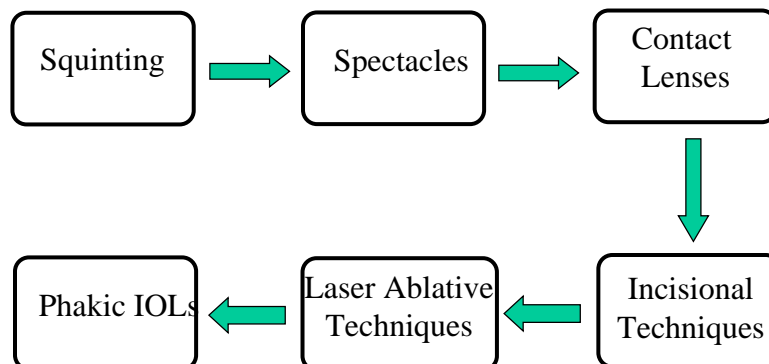


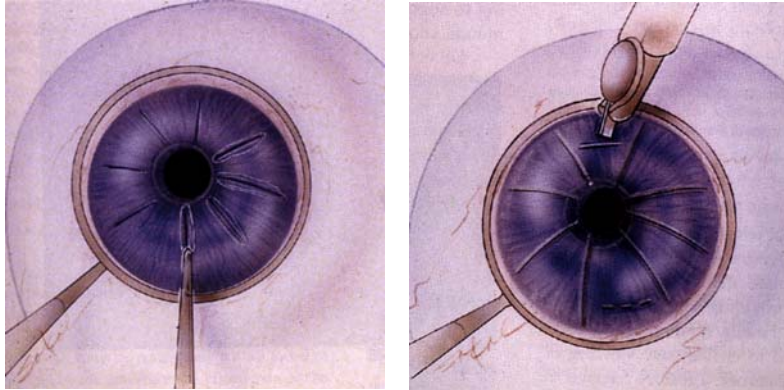
Refractive Surgery

- Techniques that correct for refractive error in the eye have undergone dramatic evolution.
- The cornea is the easiest place to place a correction, so most techniques have focused on modifying the shape of the cornea.

Evolution of Refractive Error Correction

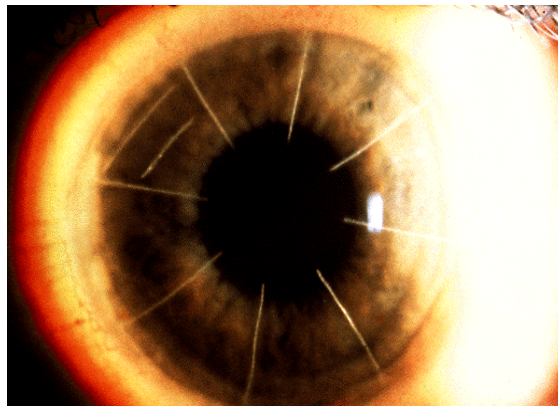


Radial Keratotomy (RK) and Astigmatic Keratotomy (AK)



From: Azar, *Refractive Surgery*, 1997

Radial Keratotomy

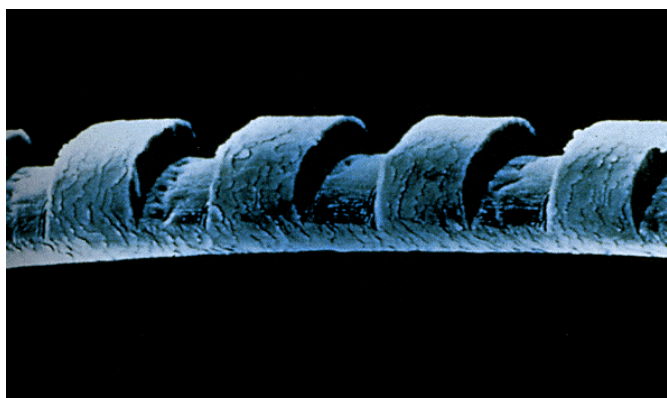


From: Machat, *Excimer Laser Refractive Surgery*, 1996

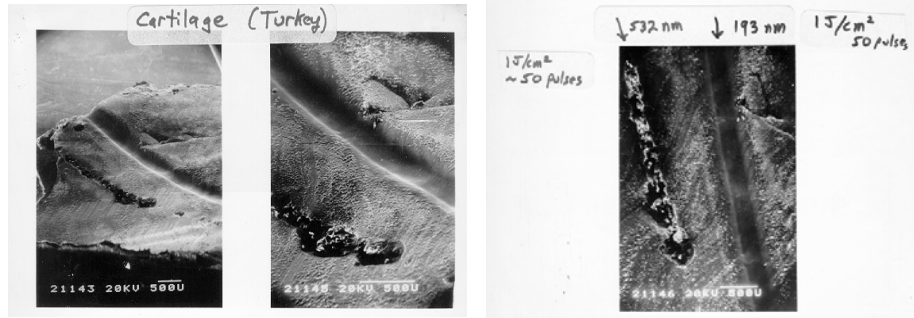
www.surgicaleyes.com



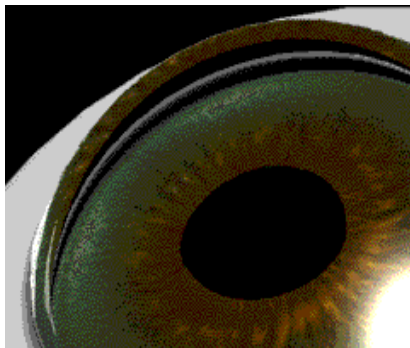
Excimer Laser - 193 nm



Excimer Laser

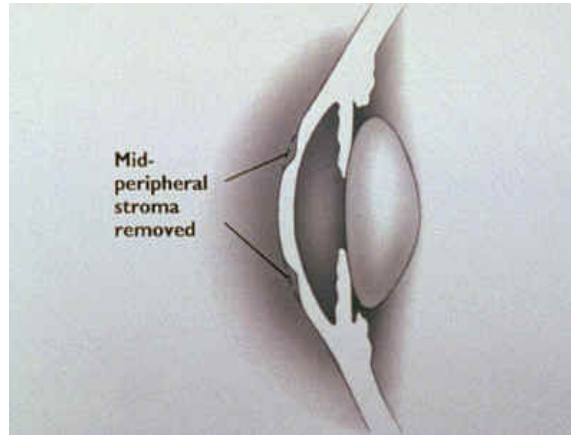


Photorefractive Keratectomy

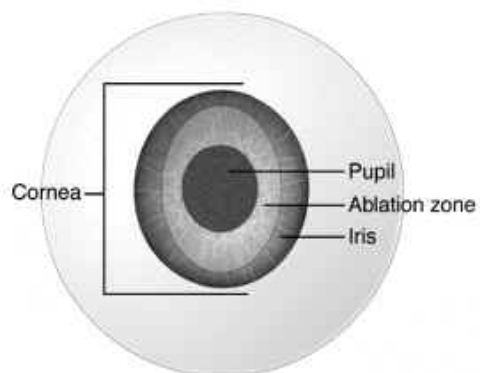


- Epithelial layer is mechanically removed.
- Excimer laser ablates underlying tissue.
- Epithelium regrows in days and weeks following surgery.

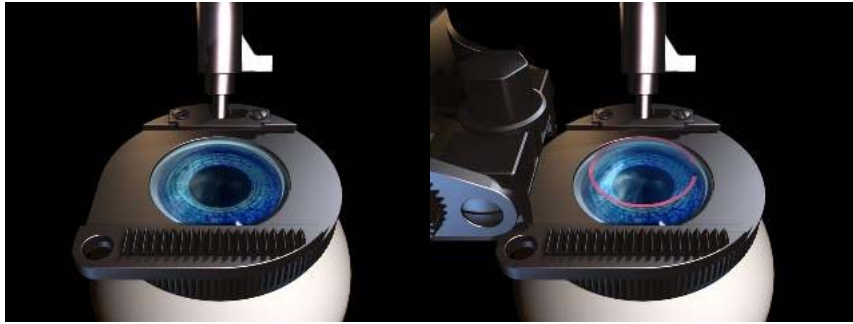
Hyperopic Correction



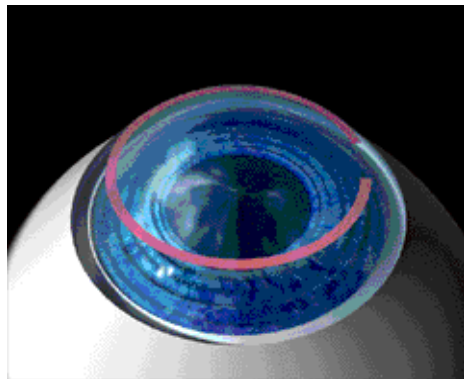
Astigmatism Correction



Microkeratome

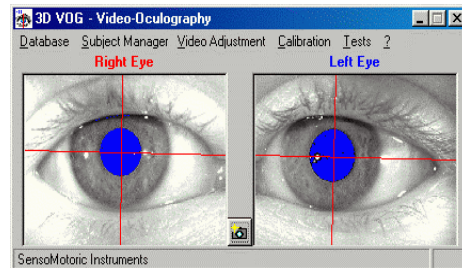


Lasik



- Flap is cut with thickness of about $\frac{1}{3}$ of the cornea.
- Flap is peeled back.
- Excimer laser ablates underlying tissue.
- Flap is replaced.

Eyetracking

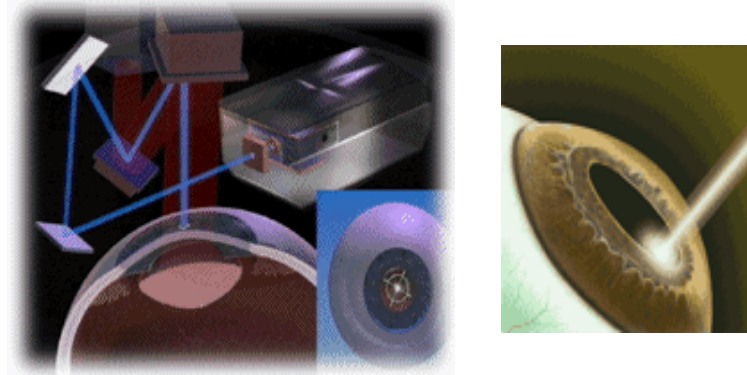


- Both translational and rotational eye motions occur.
- Active and Passive modes for tracking the eye.
- Video and LADAR based tracking are used.

Beam Homogeneity/ Scanning



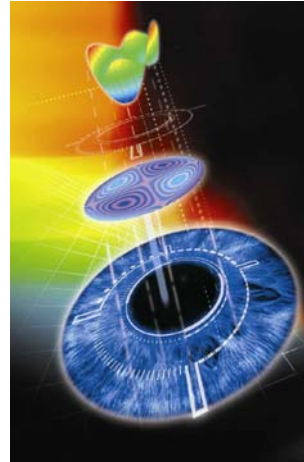
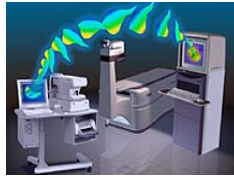
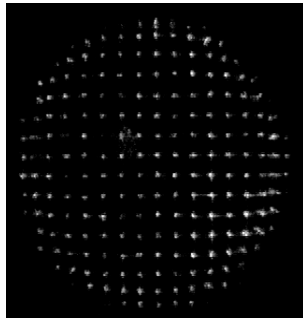
Scanning/Eye Tracking



Scanning Beam

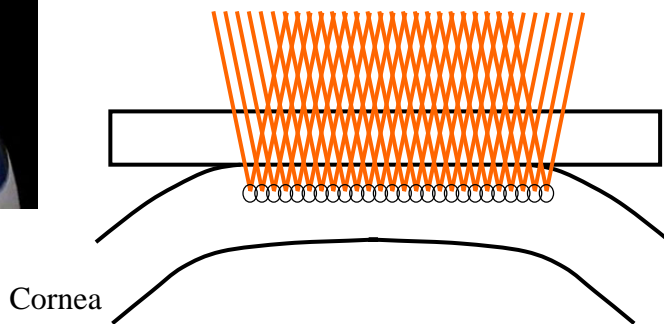
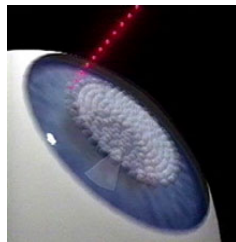


Wavefront Guided Surgery

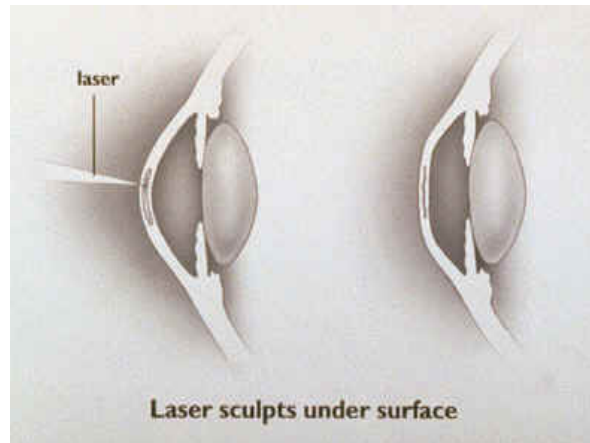


Femtosecond Laser

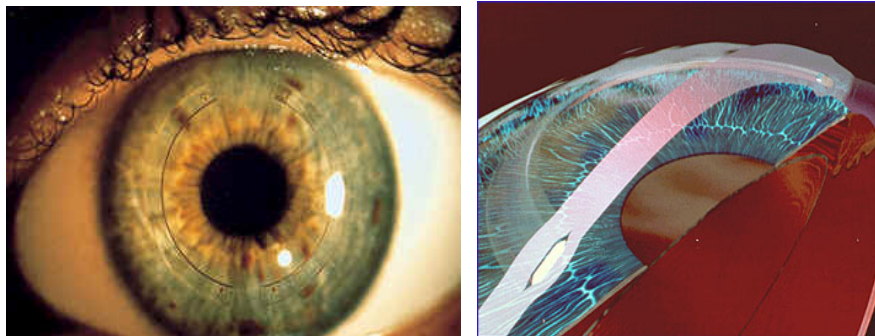
Solid State 1053 nm laser
with femtosecond pulses



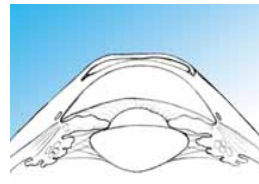
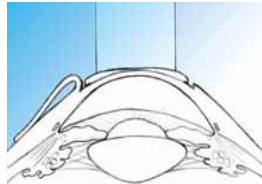
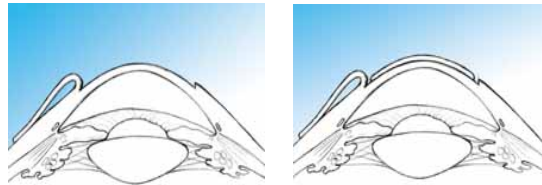
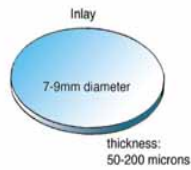
Intrastromal Ablation



Intacs (Intracorneal Rings)



Corneal Inlays



Corneal Anatomy

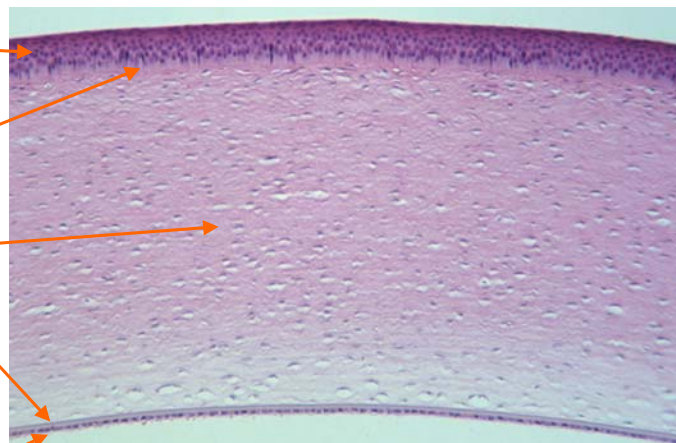
Epithelium

Bowman's
Membrane

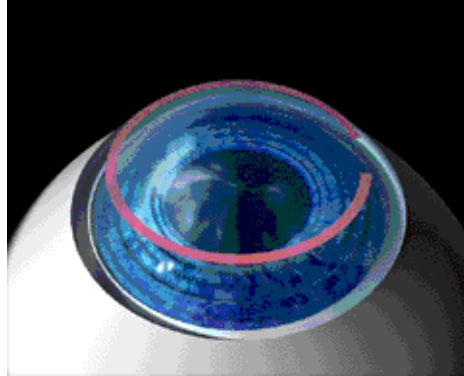
Stroma

Descemet's
Membrane

Endothelium



Lasek



- Similar to LASIK, but flap is epithelium.
- Flap is peeled back.
- Excimer laser ablates underlying tissue.
- Flap is replaced.

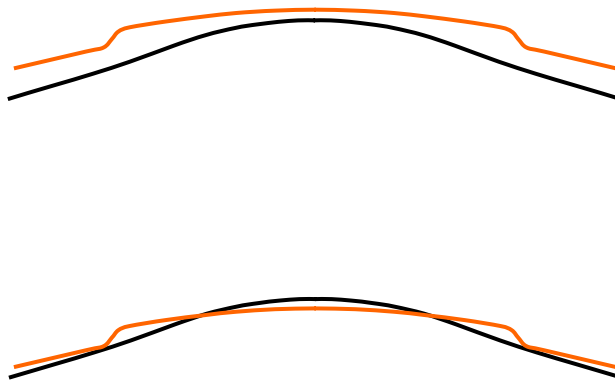
Corneal Refractive Therapy

- Evolution of Orthokeratology
- Cornea is molded to new shape that corrects for refractive error.
- Orthokeratology is a black art, practiced by few practitioners.
- Corneal Refractive Therapy is a systematic means for controlling the shape of the cornea that is FDA approved.

Corneal Refractive Therapy

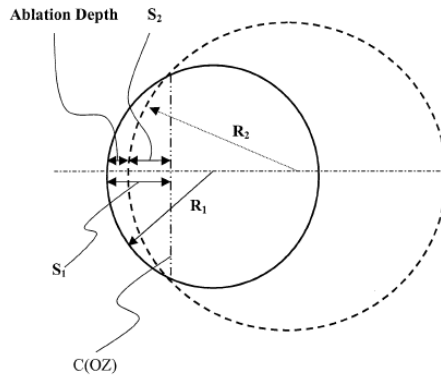
- Rigid Contact lens is fit so that the base curve of the lens is flatter than the radius of curvature of the cornea.
- This arrangement cause pressure on the epithelium.
- Lenses are worn overnight and the epithelium redistributes to match the back surface of the contact lens.
- Lenses are removed during the day and the redistribution is maintained temporarily.
- Similar to orthotics.

Paragon CRT



Munnerlyn Formula

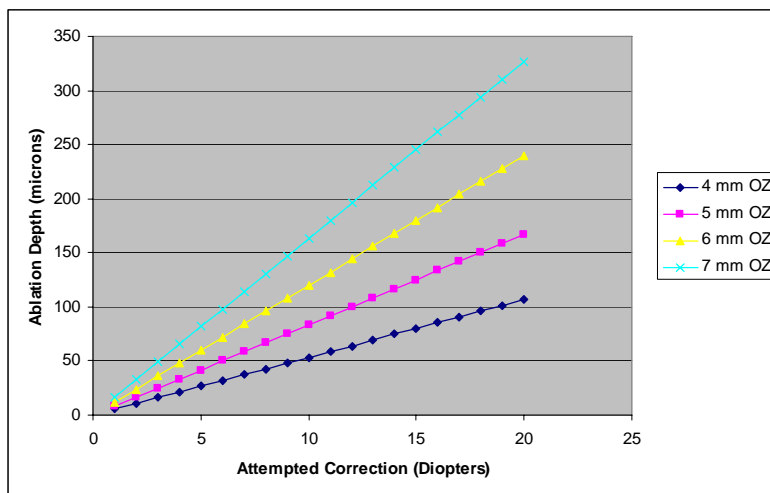
$$\text{Depth} = (R_1^2 - r)^{1/2} - (R_2^2 - r)^{1/2} + (R_2^2 - \frac{OZ^2}{4})^{1/2} - (R_1^2 - \frac{OZ^2}{4})^{1/2}$$



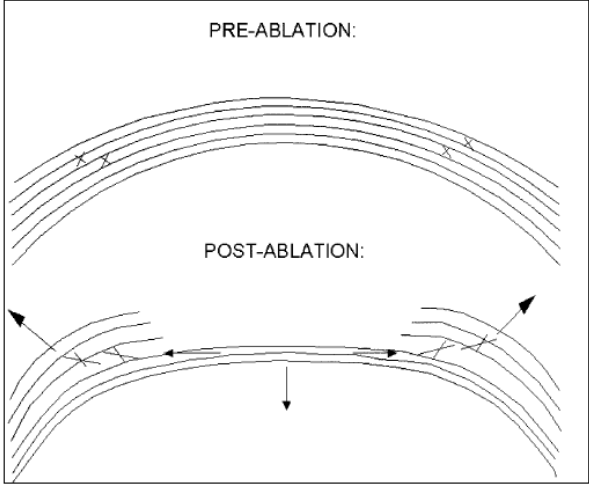
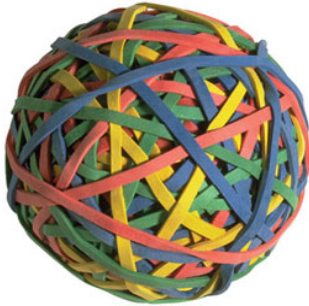
$$\text{Central Depth} \cong \frac{OZ^2}{3} \Phi$$

OZ = Optical Zone Diameter
 Φ = Refractive Power

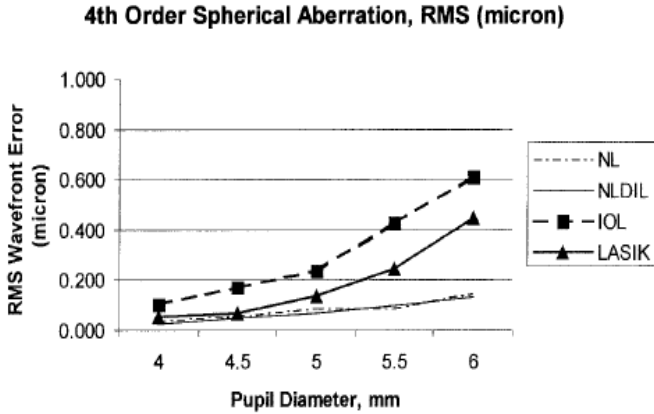
Munnerlyn Formula



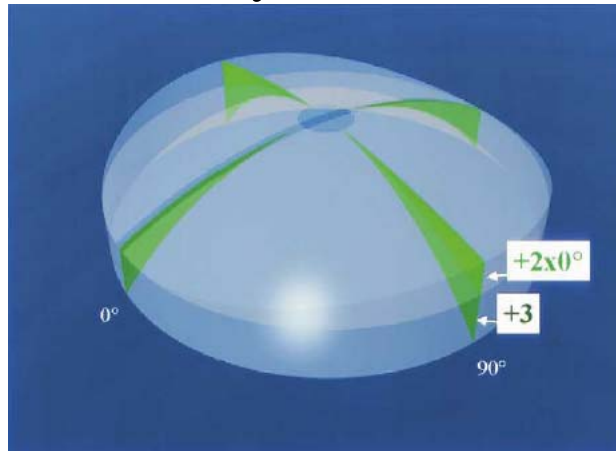
Corneal Biomechanics



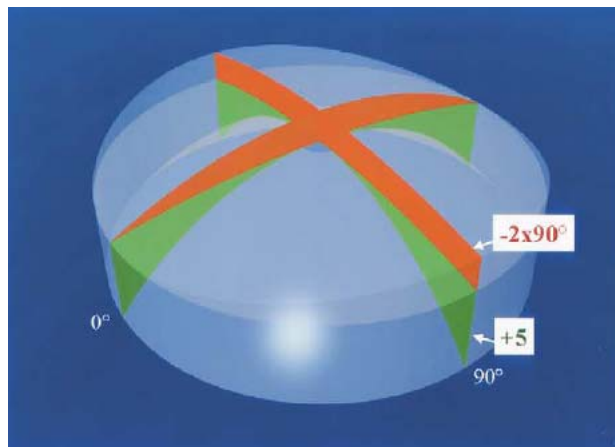
Change in Spherical Aberration



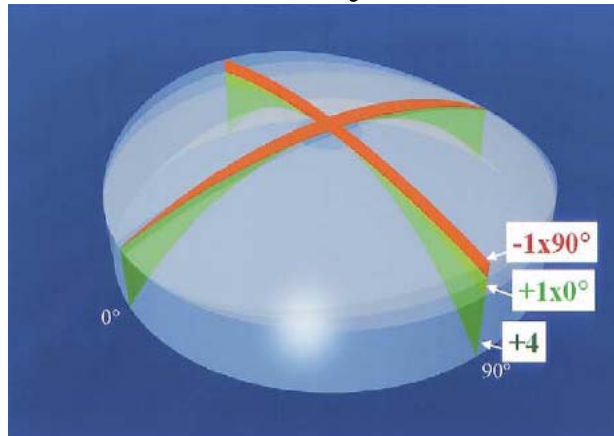
Astigmatic Correction (Plus Cylinder)



Astigmatic Correction (Minus Cylinder)



Astigmatic Correction (Crossed Cylinder)



Custom Refractive Surgery

- While “SuperVision” has been the focus of much of the marketing behind these procedures, the benefits will be from the bottom up.

Anticipate

- Higher outcomes at 20/20 than conventional.
- Fewer complaints about night vision problems.
- Patient not correctable to 20/20 with spectacles and contact lenses, now correctable with custom procedures.
- Some patients gaining a line or two of acuity.

Alcon's Ladarwave CustomCornea

- FDA approval October 2002
- Shack-Hartmann wavefront sensor
- Active eye tracking
- -7.00 D and less than 0.50 D of astigmatism
- Uncorrected visual acuity was 20/40 or better in 98.6% of the eyes.
- Uncorrected visual acuity was 20/20 or better in 79.9% of the eyes, and more recent studies have brought this up to 90%

Bausch & Lomb's Zyoptix

- Preliminary FDA approval
- Shack-Hartmann wavefront sensor
- Active eye tracking
- Myopia up to -7.00 D and astigmatism up to -3.00 D.
- 99.4% better than 20/40 uncorrected.
- Results showed that 91.5% of patients had 20/20 uncorrected visual acuity and 70.3 % had 20/16 uncorrected visual acuity following surgery.

VISX's CustomVue

- FDA approval May 2003
- Shack-Hartmann wavefront sensor
- Active eye tracking
- Myopia to -6.00 D and less than -3.00 D of cylinder
- At 6 months 96% had 20/20 or better uncorrected
- 71% had 20/16 or better uncorrected
- 22% had 20/12.5 or better uncorrected

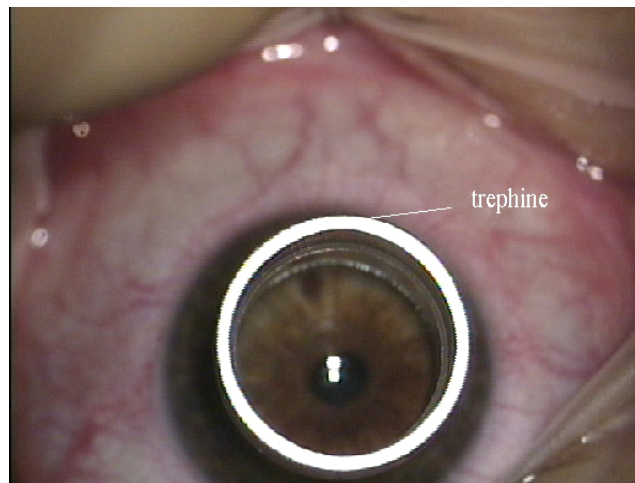
Corneal Transplants

- Infection, scarring, keratoconus and chemical burns can cause permanent damage to the cornea, requiring a corneal transplant.
- Roughly 100,000 eyes annually donated in the US, with approximately 50,000 implanted
- 90% success rate for transplantation.
- Other eyes go for basic research.

Corneal Transplant Stats

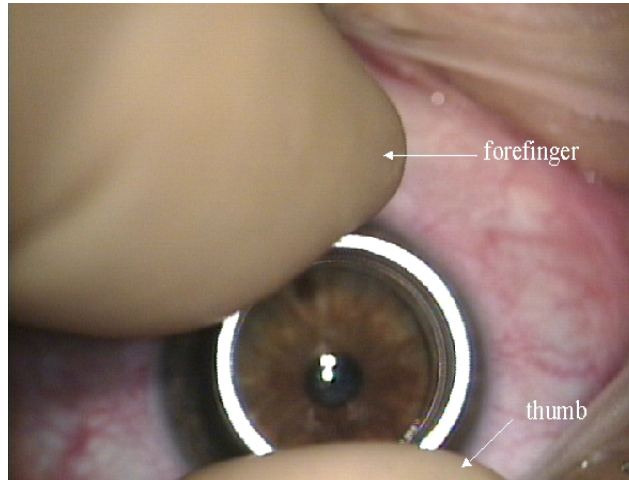
Organ / Tissue	First Performed	1998 Transplants	1999 Transplants
Cornea	1905	45,579	45,897
Heart	1967	2,340	2307
Heart / Lung	1981	45	46
Kidney	1954	11,990	12032
Liver	1967	4,450	4339
Lung	1981	849	859
Pancreas	1969	253	230

Corneal Transplant

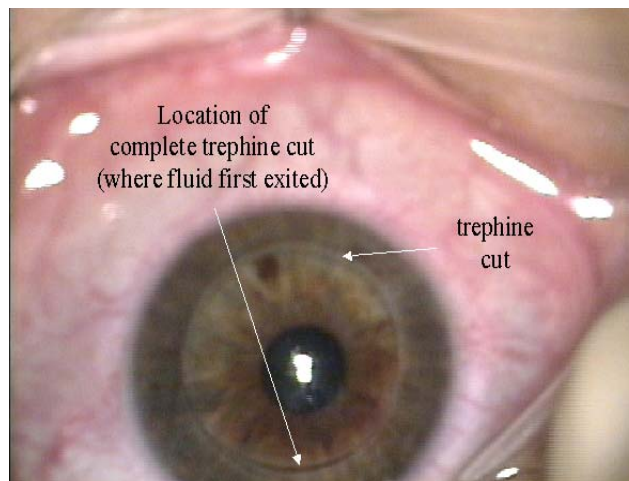


www.fyeye.com

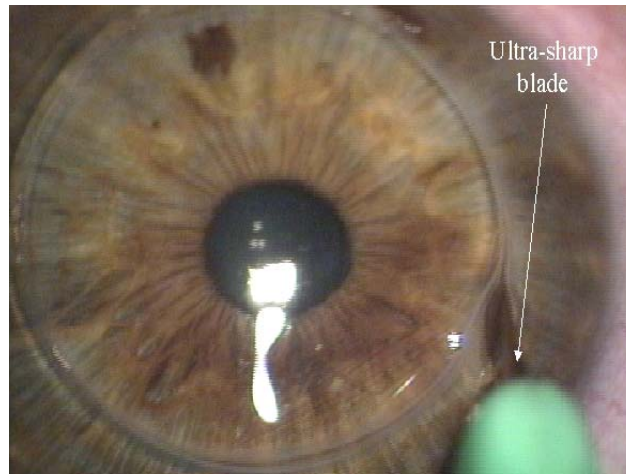
Corneal Transplant



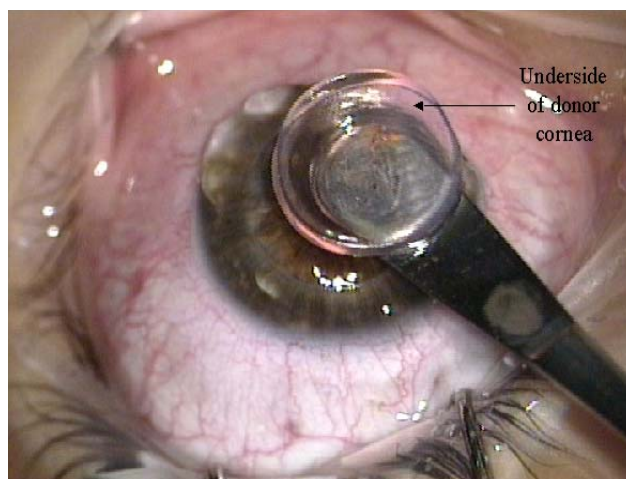
Corneal Transplant



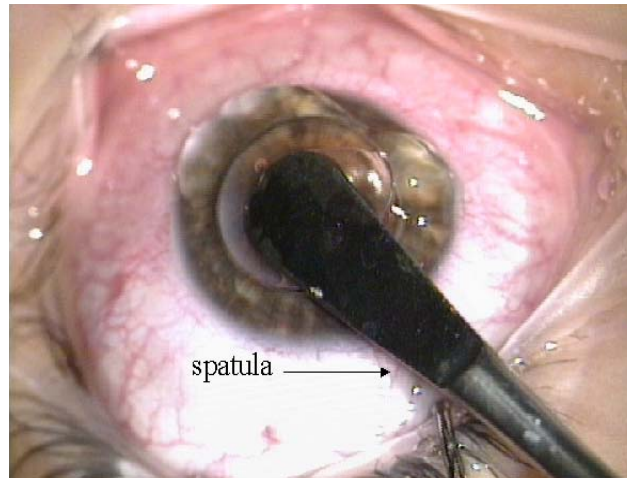
Corneal Transplant



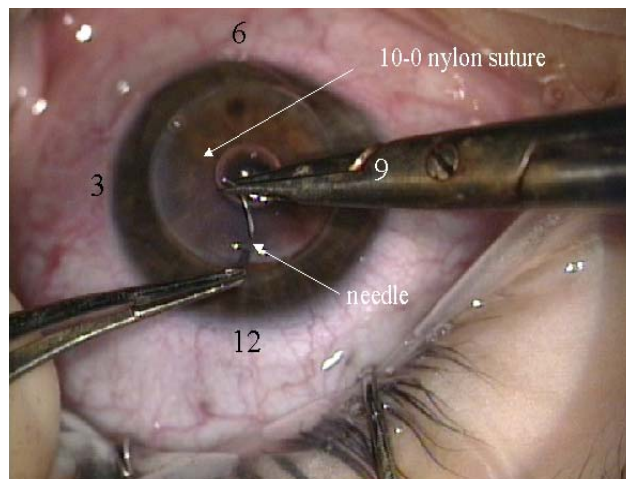
Corneal Transplant



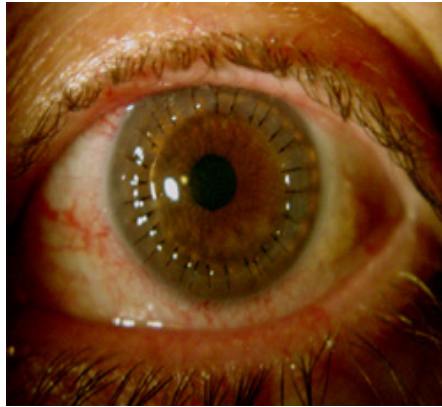
Corneal Transplant



Corneal Transplant



Corneal Graft



Corneal Transplant

- Often have high degrees of astigmatism and aberration following corneal transplant.
- Sutures tend to distort the graft into irregular shapes.
- The surgeon can adjust or cut specific sutures to try and compensate.

