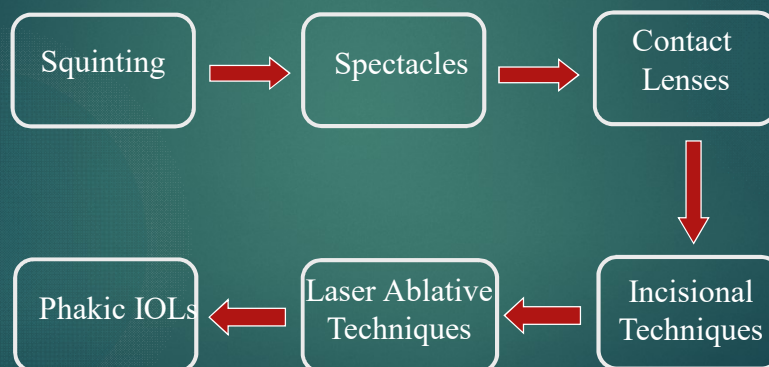


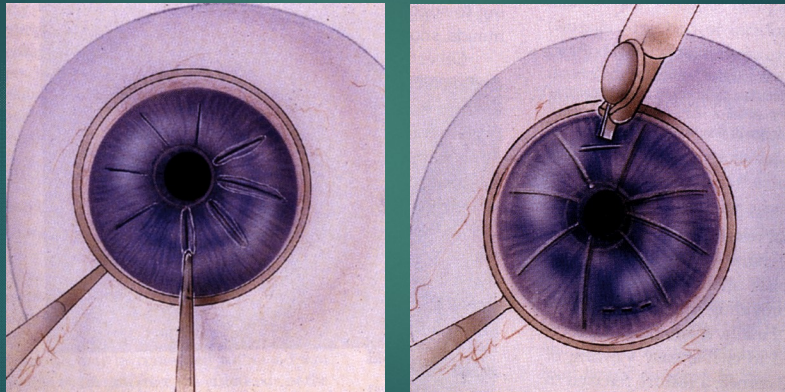
# Refractive Surgery

- ▶ 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

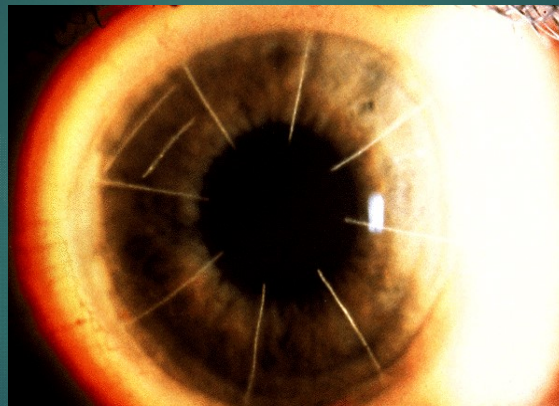


# Radial Keratotomy (RK) and Astigmatic Keratotomy (AK)



From: Azar, *Refractive Surgery*, 1997

# Radial Keratotomy

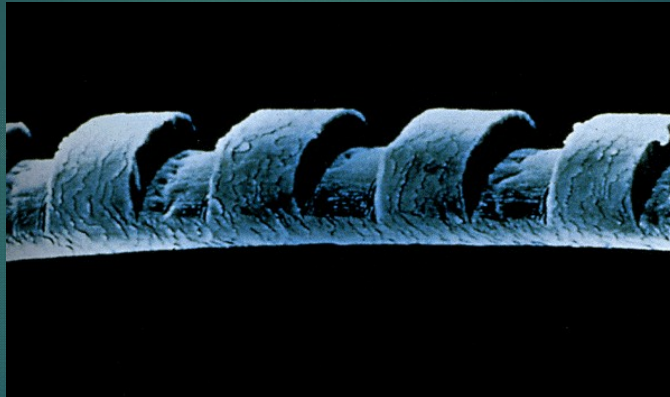


From: Machat, *Excimer Laser Refractive Surgery*, 1996

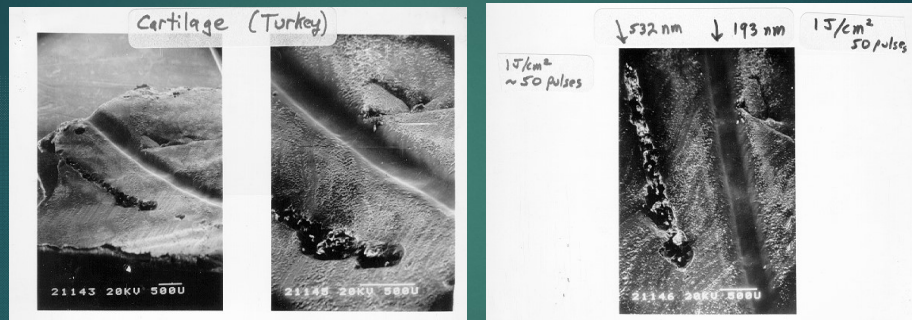
[www.surgicaleyes.com](http://www.surgicaleyes.com)



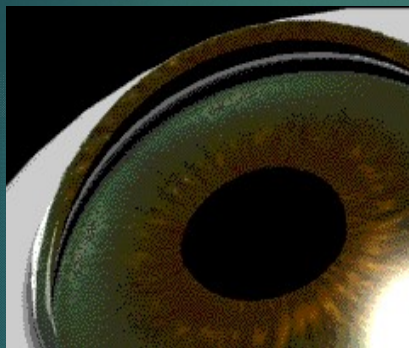
Excimer Laser - 193 nm



# Excimer Laser

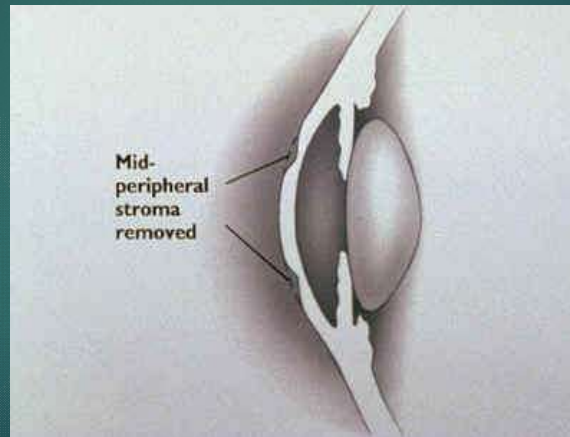


# Photorefractive Keratectomy

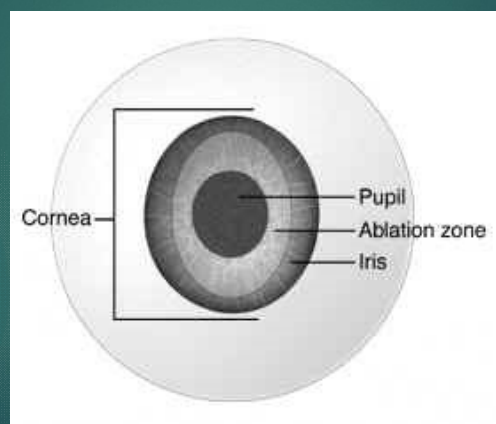


- ▶ Epithelial layer is mechanically removed.
- ▶ Excimer laser ablates underlying tissue.
- ▶ Epithelium regrows in days and weeks following surgery.

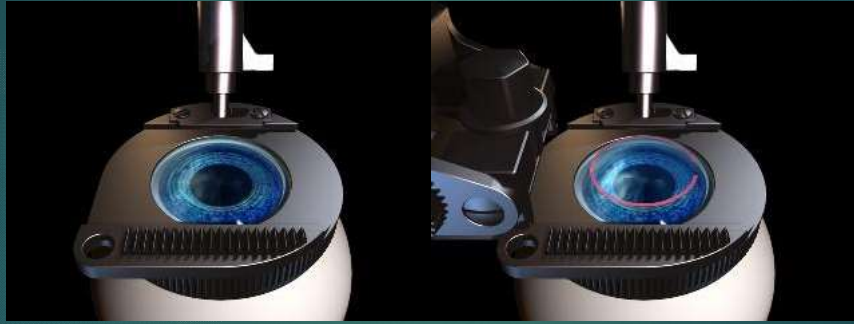
## Hyperopic Correction



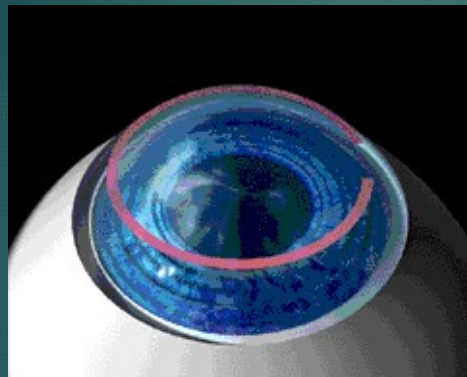
## Astigmatism Correction



# Microkeratome

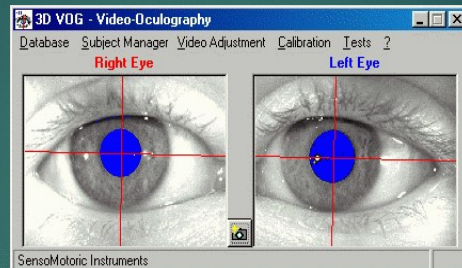


# Lasik



- ▶ Flap is cut with thickness of about 1/3 of the cornea.
- ▶ Flap is peeled back.
- ▶ Excimer laser ablates underlying tissue.
- ▶ Flap is replaced.

# Eyetracking

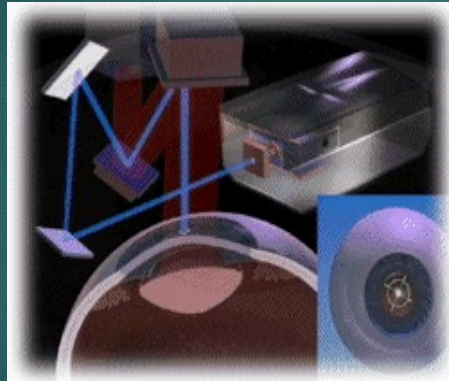


- ▶ Both translational and rotational eye motions occur.
- ▶ Active and Passive modes for tracking the eye.
- ▶ Video and LADAR based tracking are used.

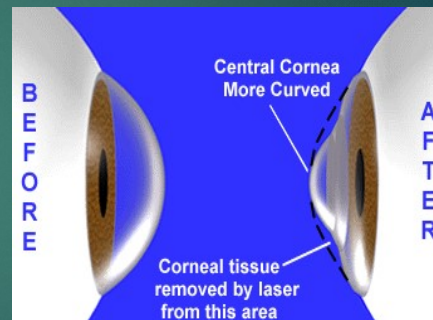
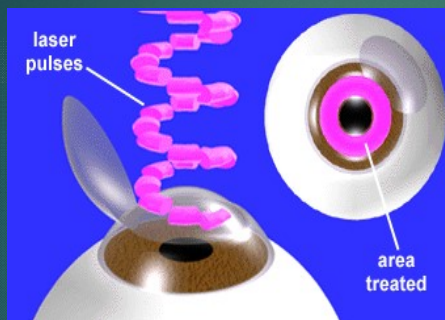
# Beam Homogeneity/ Scanning



# Scanning/Eye Tracking

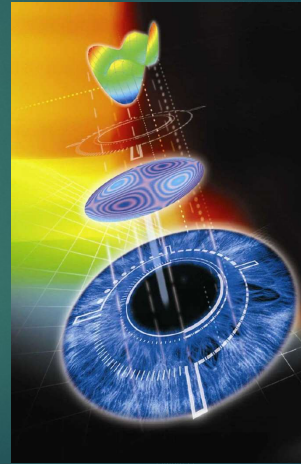
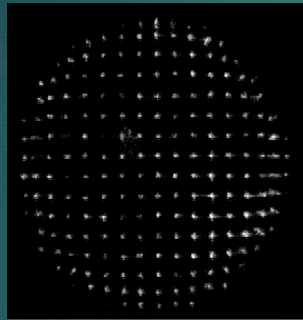


# Scanning Beam



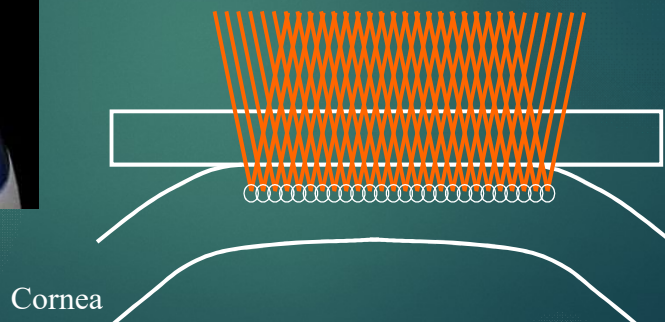
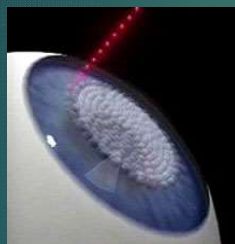


# Wavefront Guided Surgery

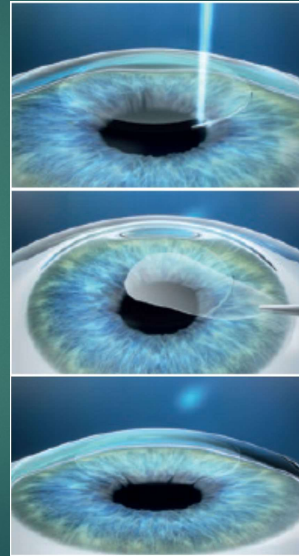
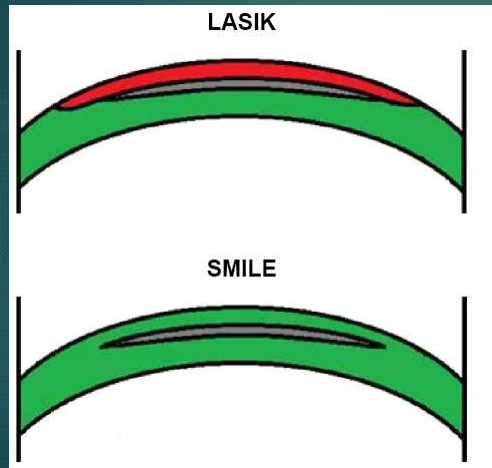


# Femtosecond Laser

Solid State 1053 nm laser  
with femtosecond pulses



## Small incision lenticule extraction (SMILE)



## 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.

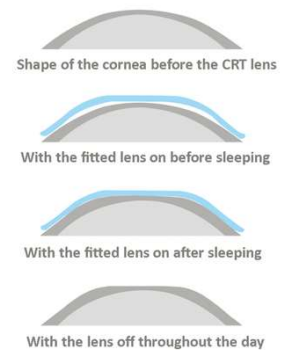
# Orthokeratology or Corneal Refractive Therapy

- ▶ 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.

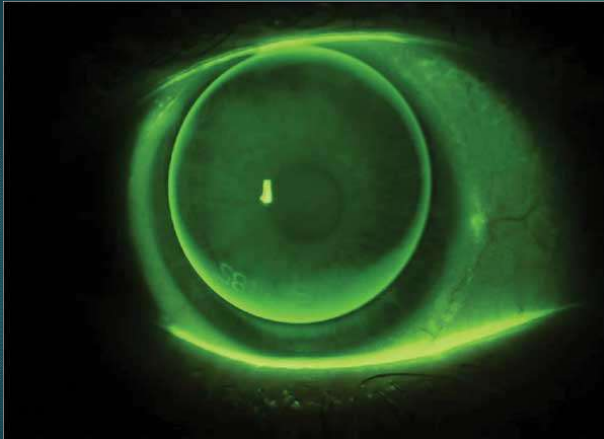
## Paragon CRT



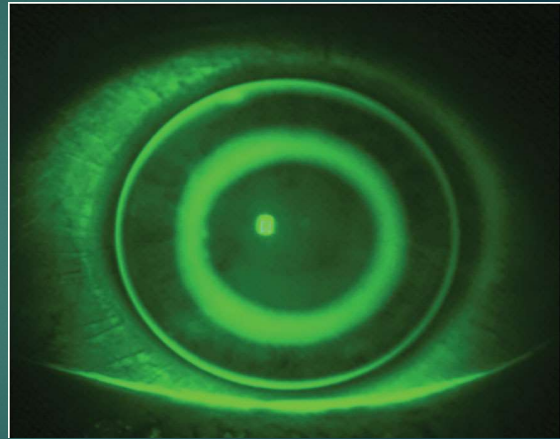
### How Corneal Refractive Therapy works



# Sodium Fluorescein



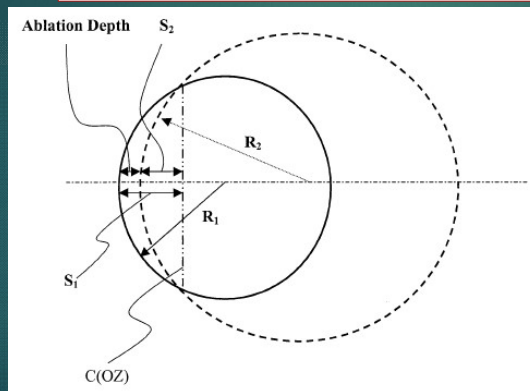
Conventional RGP Lens



Orthokeratology Lens

# Munnerlyn Formula

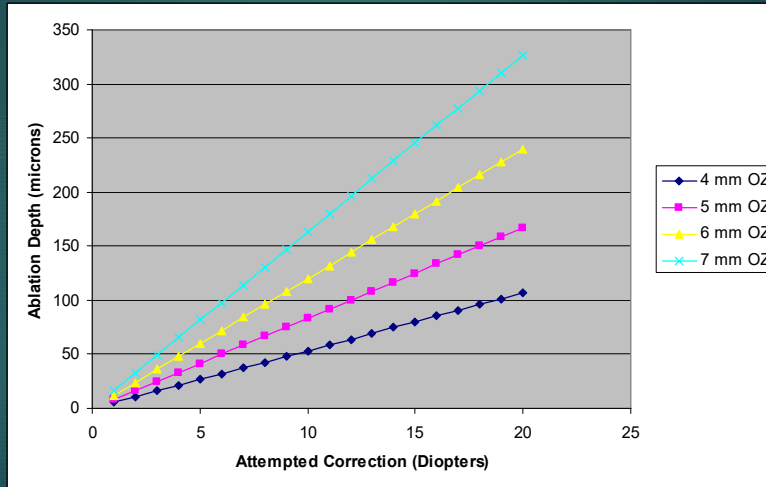
$$Depth = (R_1^2 - r^2)^{1/2} - (R_2^2 - r^2)^{1/2} + (R_2^2 - \frac{OZ^2}{4})^{1/2} - (R_1^2 - \frac{OZ^2}{4})^{1/2}$$



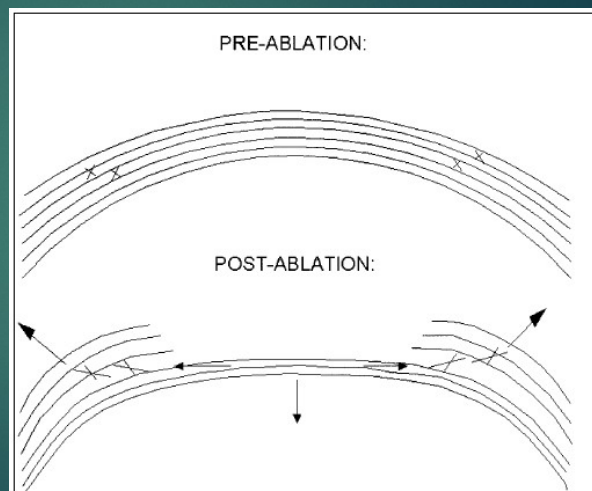
$$Central\ Depth \cong \frac{OZ^2}{3} \Phi$$

OZ = Optical Zone Diameter  
 $\Phi$  = Refractive Power

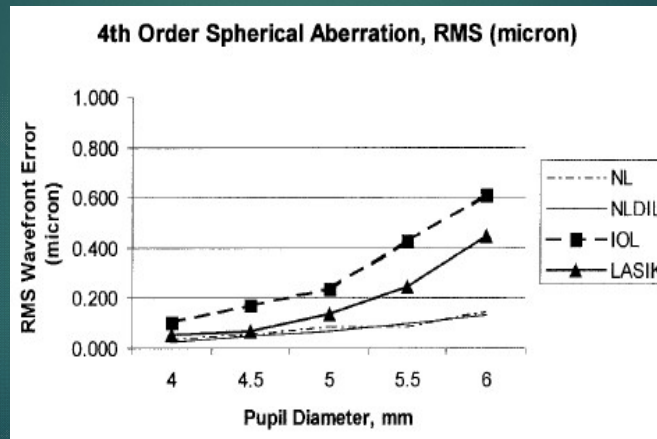
# Munnerlyn Formula



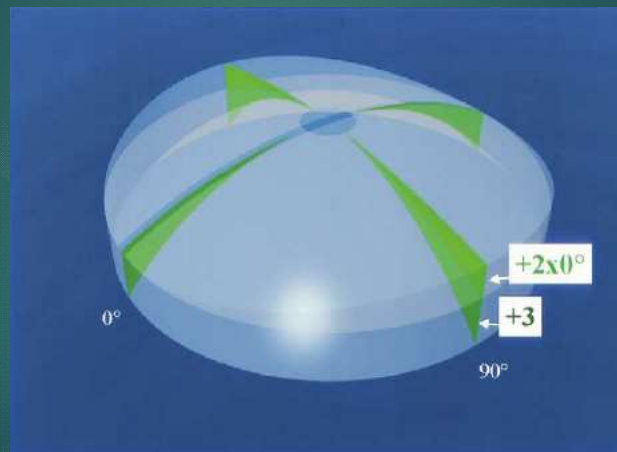
# Corneal Biomechanics



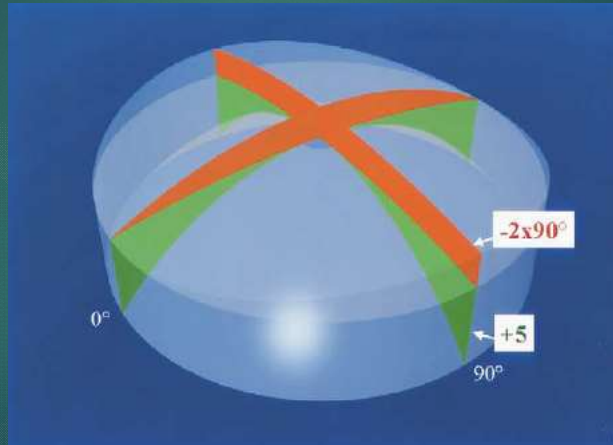
# Change in Spherical Aberration



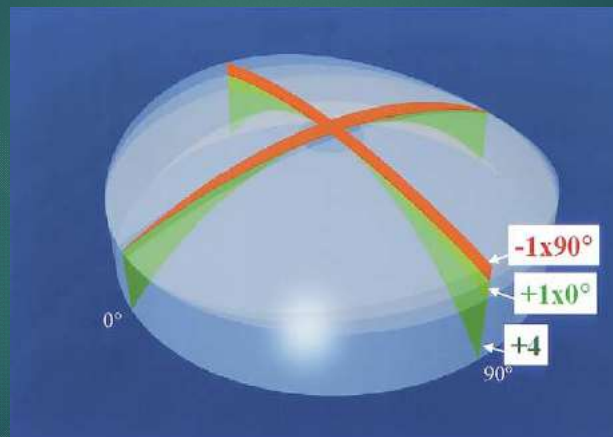
# Astigmatic Correction (Plus Cylinder)



## 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

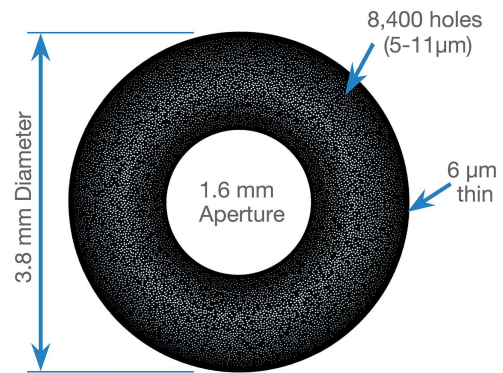
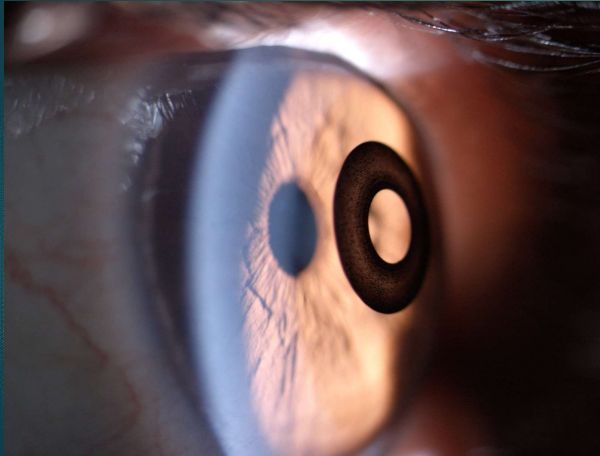
- ▶ Higher outcomes at 20/20 than conventional.
- ▶ Fewer complaints about night vision problems.
- ▶ Patient not correctable to 20/20 with spectacles and contact lenses, now correctable with custom procedures.
- ▶ Some patients gaining a line or two of acuity.

## 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



## Presbyopia Treatments



Made from Polyvinylidene Fluoride (PVDF)

## 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

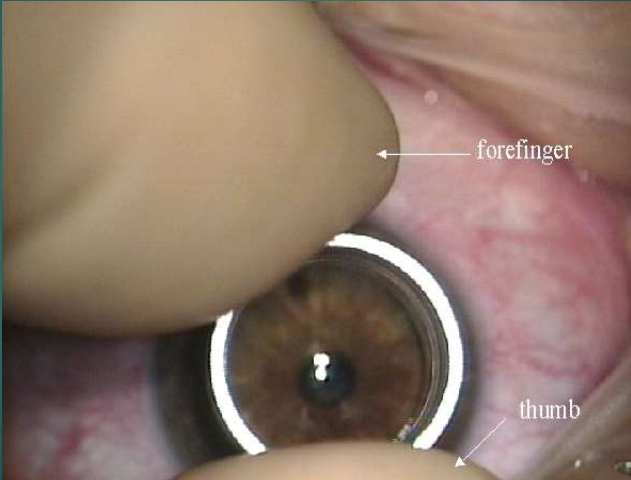
<b>Organ / Tissue</b>	<b>First Performed</b>	<b>1998 Transplants</b>	<b>1999 Transplants</b>
Cornea	1905	45,579	45,897
Heart	1967	2,340	2307
Heart / Lung	1981	45	46
Kidney	1954	11,990	12032
Liver	1967	4,450	4339
Lung	1981	849	859
Pancreas	1969	253	230

# Corneal Transplant

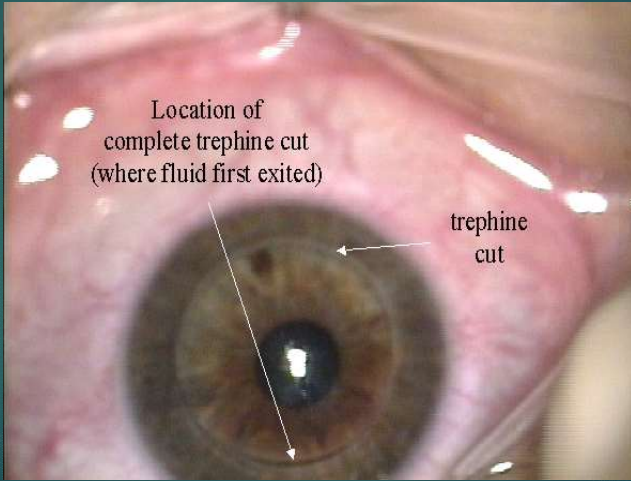


[www.fyeye.com](http://www.fyeye.com)

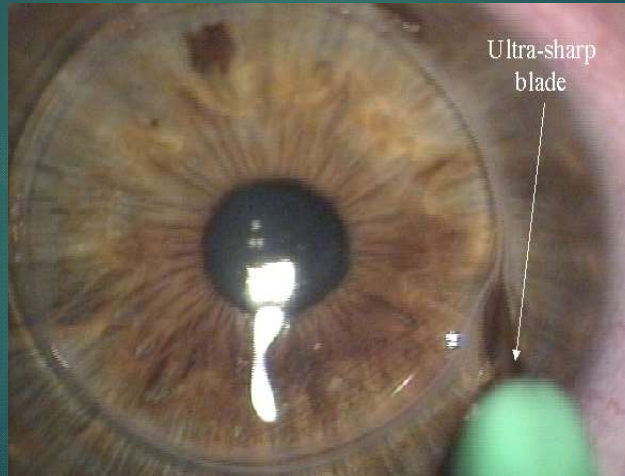
# Corneal Transplant



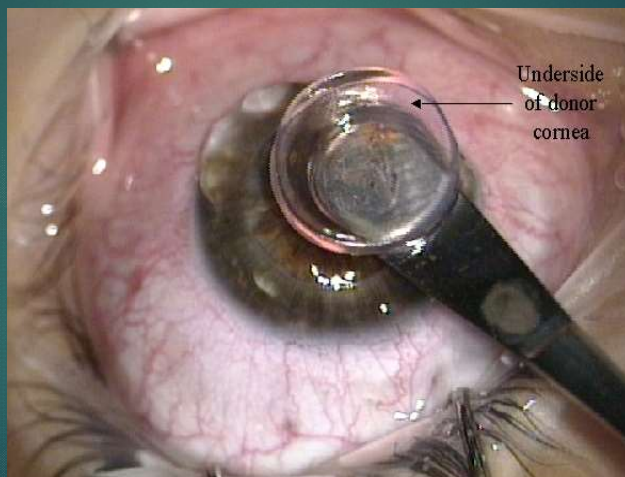
# Corneal Transplant



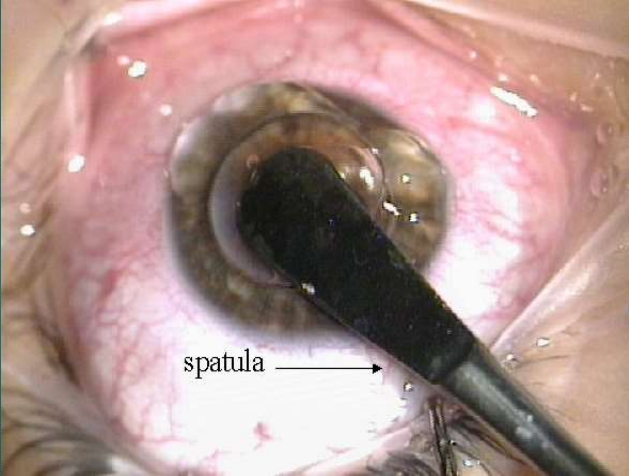
# Corneal Transplant



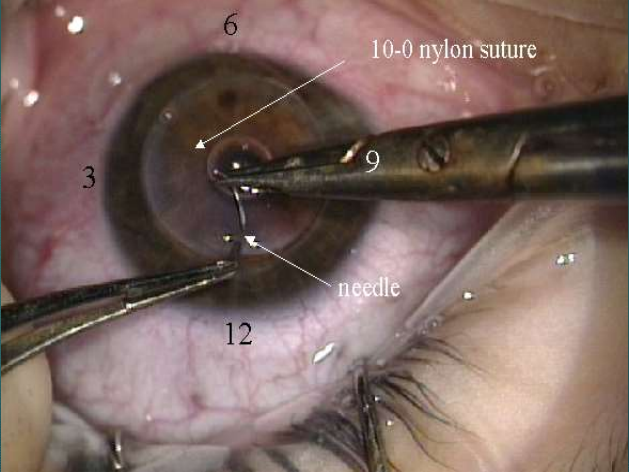
# Corneal Transplant



# 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.

