Optics and Refraction for 5th Year Medical Students.

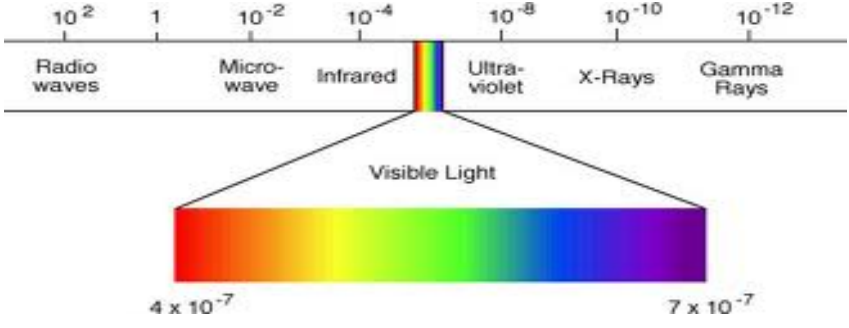
The University of Jordan

Objectives

- Know the principles of refraction
- Define Emmetropia and ametropia
- Get familiar with terms related to refractive errors
- Be familiar with different modalities for treatment of refractive errors

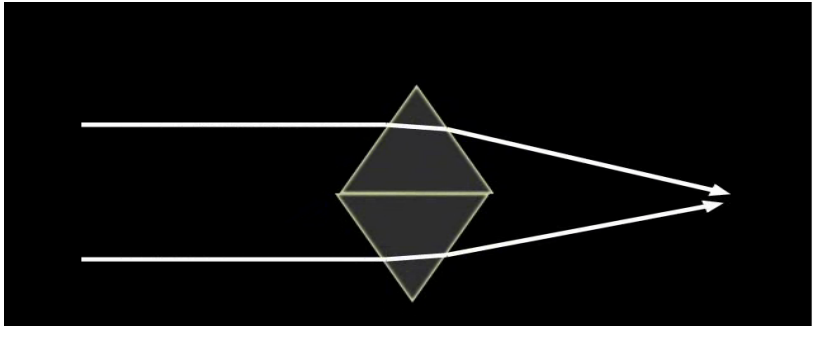
Physical optics

- The visible part of the EM spectrum, to which the retina is sensitive, lies between the wavelengths 390nm & 760nm.
- Light should be correctly focused on the retina for the eye to generate accurate visual information.



Light travels in a straight line. But when it reaches another medium it will bend. This is called refraction.

This is how lenses work, and also how we see.



The focus must be adjustable to allow clear vision for both near & distant objects (accommodation).

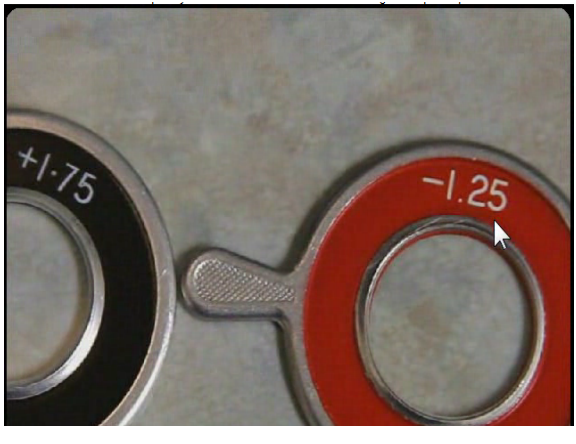
Refractive components of the eye or the focusing power is :

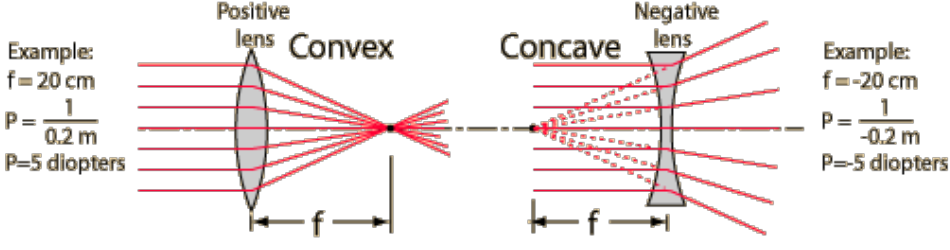
** 2/3 (cornea and “air/tear” interface), fixed power
** 1/3 lens, power increases with accommodation

These two elements converge parallel rays because :-

1) Cornea has higher refractive index than air.
2) lens has higher refractive index than aqueous and vitreous humours.
3) Cornea & lens are spherically convex in shape

Diopter (D) : measurement of the refractive power of a lens, equal to the reciprocal of the focal length in meters “ 1/meters” . Simply describes the power of the lens.




Example:
f = 20 cm
P = 1 / 0.2 m
P=5 diopters
Positive lens
Convex
f
Concave
Negative lens
f
Example:
f = -20 cm
P = 1 / -0.2 m
P=-5 diopters

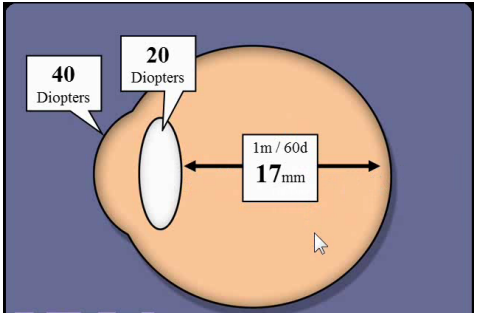
**** A negative lens is a diverging lens ,concave ,corrects for myopia

**** A positive lens is a converging lens ,convex ,corrects for hypermetropia.

Example: +1 D lens focuses light at 1m.

+2 D lens focuses light at 0.5m.

Eye is a bunch of lenses.

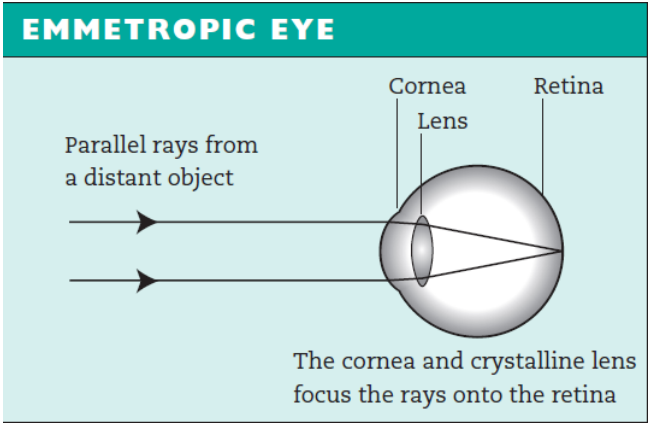


Definitions

- Presbyopia: Loss of accommodative ability of the lens resulting in difficulties with near tasks.
- Astigmatism: the curvature of the cornea and/or lens is Not spherical and therefore causes image blur on the retina. Optical power on different planes is not equal
- Aniseikonia: a difference of image size between the 2 eyes as perceived by the patient.
- Anisometropia: a refractive power difference between the 2 eyes (usually > 2D)
- Aphakia: (Phakos=lens), aphakia is no lens.
- Pseudophakia: artificial lens in the eye.

Refractive errors

Emmetropia :- when parallel rays of light from a distant object are brought to focus on the retina with the eye at rest “not accommodating “.



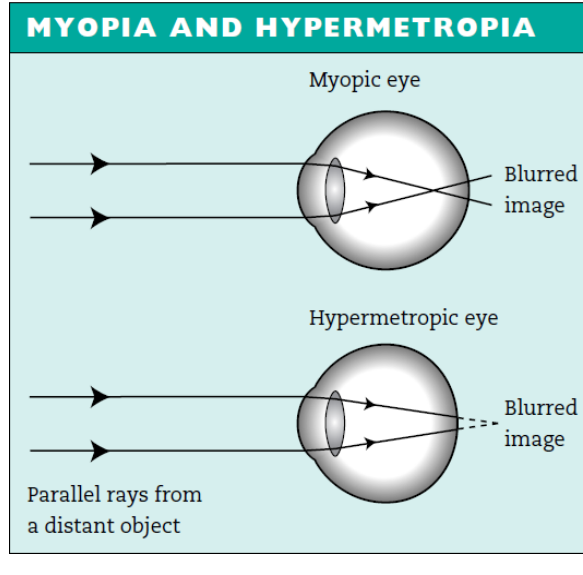
Ametropia :- when parallel rays of light are not brought to a focus on the retina in an eye at rest. It's simply "refractive error". A change in refraction is needed to achieve sharp vision.

Ametropia is divided into:

1) Myopia: Short sightedness

2) Hyperopia (Hypermetropia):
= Long sightedness.

3) Astigmatism :non spherical cornea.



Hypermetropia

Hypermetropic eye is too short for its converging ability.

The eye's optical system is less powerful, and/or the eye is too short.

A lot of children are farsighted ,this makes sense as they have small weak eyes. So it's a stage in normal development of the eye (physiologic) , or due to any cause that shortens the globe (pathological Hyperopia).

Special forms: Ectopia lentis(displacement of lens from its normal position.
Post operative aphakia.

Rays of light converge behind the retina, which causes blurring of vision for near objects ± distant objects.

Hypermetropes must accommodate with distant gaze to bring image into retina.

Hypermetropia- why?

- The length of the eyeball is shorter than it should be.
- stage in normal development of the eyes—at birth eyes are hypermetropic (2.5 to 3.0 Diopters)
- When persists in adulthood it represents an imperfectly developed eye.

Hypermetropia -symptoms

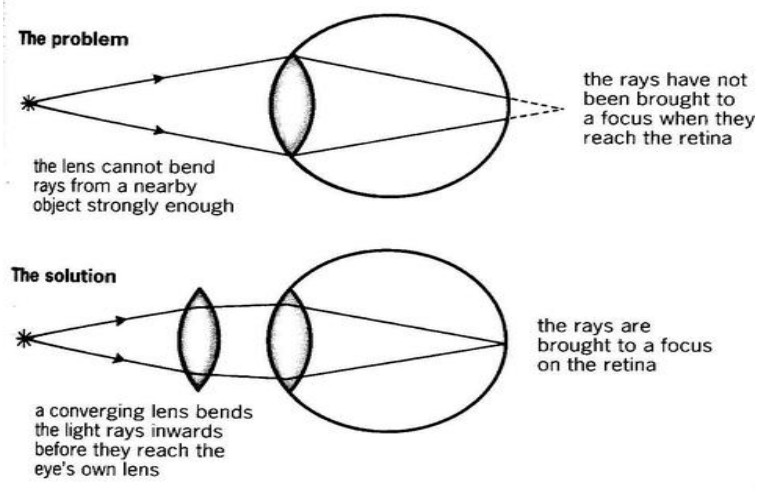
- Eye-strain (ciliary muscle is straining to maintain accommodation) ; fatigue, pain in or around the eyes, blurred vision, headache.
- Redness.
- In a child with an equal degree of long sight in both eyes, a convergent squint may develop because of increased accomodative effort to focus distant, and particularly nearby objects.
- Headaches in later part of the day.
- Complain of blurring of text.

Clinical features:

-Youth: usually don't require glasses, they have sufficient accommodative ability to focus the image on the retina, but may develop accommodative EsoTropia(convergent squint).

- >50s: blurring of distance vision due to severely decreased accommodation. corrected by adding a powerful lens, a converging (convex) lens.

Complications: Angle-closure glaucoma, particularly later in life.


The problem
the rays have not been brought to a focus when they reach the retina
the lens cannot bend rays from a nearby object strongly enough
The solution
the rays are brought to a focus on the retina
a converging lens bends the light rays inwards before they reach the eye's own lens

Myopia

Globe too long relative to refractive mechanisms, or refractive mechanisms too Strong ,strong big eye.

Usually presents in 1st or 2nd decades ,rarely begins after the age of 25,except in pts with D.M or cataract.

Keratoconus(conical cornea) is a pathological cause of myopia, (comes also with irregular stigmatism).

Blurring of distance vision, the near isn't affected .

Complications (though rare) : retinal tear or detachment, macular hole, and open angle glaucoma.

Not prevented with refractive correction.

Management: corrected by a diverging lens "concave", or refractive eye surgery.

DEGREES OF MYOPIA

Low myopia:

usually describes myopia of −3.00 diopters or more

Medium myopia usually describes myopia between −3.00 and −6.00

diopeters Those with moderate amounts of myopia are more likely to have

Pigmented dispersion syndrome or pigmented glaucoma

High myopia usually describes myopia of −6.00 or less

(toward -10.00). People with high myopia are more likely to have

retinal deatachment and primary open angle glaucoma,

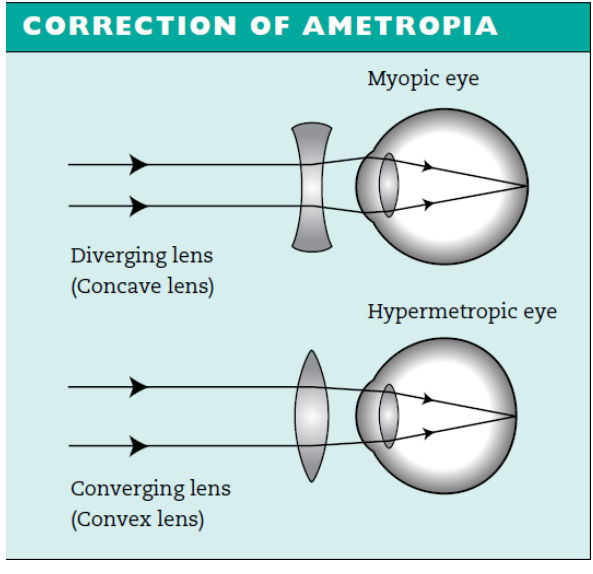
also more likely

to experience floaters, shadow-like shapes which appear singly or

in clusters in the field of vision.

How myopes usually see

. In high myopia even near vision is affected e.g. reading



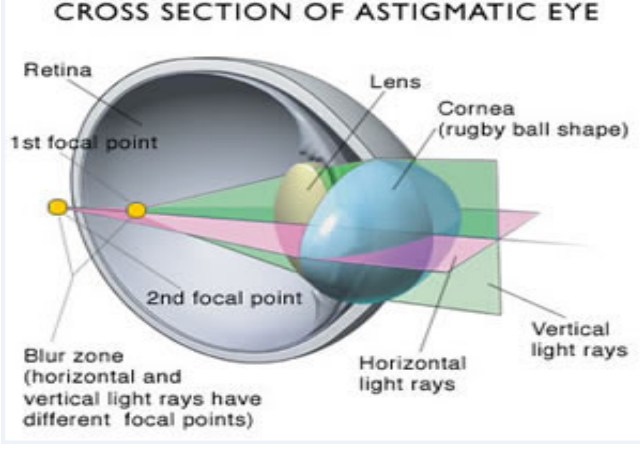
Astigmatism "اللا بؤريه":

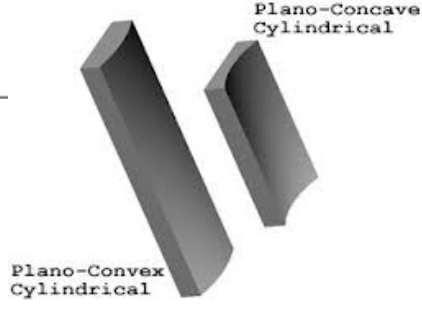
Light rays aren't refracted uniformly in all meridians due to non spherical shape of cornea or lens, parallel rays passing through theses different planes are brought to different points of focus.

The cause of astigmatism is unknown. It is usually present from birth, and often occurs together with nearsightedness or farsightedness.

Astigmatism makes it difficult to see fine details, either close up or from a distance. Corrected with a cylindrical lens(planoconvex or planoconcave) or refractive eye surgery.

Astigmatism is very common.





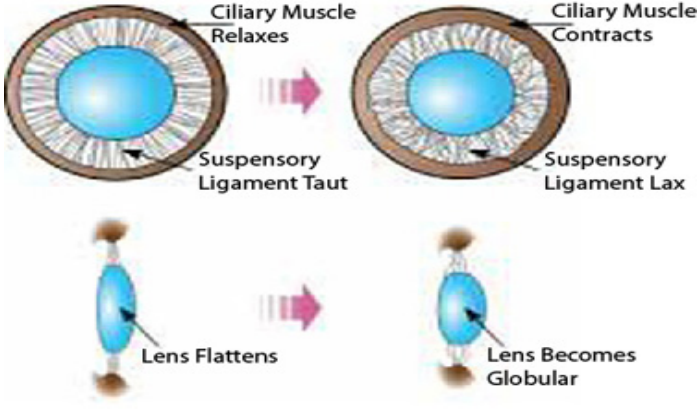
Another misnomer :
Astigmatism is not
انحراف

Accommodation

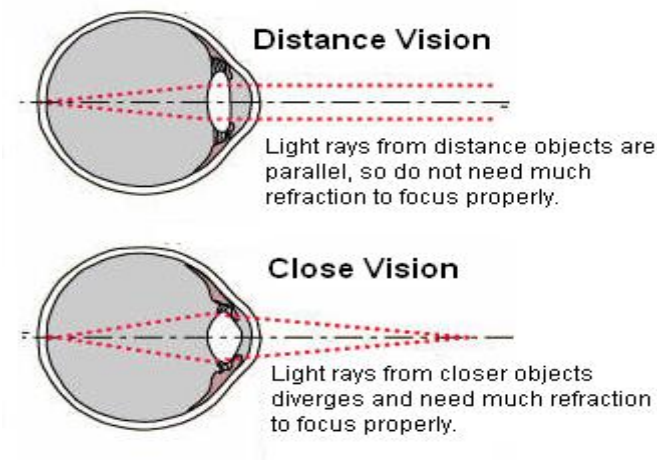
Near focusing of the eye.

Ciliary muscle contraction……..zonules relax……..lens more spherical,thick and globular)

Eyes converge, pupils constrict.



Why do we need accommodation in near vision???

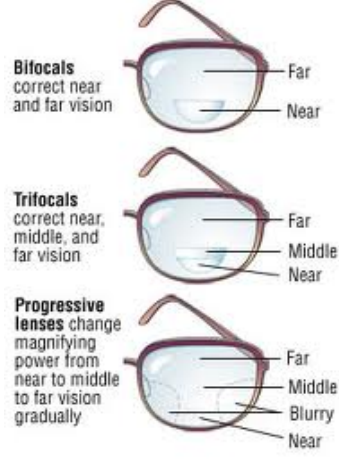


This ability decreases with age esp. after 40.

Presbyopia : normal aging process, when near images can't be focused on the retina due to reduced accommodative ability.
The focus is behind the retina as in hyperopia.

If initially emmetropic: person begins to hold reading material farther away and distance vision is unaffected.

If initially hyperopic : presbyopia occurs earlier.
Corrected with a convex lens for reading (bifocal).



Refractive error correction

Contact lenses

Spectacles

Refractive surgery

Contact lenses

- Soft, hydrophilic better tolerated physically but, less permeable to oxygen.
- Rigid gas permeable

Advantages of rigid gas-permeable:

- Their greater oxygen-permeability reduces the risk of corneal damage from hypoxia
- Their rigidity allows easier cleaning and offers less risk of infection
- Their rigidity permits an effective correction of astigmatism
- Proteinaceous debris is less likely to adhere to the lens and cause an allergic conjunctivitis

Contact Lenses

- Hard contact lenses are mainly used in the treatment of keratoconus.
- Soft contact lenses for:

  1) Optical correction

  2) Bandage contact lenses(no refractive function) for the relief of pain like in epithelial defects or bullous(endoth) keratopathy.

Complications Of Contact Lenses

- Superficial punctate keratitis(epith breakdown in pinpoint) is the most common complication. It is staining at 3 and 9 o'clock and this is associated with incomplete blinking and drying in rigid lens syndrome.
- The tight lens syndrome, characterized by indentation and staining in the conjunctival epithelium in a ring around the cornea.
- Acute hypoxia Epithelial microcysts, necrosis and endothelial blebs.
- Chronic Hypoxia Vascularization and lipid deposition.

Refraction

Refraction is a process your eye care professional uses to measure your refractive error, or vision problem to determine how much power is needed to bring your eyes to normal, perfectly focused vision. Refraction consists of two parts, objective and subjective.

Objective Refraction:

refraction obtained without receiving any feedback from the patient, obtained by using different instruments:

1) retinoscope or
2) auto-refractor .

Automated refractor

Computerized instrument that shines light into your eye.

The light travels through the front part of your eye to the back part of your eye, then back again.

The information bounces back to the instrument, giving an objective measurement of your refractive error.

Auto-refractors are quick and easy to use, and require no feedback from you.

Retinoscopy

The doctor will project a streak of light into your pupil.

A series of lenses are flashed in front of your eye.

By looking through the retinoscope, the doctor can study the light reflex of the pupil.

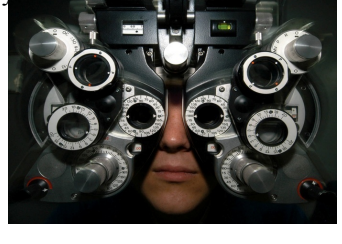
Based on the movement and orientation of this retinal reflection, the refractive state of your eye is measured.

Subjective refraction

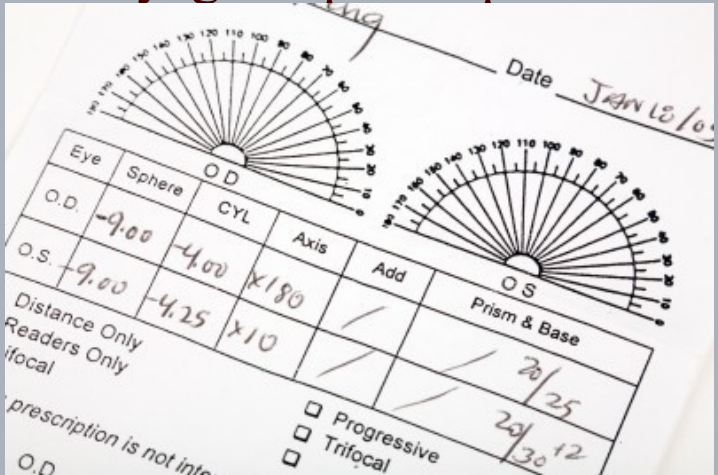
A subjective refraction requires responses from the patient. The doctor may use a phoropter to measure your subjective refractive error to determine your eyeglass prescription.

Typically, you will sit behind the phoropter and look at an eye chart. The doctor will change lenses and other settings while asking you for feedback on which settings give you the best vision.

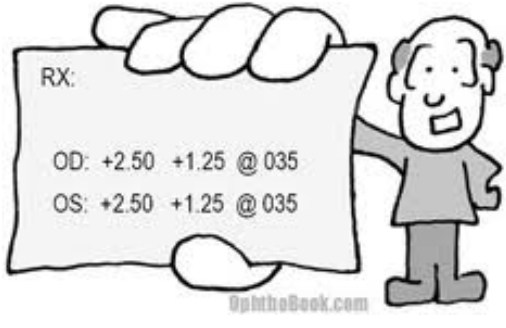
Sometimes eye doctors prefer to obtain a cycloplegic refraction , especially when trying to obtain an accurate refraction in young children who may skew refraction measurements by adjusting their eyes.

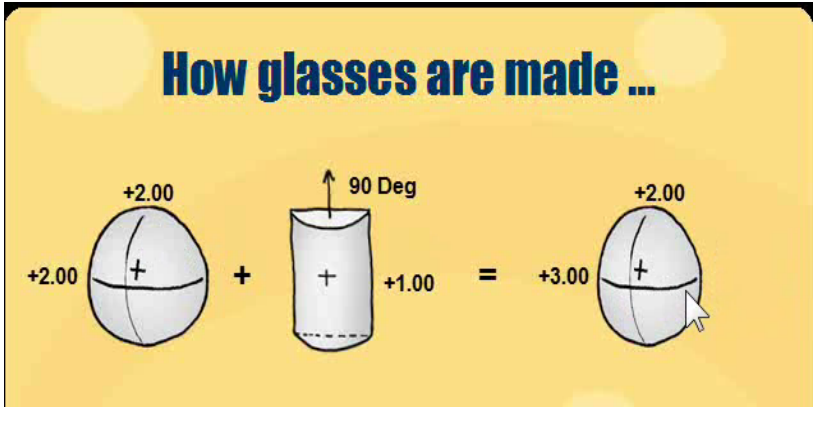


Spectacles
eyeglass prescription



The parameters specified on spectacle prescriptions vary, but typically include the power to which each lens should be made in order to correct blurred vision due to refractive errors, including myopia, hyperopia, astigmatism, and presbyopia.



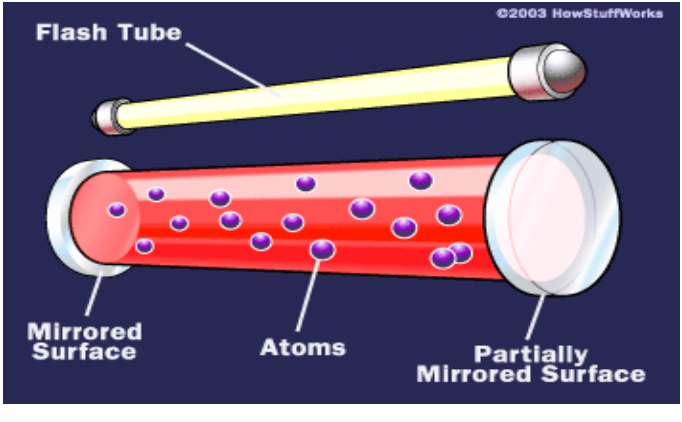

How glasses are made ...
+2.00
+2.00
+
90 Deg
+
+1.00
=
+2.00
+3.00
+

Refractive surgery

- Corneal surgery
- PRK - photorefractive keratectomy
- LASEK - laser subepithelial keratomileusis
- LASIK - laser assissted in-situ keratomileusis
- Lens surgery

What is laser ?

Acronym "light amplification by stimulated emission of radiation" not only visible light, hence *infrared laser*, ***ultraviolet laser,*** *X-ray laser*, and so on .



Excimer laser : subtype of laser

Excited dimers, is a cool laser beam, because it causes little thermal damage to adjacent tissues.

UV laser that works by photoablative decomposition of the corneal stroma laser energy destroys intermolecular bonds in cornea to alter its shape.

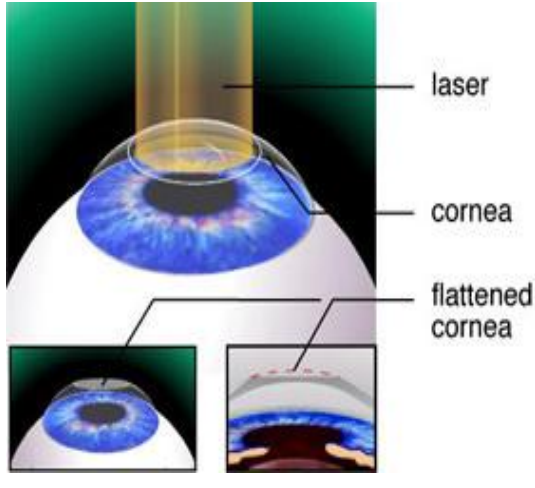
In myopia it flattens the cornea while in hypermetropia it steepens it.
In astigmatism it flattens the steepest meridian .

PRK

- PRK stands for PhotoRefractive Keratectomy.
- It this case, we don't do any cuts in the cornea like LASIK, instead we remove the corneal epithelium, and the Excimer laser is applied to the cornea which is followed by application of a contact lens to the eye until the epithelium heals completely, then the contact lens is removed.
- PRK is usually done when the corneal thickness is not enough to do LASIK.
- The procedure is usually painful post operatively up to 2 – 3 days until the epithelium heals.

PRK

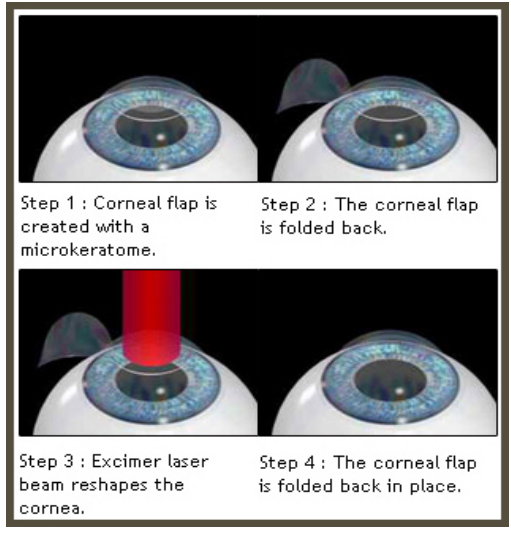
Laser is applied to the corneal surface after removing the epithelium , the cornea is resurfaced later.

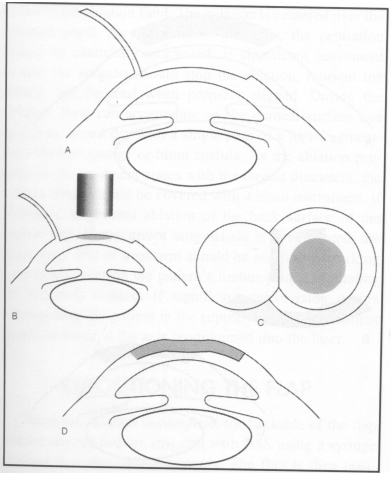


LASIK

laser assisted in situ keratomileusis

* corneal flap (in situ)
* reshape the cornea (keratomileusis)

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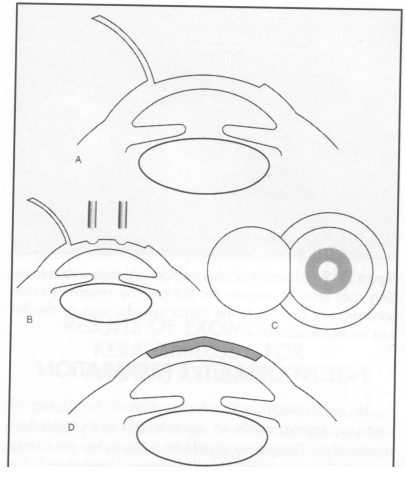
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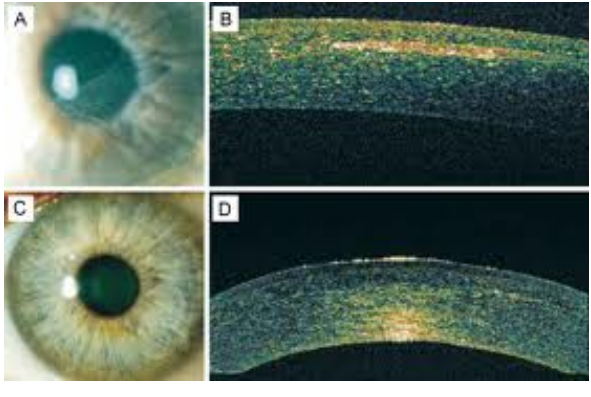
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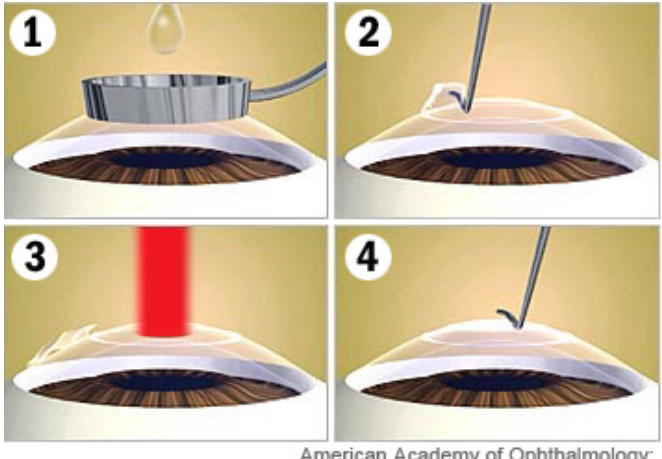
LASEK (sub epithelial)



American Academy of Ophthalmology;
UCLA Laser Refractive Center at the Jules Stein Eye Institute

Complications of LASIK

- Operative Complications:
- Flap complications:

1) Free flap
2) Incomplete flap
3) Button hole of the flap
4) Irregular cut
5) Epithelial defects
6) Corneal perforation

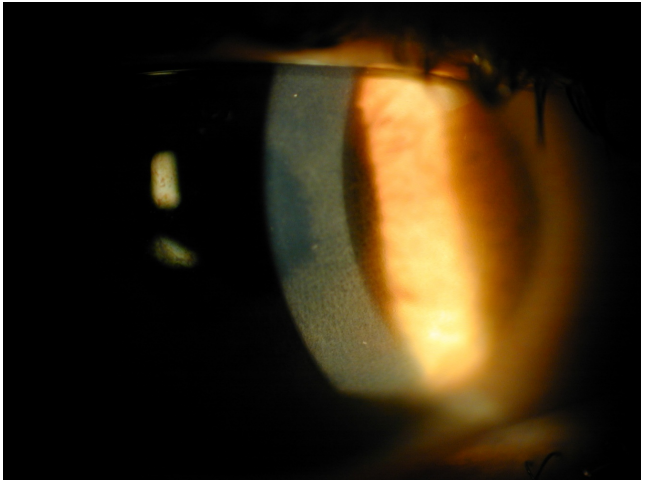
- Laser Complications:

1) De-centered ablation

- Post Operative Complications:

1) Overcorrection
2) Under correction
3) Infection
4) Epithelium in-growth under the flap

- DLK □ Diffuse Lamellar Keratitis



Complications Of PRK

- Overcorrection
- Under correction
- Corneal haze
- Infection

Thank you