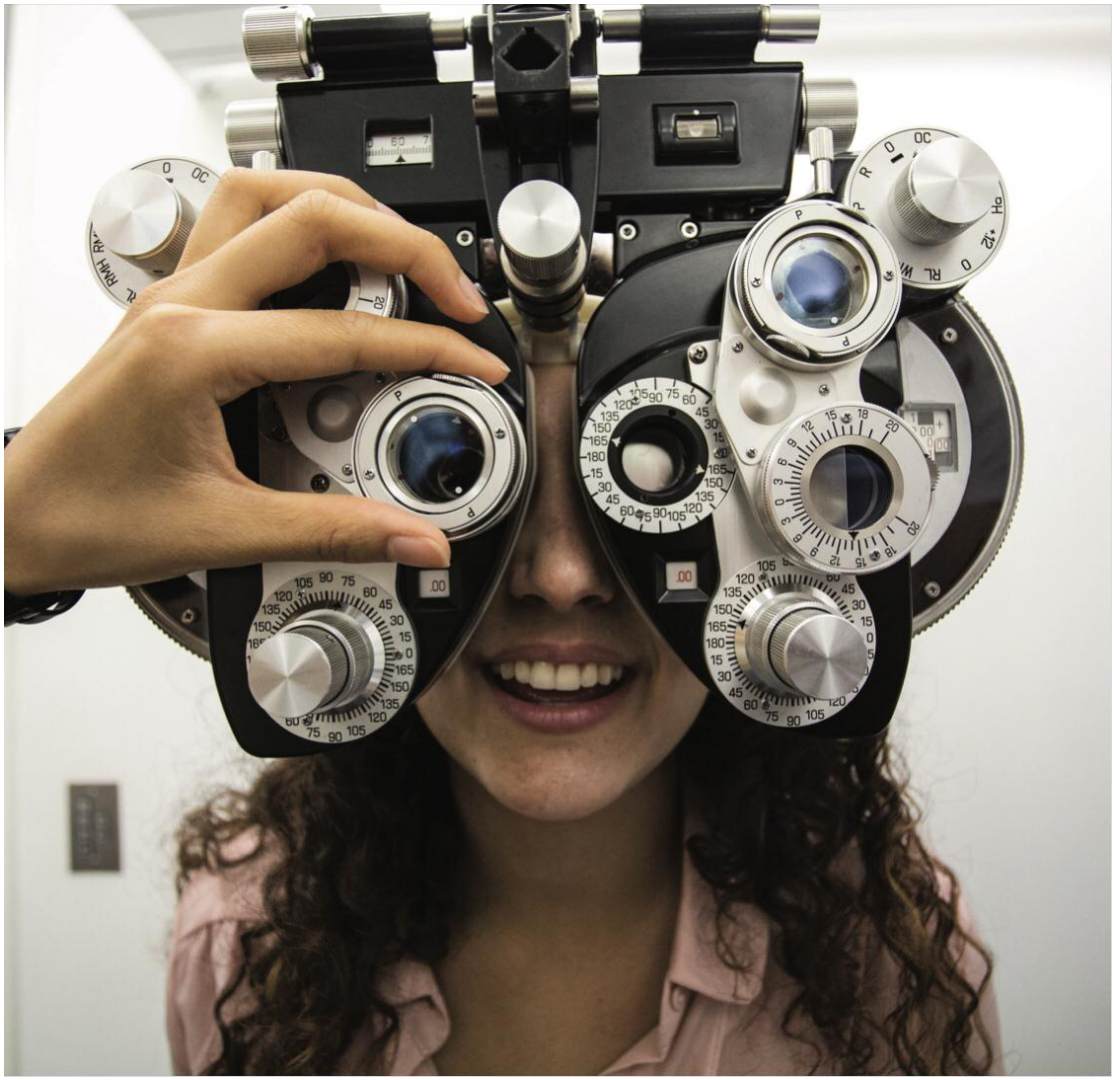
AMETROPIA

Refractive error



Dr. Haneen Adnan.

LEARNING OBJECTS

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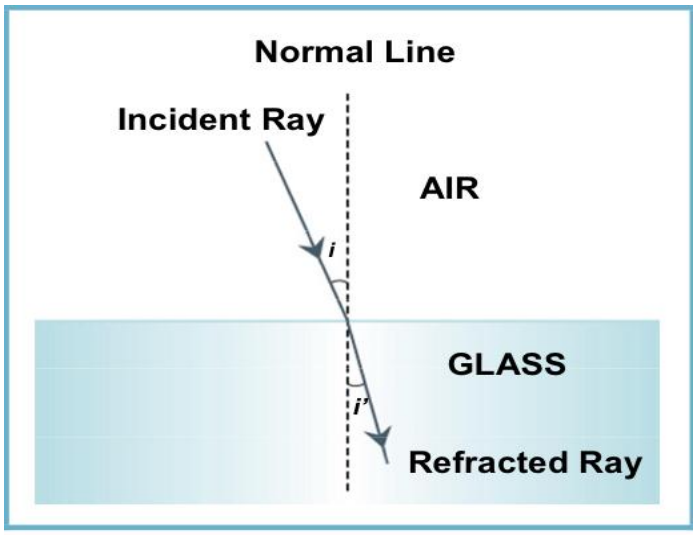
Emmetropia

Light refraction (basic optics)

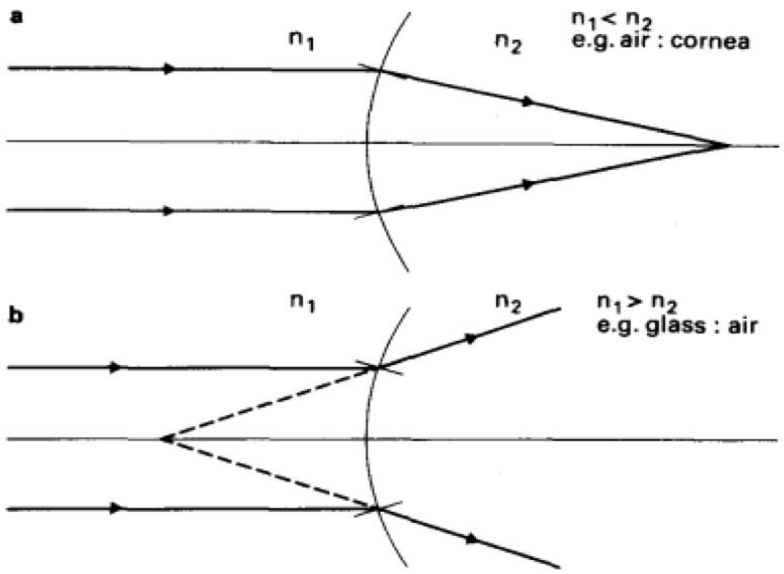
A.When a light ray travels from a medium with a lower optical density into a medium with a higher optical density, the light ray is



bent towards the normal.(fig.1)

(Fig.1): light refraction.

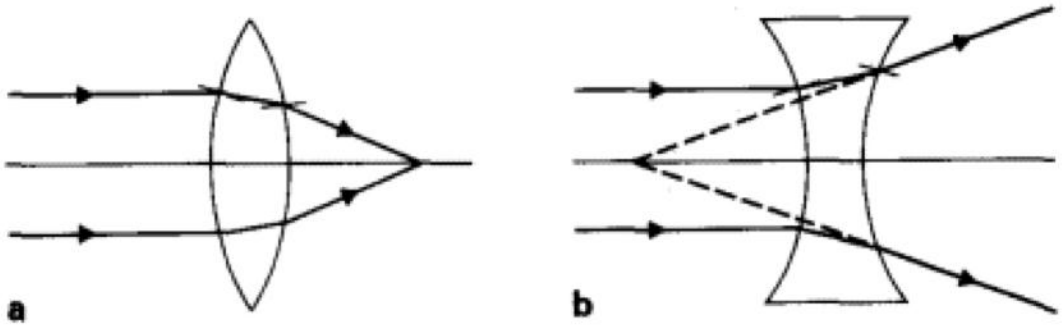
B.Refraction of light through a curved surface (e.g:cornea), it obey



the rule A.(fig. 2)

(Fig. 2):Light refraction through convex surface e.g. cornea, refractive index (n) is a measure for optical density ,higher n = higher optical density.

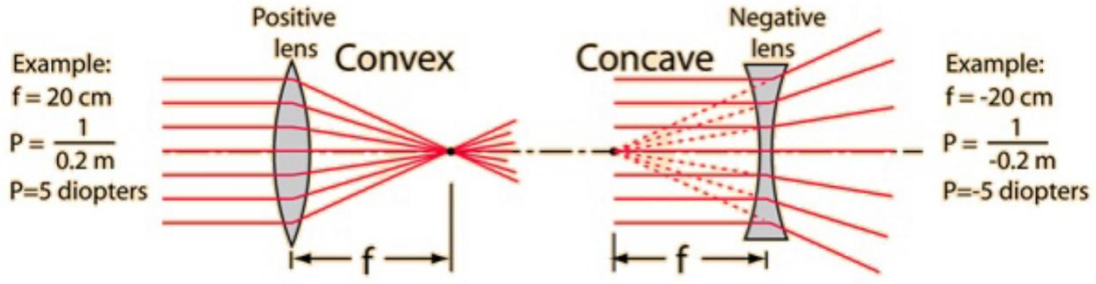
C.Light refraction through lenses also obey rule A , so the convex lens (e.g.human lens) is converging the light and has positive sign (plus lens +) while the concave lens is diverging the light and has



negative sign (minus lens -).(fig 3)

(Fig.3): Optics of lenses. A.plus lens. B.minus lens.

The dioptric power of a lens is measure of its focusing ability , since the lens converge or diverge all rays into one point (focal point) so its power (in diopter) is the reverse of its focal length f(in m).(fig.4)



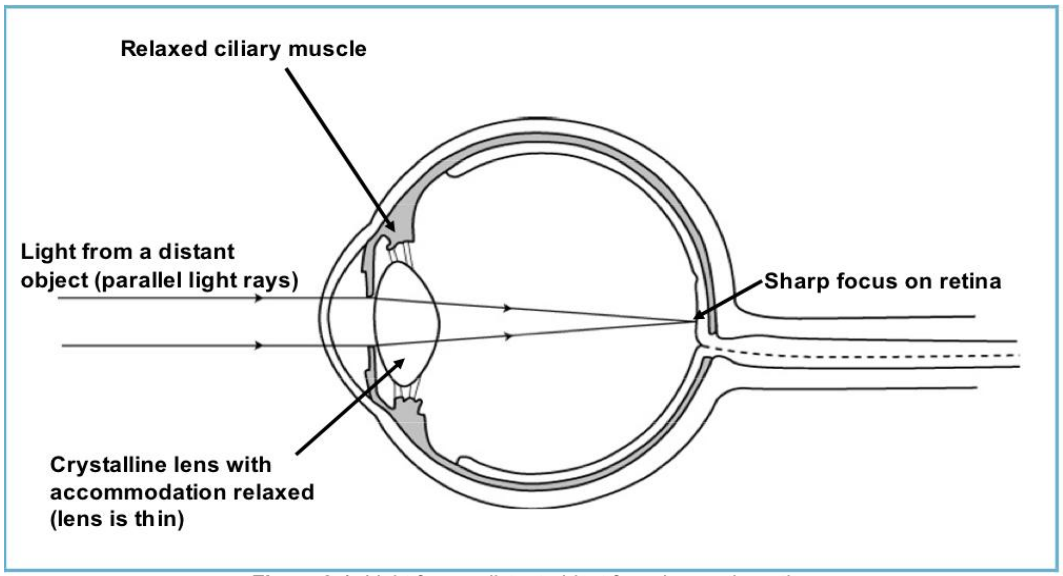
(Fig.4):Dioptric power of lenses.

Refraction of the Eye (focusing light in the Eye)

It is important to know that light rays coming from a distant object are parallel(any object that is further than 6 metres away). Light rays coming from a close object are divergent. The closer the object

is to the eye, the more divergent the light rays become.For light rays to focus exactly on the retina, the eye must have the following: (fig. 5)

- The cornea and the lens must converge the light by the correct amount.
- The eyeball must be of the correct length (the distance between the cornea and the retina).
- The tear film, cornea, aqueous humour, crystalline lens, and vitreous must be clear so that the light can reach the retina without being interrupted.



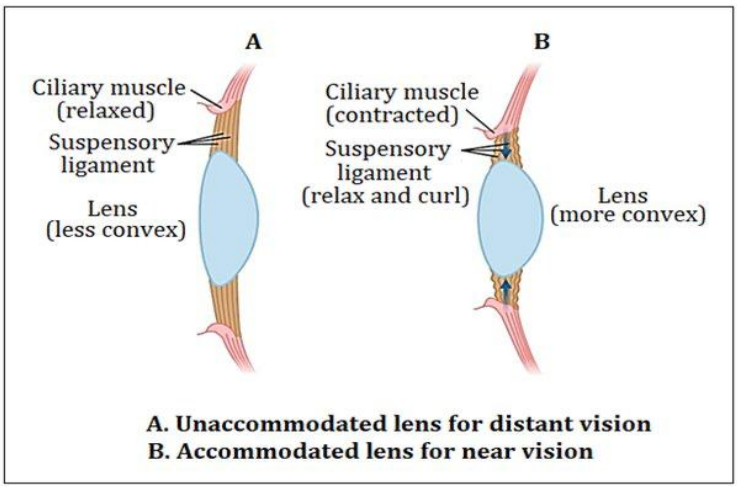
(Fig. 5): Refraction of the eye in non accommodative state.

From above we define the Emmetropia as The refractive state of an eye, which, with relaxed accommodation, focuses objects at optical infinity on the fovea.

Accommodation of the eye

If the refractive power of an emmetropic eye were fixed and unalterable, only objects at infinity would be clearly seen. Light from nearer objects has diverging rays , to overcome such problem, the eye has ability to increase its dioptric power. The crystalline lens is held suspended under tension by the suspensory ligament which attaches it to the ring of ciliary muscle. Ciliary muscle contraction reduces the tension on the suspensory ligament and lens, allowing

the lens to assume a more globular shape (Fig. 6). The curvatures



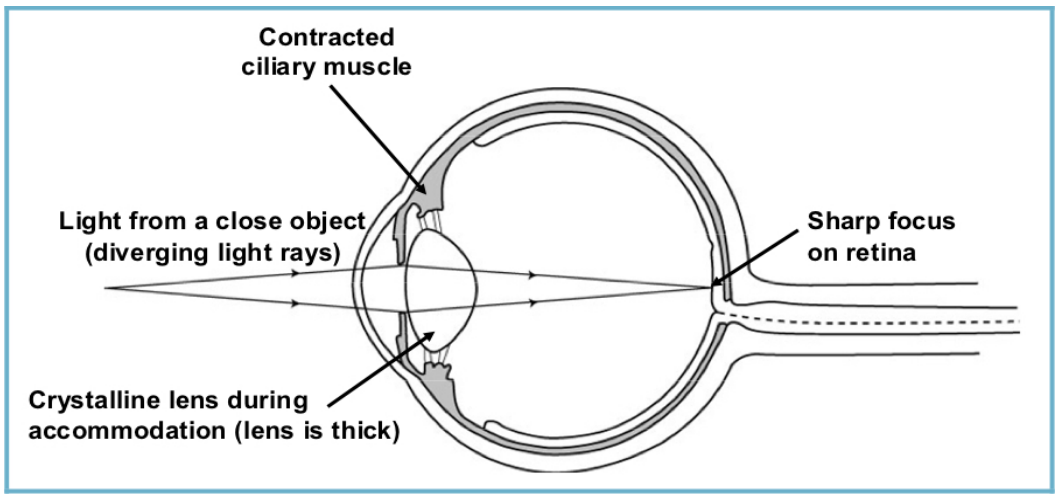
of the lens surfaces and the lens thickness are increased and thus the dioptric power is increased (fig 7). Most of the change in curvature occurs at the anterior lens surface, which moves forwards slightly toward the cornea. This ability of the eye to increase its dioptric power is called accommodation.

(Fig. 6): Accomodation of the lens.

(Fig. 7): Light rays from a close object focusing on the retina in an accommodating eye.

Notes:

- The cornea provides 2 / 3 of the eye's total focusing power. It is the curved shape and thickness of the cornea that provides its focusing power.The shape and thickness of the cornea cannot change, so the focusing power of the cornea does not



change.

- The lens provides 1 / 3 of the eye's total focusing power.The curved shape and thickness of the lens provide its focusing power.The lens can change its shape to become thicker &more curved (Accommodation) so the focusing power of the lens can change.

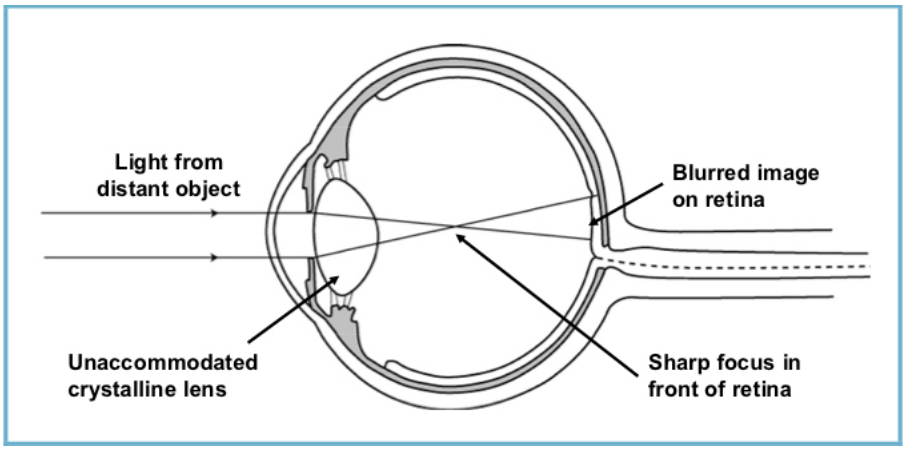
Ametropias (refractive errors)

Optics & classification

In contrast to emmetropia, the ametropic eye fails to bring parallel light to a focus on the retina.

A.In the myopic eye, the focus lies in front of the retina (Fig. 8). This may be because:

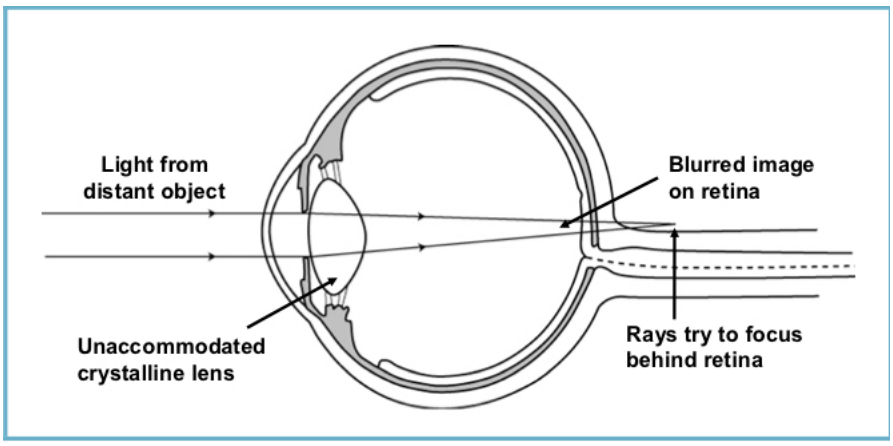
a. the eye is abnormally long. This is called axial myopia and includes high myopia.
b. the eye may be of normal length, but the dioptric power may be increased. This is called refractive or index myopia. Examples of this are keratoconus, where the corneal refractive power is increased, and nucleosclerosis, where the refractive power of the lens increases as the nucleus becomes more thick.



(Fig. 8): myopia.

B. In the hypermetropic eye, the focus lies behind the retina (Fig. 9). This may be because:

- the eye is short relative to its focal power, then axial hypermetropia results.
- the refractive power of the eye is inadequate, then refractive hypermetropia results. Aphakia is an example of



refractive hypermetropia.

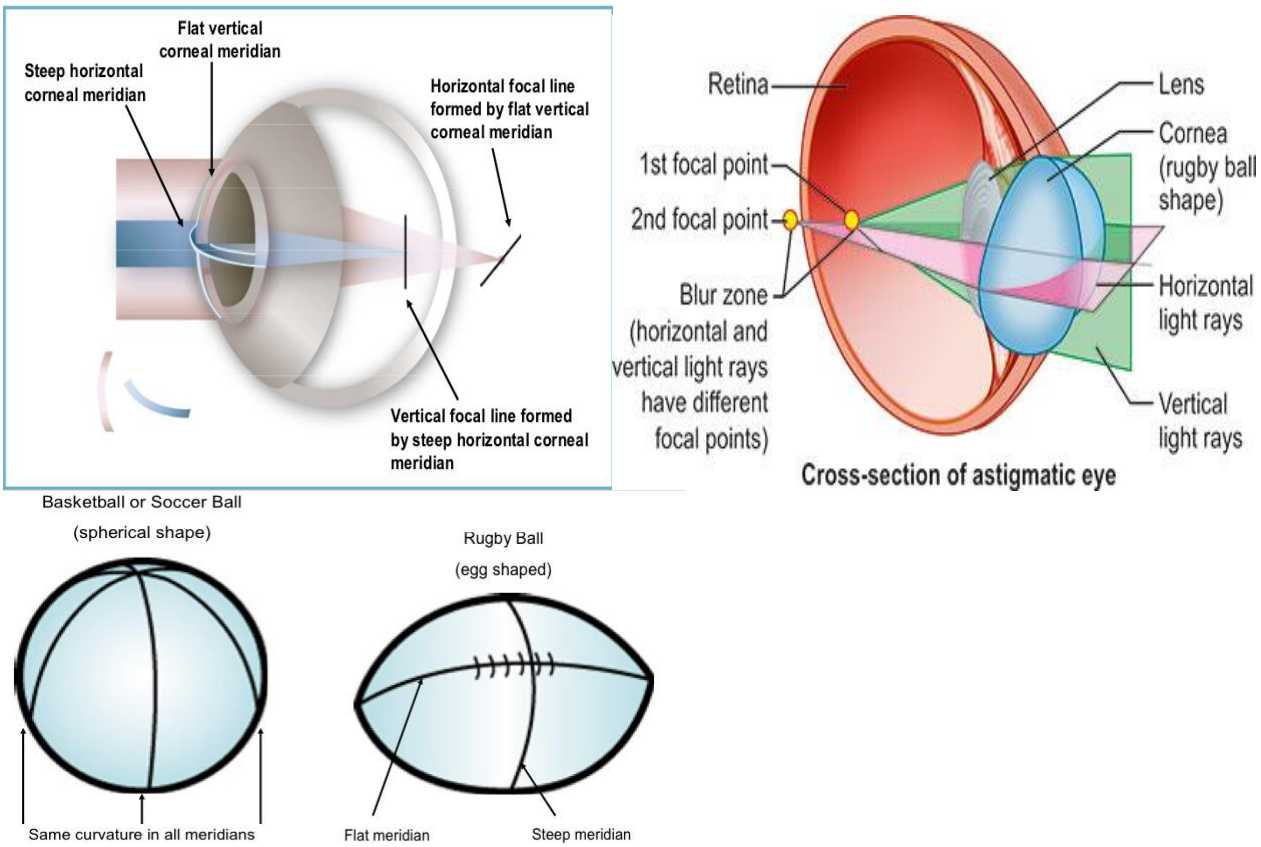
(Fig. 9):Hypermetropia.

Hypermetropia is also classified into manifest and latent.

- **Manifest hypermetropia** is defined as the strongest convex lens correction accepted for clear distance vision.
- **Latent hypermetropia** is the remainder of the hypermetropia which is masked by ciliary tone and involuntary accommodation. This may account for several diopters, especially in children, for whom cycloplegic refraction is necessary to ascertain the full magnitude of the refractive error.

C. Astigmatism (a = without, stigmos = point) is an optical condition of the eye in which light rays from a point source do not focus to a single point. Typically, light rays from a single object

point are refracted to form 2 focal lines (fig. 10).

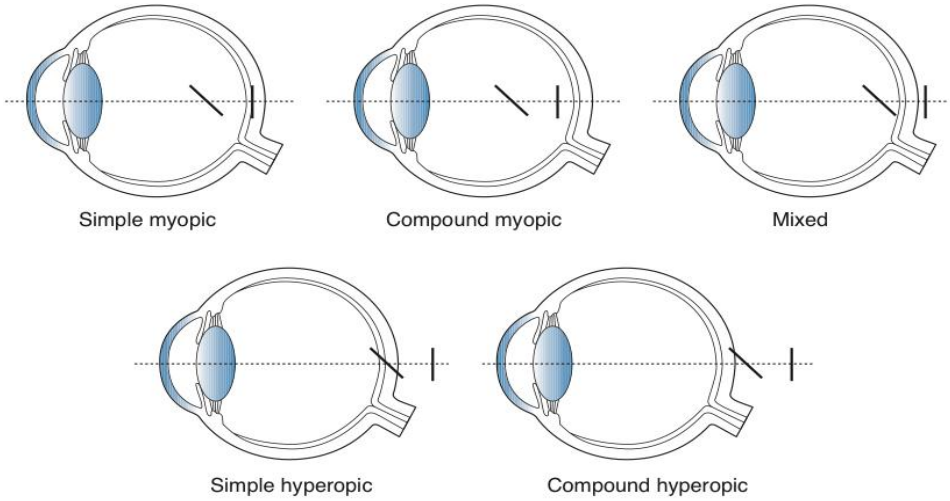


(Fig. 10):Astigmatism.

<u>Classification</u> (fig. 11):

- If 1 focal line lies in front of the retina and the other is on the retina, is classified as simple myopic astigmatism.
- If both focal lines lie in front of the retina, the condition is classified as compound myopic astigmatism.
- If, 1 focal line lies behind the retina and the other is on the retina, is classified as simple hyperopic astigmatism.
- If both focal lines lie behind the retina, is classified as compound hyperopic astigmatism.

- If, one focal line lies in front of the retina and the other behind it, is classified as mixed astigmatism.



Types :

- If the principal meridians are at 90° to each other, this is called regular astigmatism.
- If the principal meridians are not at 90° to each other, this is called irregular astigmatism and cannot be corrected by spectacles.

Prevalence & aetiology

a) ***Age**: Myopia is more common in adolescence (11 to 17 years old), while hyperopia is more common with increasing age (fifth to eighth decades).*

b) ***Race**: Asians (Japan, China) have much higher rates of myopia at all ages, while African-Americans have less rates.*

c) ***Hereditary**: Heredity is the most significant factor in causation and progression of myopia.*

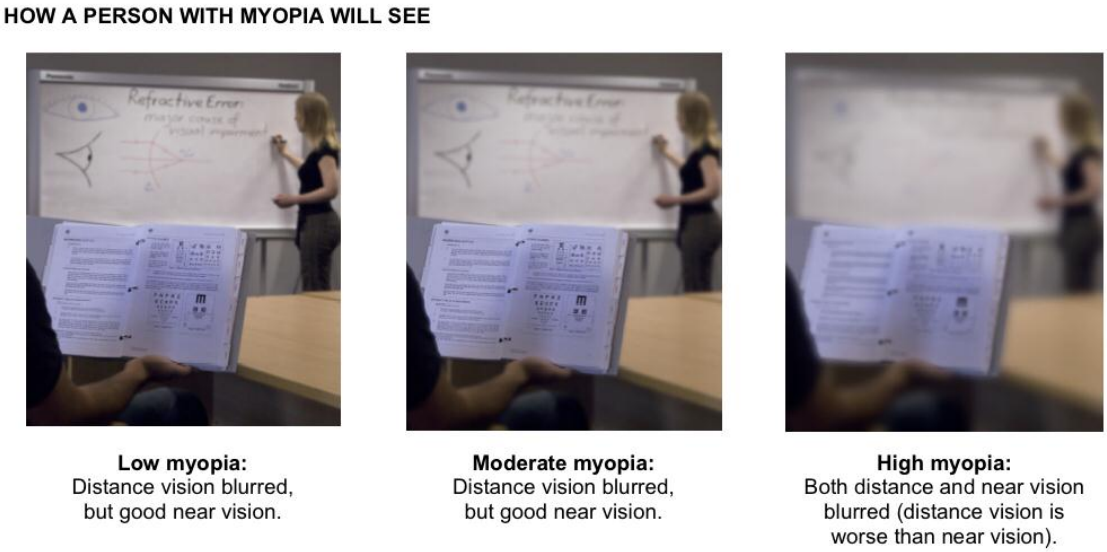
d) ***Intelligence and Myopia**: A large number of studies have reported a relationship between myopia and high IQ.*

e) ***Environmental factors**: longer duration of education with near work and reduced outdoor activities have been associated with myopia progression. In contrast to myopia, hyperopia has been associated with lower educational achievement.*

Symptoms :

Myopia

Is often called "shortsightedness". The reason for this is that a person with myopia will have near vision better than their distance vision.People with myopia usually complain of blurry distance vision, or say that they cannot recognise people who are far away. They may notice, that they see better when they almost close their eyes

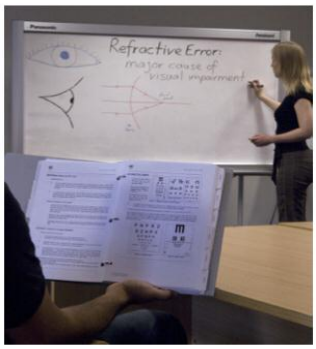


("screw up").

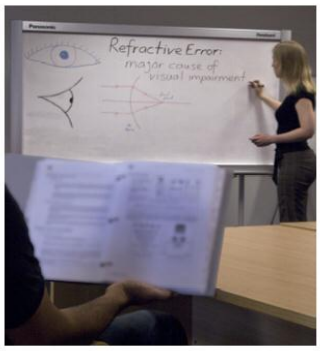
Hyperopia

- low hyperopia, the person may be able to accommodate enough to compensate for their hyperopia – they will have clear vision, both in the distance and at near, without spectacles. They may complain of "asthenopia" (eye strain or visual fatigue) and are caused by fatigue of the ciliary muscle which works to make the lens accommodate.
- moderate hyperopia, the person may complain of blurry near vision, but may have clear distance vision.
- high hyperopia, the person may tell you that both their distance and near vision is blurred.

HOW A PERSON WITH HYPEROPIA MAY SEE



Low hyperopia:
May have good distance vision and good near vision, but may have eyestrain and headaches.



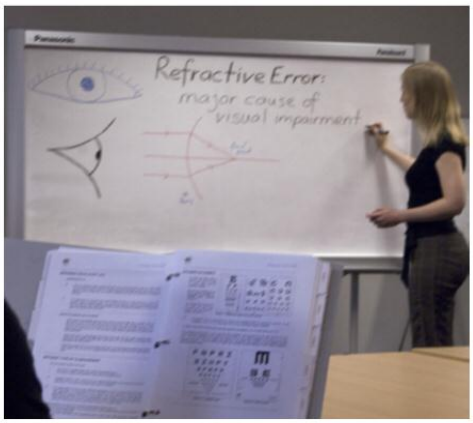
Moderate hyperopia:
Near vision blurred, but good distance vision.

High hyperopia:
Both distance and near vision blurred (near vision is worse than distance vision).

Astigmatism

- A person with astigmatism may tell you they have problems with both distance and near vision.
- The young person with astigmatism often has asthenopia or headaches. This is because young people have very active accommodation and often try to use their accommodation to compensate.

HOW A PERSON WITH ASTIGMATISM MAY SEE



Moderate astigmatism:
Distance and near vision slightly blurred.

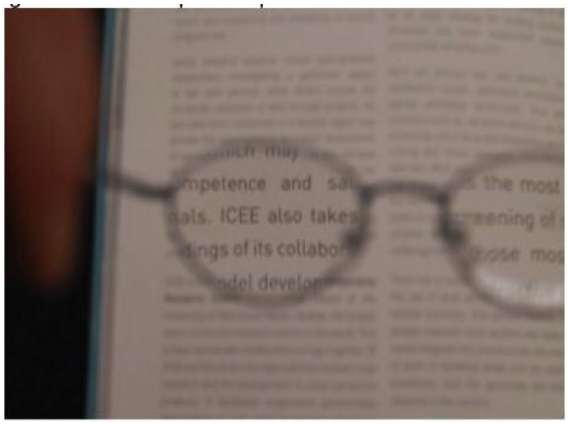
High astigmatism:
Distance and near vision more blurred.

Correction of refractive errors

A.Spectacles.

Spectacle was and will remain the mainstay of refractive errors correction.

- Concave (or "minus") spherical lenses correct myopia.
- Convex (or "plus") spherical lenses correct hyperopia.



- Spherocylindrical lens correct astigmatism.

Lt pic for plus lens that has magnifying effect .

Rt pic for minus lens that has minifying effect.

B.Contact lenses.

Advantages vs spectacles

- Wider field of view because it moves with the eyes. In glasses, lenses and frames restrict field of view.
- Not affected by fogging up or rain.
- Fewer magnification effect , The size of viewed objects is more constant with contact lenses ('real-world').
- Less adaptation may be need.
- Fewer reflections ,fewer distortion.

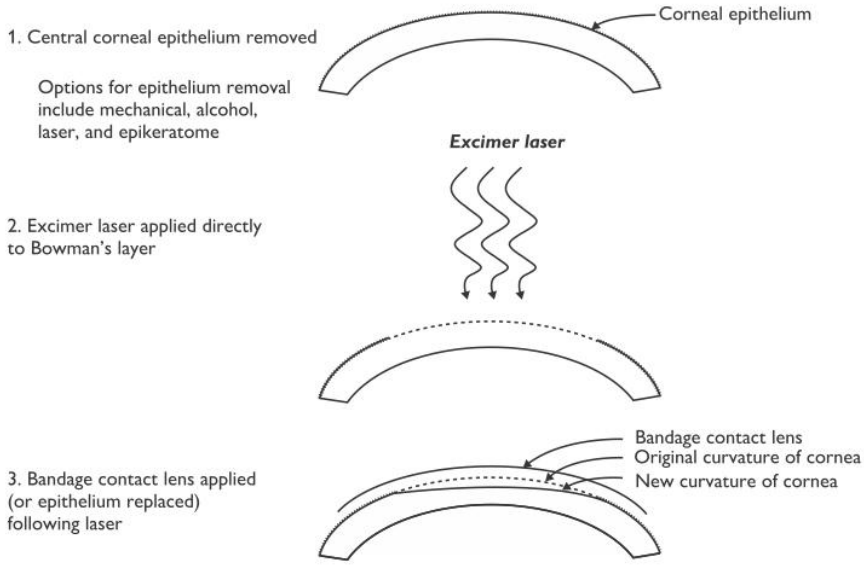
Problems with contact lenses

- Infectious (Conjunctivitis, Keratitis).
- Corneal neovascularization.
- Dry eye
- Ptosis.
- Corneal abrasions.
- allergic reactions.
- Giant papillary conjunctivitis.

C.Refractive surgery

1.Photorefractive keratectomy (PRK)

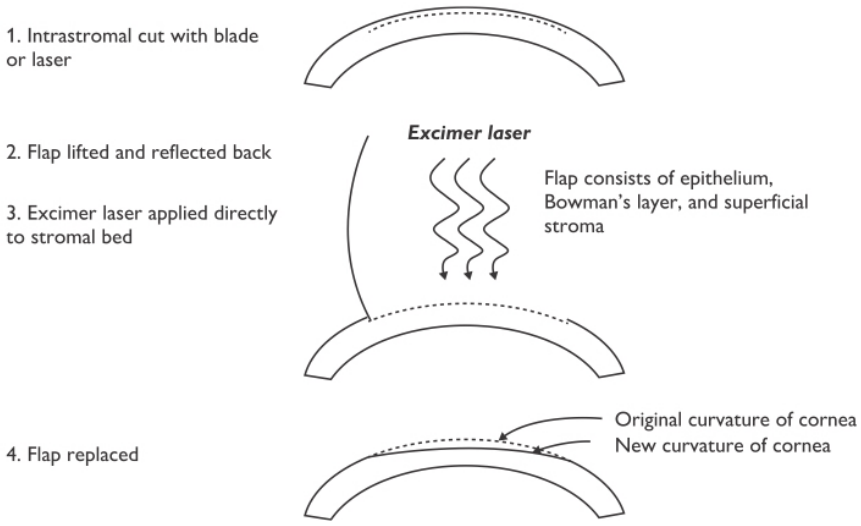
Surface ablation technique by excimer laser: epithelium removed,



stroma selectively ablated with excimer laser, BCL inserted.

2. Laser assisted in situ keratomileusis (LASIK)

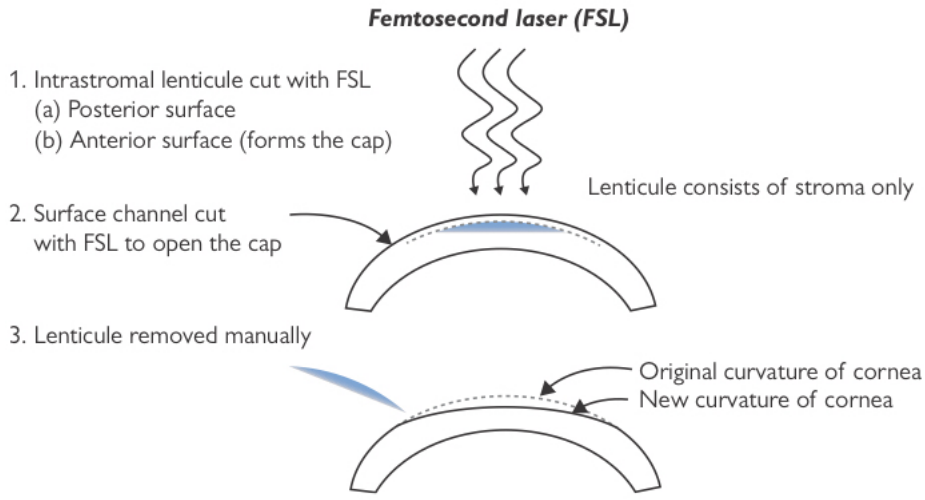
partial thickness superficial corneal flap created with microkeratome



or FSL(femtoLASIK), stroma selectively ablated with excimer laser, flap replaced.

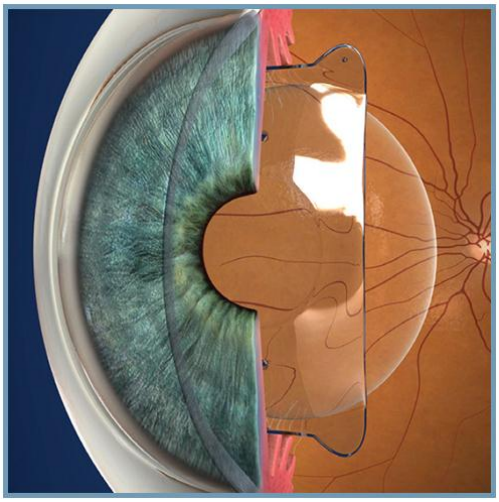
3. Small-incision lenticule extraction (SMILE)

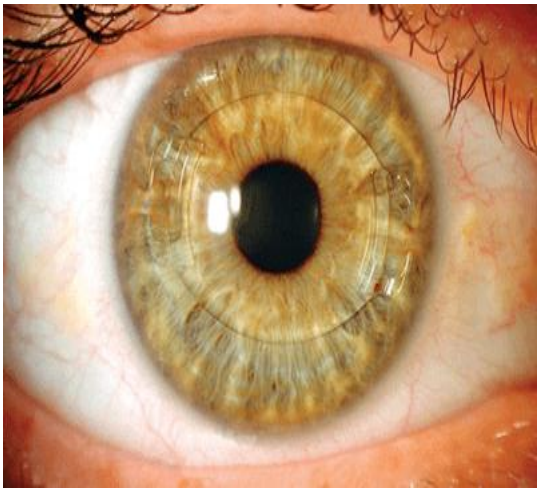
Femtolaser technique :Single step where a lenticule of tissue is removed through a small incision with no flap, not correct hypermetropia.



4. Phakic intraocular lens(Phakic IOL) (only for myopia)

Synthetic IOL which can be in the AC (iris-fixated) or in the

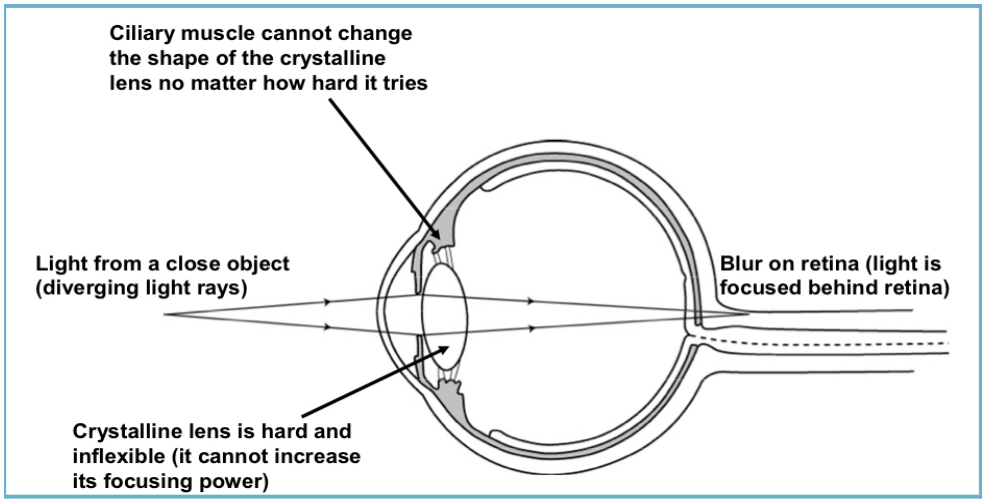




posterior chamber (ICL).

Presbyopia

Presbyopia is caused by the loss of accommodative ability that is associated with ageing. As we get older, the crystalline lens gradually gets harder and cannot change shape easily when the ciliary muscle contracts. This is a normal, natural aging process. Near object will appear blurry or out of focus. Sometimes an early presbyope will hold things further away from their eyes so that they can see it more clearly. This is because less accommodation is needed to see things that are further away from the eyes. Everyone



over the age of 40 to 45 years is affected by presbyopia.

Correction of presbyopia

Presbyopia is corrected with a near addition (or "add").The add is a positive spherical lens power that is added to the distance correction. Distance Spectacle Prescription + Near Addition = Near Spectacle Prescription.

TYPES OF PRESBYOPIA SPECTACLES

1. **Reading spectacles**: are only worn for close work, but distance vision blurry.
2. **Bifocal spectacles**: have two parts divided by a line: the top part for distance vision, while the bottom part has for near vision.

References

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2. *Borish's Clinical Refraction 2nd edition 2006.*
3. *Clinical Optics elkington 3rd edition 1999.*
4. *Refractive Error Manual by Brien Holden Vision Institute Academy version 1-2015.*
5. *Oxford Handbook of Ophthalmology 4th edition 2018.*

FAQ.

1.Does spectacles cure or prevent progression of refractive error?

Ans: Spectacles doesn't cure neither prevent progression of your refractive error. According to researches, the progression determined by genetics and environmental factors.

2.Does refractive surgery cure my refractive errors?

Refractive surgery correct the current error , doesn't prevent its progression.

3.Does nutrition affect occurrence and progression of refractive error in children ?

Off course, according to several studies ,Malnutrition increase risk for refractive errors and its progression.

4.How could I prevent progression of my myopia ?

According to several recent studies ,there are many attempts to prevent myopia progression:

- *removal of distance spectacles when one performs close work.*
- *low-dose atropine (eg, 0.01% eye drops) may slow myopia progression by 30%–60%.*
- *more than 2 hours of outdoor activity per day and avoidance of excessive near work has also been shown to reduce myopia progression.*