Refraction 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

- Squinting
- Spectacles
- Contact Lenses
- Phakic IOLs
- Laser Ablative Techniques
- Incisional Techniques
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

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

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

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

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

Cornea
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

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

Central Depth \( \geq \frac{OZ^2}{3} \Phi \)

\( OZ = \text{Optical Zone Diameter} \)
\( \Phi = \text{Refractive Power} \)
Corneal Biomechanics

Change in Spherical Aberration

4th Order Spherical Aberration, RMS (micron)
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

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

Corneal Transplant

www.fyeye.com
Corneal Transplant

Ultra-sharp blade

Corneal Transplant

Underside of donor cornea
Corneal Transplant

Corneal Transplant

10-0 nylon suture

needle
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.