt’s eye prior to making the incisions, how should the pt be positioned?
Seated upright
Why seated upright?
In a word—cyclotorsion. When a pt lies down, their eyes rotate up to 15°. Thus, assuming the pt was refracted and had her pre-op topography performed while seated, incisions based on the position of the eye while the pt is supine will be off by up to 15°.
With regard to AKs and LRIs, what factors influence their effectiveness?

--Pt age
--The number of incisions
--The length of the incisions
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With regard to AKs and LRIs, what factors influence their effectiveness?

- Pt age
- The number of incisions
- The length of the incisions
- The depth of the incisions

What is the relationship between pt age and the effect of a given LRI or AK incision?

When marking the pt’s eye prior to making the incisions, how should the pt be positioned?

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With regard to AKs and LRIs, what factors influence their effectiveness?

- Pt age
- The number of incisions
- The length of the incisions
- The depth of the incisions

What is the relationship between pt age and the effect of a given LRI or AK incision?
The older the pt, the greater will be the effect.

When marking the pt's eye prior to making the incisions, how should the pt be positioned?
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--Pt age
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--The length of the incisions
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What is the relationship between length and the effect of a given LRI or AK incision?

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The longer the incision, the greater will be the effect

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LRI effect as a function of incision length

Larger Incisions = More Flattening

Smaller Incisions = Less Flattening

This cornea still has 1 diopter of residual astigmatism

Larger Incisions = More Flattening

This cornea has no residual astigmatism
With regard to AKs and LRIs, what factors influence their effectiveness?
-- Pt age
-- The number of incisions
-- The length of the incisions
-- The depth of the incisions

Generally speaking, one of the two is made to a greater relative depth than the other. Which one?
With regard to AKs and LRIs, what factors influence their effectiveness?
--Pt age
--The number of incisions
--The length of the incisions
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Generally speaking, one of the two is made to a greater relative depth than the other. Which one? AK

Other factors that influence the effectiveness of AKs and LRIs are:

- Pt age
- The number of incisions
- The length of the incisions
- The depth of the incisions

When marking the pt's eye prior to making the incisions, how should the pt be positioned? Seated upright. Why seated upright? In a word—cyclotorsion. When a pt lies down, their eyes rotate up to 15°. Thus, assuming the pt was refracted and had her pre-op topography performed while seated, incisions based on the position of the eye while the pt is supine will be off by up to 15°.

Generally speaking, one of the two is made to a greater relative depth than the other. Which one? AK
Incisional Corneal Refractive Surgery

With regard to AKs and LRIs, what factors influence their effectiveness?

Speaking of effectiveness... For a given incision length and depth, which has more effect on astigmatism: LRIs, or AKs?

-- The depth of the incisions

--- The number of incisions

--- The length of the incisions

--- The depth of the incisions

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Speaking of effectiveness... For a given incision length and depth, which has more effect on astigmatism: LRIs, or AKs? Because they are more centrally located, AK incisions have a greater effect.
With regard to **AKs and LRIs**, what factors influence their effectiveness?

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Incisional Corneal Refractive Surgery

With regard to **AKs** and **LRI s**, what factors influence their effectiveness?

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--The depth of the incisions

Speaking of effectiveness part deaux... There is a means of manipulating the refractive impact of AKs that is not available in LRI use. What is it?

--The distance of the incision from the central cornea

How does the distance between an AK incision and the central cornea impact refractive outcome?

The closer AKs are to the central cornea, the greater their refractive effect.

Why is this not the case for LRI s?

Well, it would be, except for the fact that if an incision is placed anywhere but the limbus, then by definition it ain't an LRI.

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Other

CK
SAI
CRI
CXL
ICRS

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Other

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PRK
LASEK
Epi-LASIK
LASIK
SMILE
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- SAI
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Astigmatic keratotomy effect as a function of incision location

Central Incisions = More Flattening

Peripheral Incisions = Less Flattening

This cornea still has 1 diopter of residual astigmatism

The same sized incisions placed more centrally result in no residual astigmatism
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