Laser EYE SURGERY

LASIK and Excimer Lasers
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Myopia - near sightedness

Caused by either an elongated eye or steep cornea.

The focal point is in front of the retina instead of on it.

Typically corrected with concave (negative optical power) lenses.
THE PROBLEM

- Hyperopia - far sightedness
- Caused by a flat cornea or short eye.
- Focal point is behind the retina.
- Corrected with concave lenses (positive optical power).
Astigmatism arises from different focal points in different planes of the eye.

Caused by non-uniform curvature of the cornea or scarring on the lens.

Irregular astigmatism cannot be fixed by glasses, just contacts.
INTERNAL CORRECTIONS

LASIK - Laser Assisted in Situ Keratomileusis

Keratomileusis is the procedure of opening the eye and altering the cornea.

LASIK uses an excimer laser to perform the alterations and either a knife or a femtosecond laser to create the opening.

LASIK is an alternative to wearing glasses or contacts as it corrects myopia, hyperopia and astigmatism.
LASIK began in 1950 in Bogotá, Columbia with the development of keratomileusis.

A breakthrough was the 1973 announcement of the excimer laser.

Gholam Peyman filed the first LASIK patent in 1989 as a "Method for modifying corneal curvature". It includes the procedure of revealing the cornea, using an excimer laser without opening the eye.
LASIK is performed while awake with an occasional mild sedative.

A hinged flap is cut with either a metal blade or a femtosecond laser.

An Excimer laser remolds the cornea by ablating tissue.

The flap is repositioned and left to heal.
LASIK

Cutting the flap is either done with a microkeratome or a femtosecond laser.
Excimer Lasers

Excimer lasers are UV lasers that utilize noble gas halides. They often use a combination of an inert gas such as argon, krypton or xenon with a highly reactive gas like chlorine or fluorine. A short lived molecule called an excimer gives rise to the laser light.
Excimer Lasers

Excimers are formed when the inert gas goes into an excited state, in this state they bond with the halide to form a molecule.
Excimer Lasers

When the noble gas returns to its ground state it repels the halide which gives rise to the ultraviolet light.
EXCIMER LASERS

• Typical wavelengths for various excimers.

Bond energy of an H-O bond of H₂O is about 4.76 eV and to break a C-H bond in ethane it is 4.38 eV.

Visible light is 2-3 eV while room temperature is 1/40 eV.

<table>
<thead>
<tr>
<th>Excimer</th>
<th>Wavelength (nm)</th>
<th>Energy (eV)</th>
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<tbody>
<tr>
<td>Ar₂*</td>
<td>126</td>
<td>9.85</td>
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<tr>
<td>Kr₂*</td>
<td>146</td>
<td>8.50</td>
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<tr>
<td>F₂</td>
<td>157</td>
<td>7.90</td>
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<tr>
<td>Xe₂*</td>
<td>172 &amp; 175</td>
<td>7.21 &amp; 7.09</td>
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<tr>
<td><strong>ArF</strong></td>
<td><strong>193</strong></td>
<td><strong>6.43</strong></td>
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<tr>
<td>Cl₂</td>
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</table>
Excimer Lasers

Ultraviolet light is absorbed by tissue and organic matter. The added energy breaks the bonds of molecules at the surface. These molecules ablate into the air without adding heat to the area. This is called Ablative Photodecomposition.

Current excimer lasers typically pulse for 10 ns at 100 Hz. Those used in eye surgery reposition to follow the eye 4000 times per second.
Excimer Lasers

- Low absorption depth: 0.1 to 0.5µm.
- Energy highly absorbed by materials.
- Uniform power density over relatively large area.
- Discharge circuit - expensive and require frequent maintenance.
- Laser gas mixture is toxic and corrosive.
- The laser must be refilled with fresh gas regularly.
LASIK Side Effects

Some higher order aberrations can occur as they cannot be diagnosed with normal eye exams.

One is halos and starbursts: vision fine during the day but at night the pupil can expand and pass the edge of the LASIK flap, this gives rise to halos and other aberrations.
LASIK Alternatives

LASIK is limited by the excimer laser and can cause some damage to the eyes' nerves so new methods are being developed.

Another popular method is PRK—it is similar to LASIK without necessitating a flap to be cut (necessary for pilots).

Compared to LASIK, it has a longer recovery period and more discomfort.
References

Wikipedia entries on: LASIK, Excimer Laser, Excimer, Myopia, Hyperopia, Astigmatism (eye), Keratomileusis, Photorefractive Keratectomy