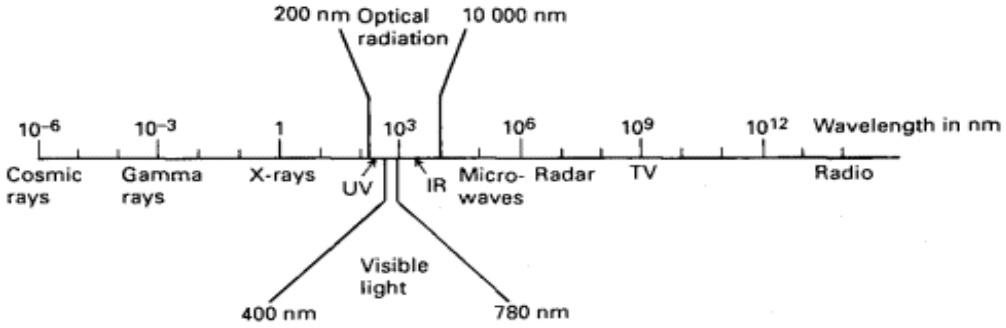
Refractive Errors

د. نور حسين عبادي

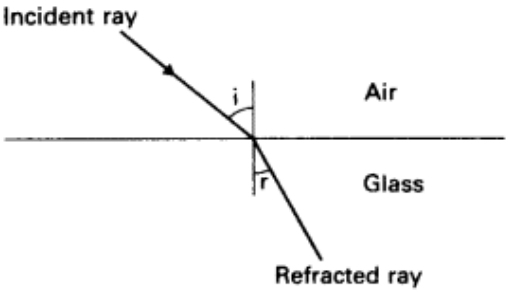
Properties of Light

Light is defined as energy to which the human eye is sensitive. The visible wavelengths of the electromagnetic spectrum lie between 400 nm and 780 nm (violet to red).

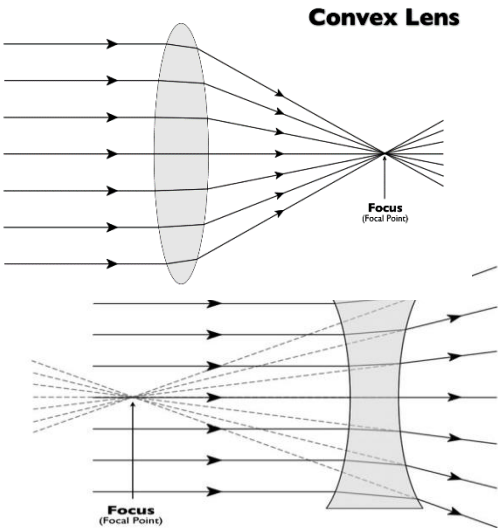


When light fall on an opaque surface it will undergo Reflection, while it will undergo a refraction when it falls on a transparent surface.

Refraction of light is defined as the change in direction of light when it passes from one transparent medium into another of different optical density (refractive index).



When light rays fall on a convex lens, the lens will cause a convergence of incident light, whereas a concave lens causes divergence of incident light.



The refractive power of the spherical lenses is measured by (dioptre), in which the convex lens has a positive power and concave lens has a negative power.

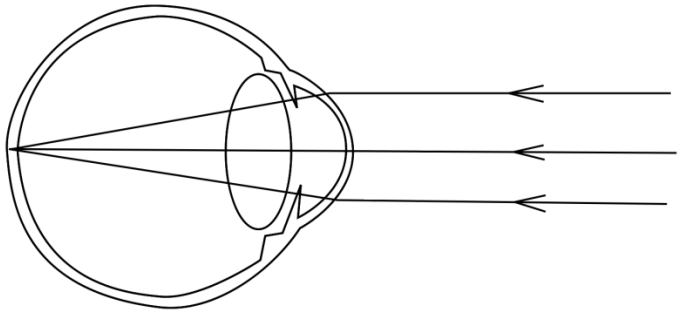
*The refractive power of the spherical lens increases by increase its curvature and vice versa.

Refraction by the eye

The most important two refractive surfaces of the eye are those of the cornea and lens which act as convex lenses. The power of the cornea and lens depend on curvatures of their surfaces and the differences in the refractive indices of their material in relation to the surrounding media.

The refractive index (RI) of air = 1, cornea = 1.376, aqueous humer = 1.336, lens (cortex – nucleus) = 1.386 – 1.4, vitreous = 1336.

The cornea is the major refractive surface of the eye as it has a total refractive power of (43 dioptres), while the lens has a power of (15 dioptres). This is because the air has the least refractive index is in contact with cornea.



Axial diameter (antero-posterior diameter) of the eyeball, is the distance from the central tip of the cornea to the centre of the posterior pole of the retina which is normally 23mm (range 22 – 24 mm).

The overall refractive power of the eye is (58 dioptres) which is required to focus parallel light rays on the retina that is 23 mm from the cornea.

Accommodation: is the increase in the refractive power of the eye on looking on a near object so that its image is brought to focus on the retina.

Accommodation is part of the near reflex (near vision triad) which consists of;

1. increase in refractive power of the lens (Accommodation).
2. Convergence of the visual axis.
3. Constriction of the pupils (Miosis).

Emmetropia (normal refraction)

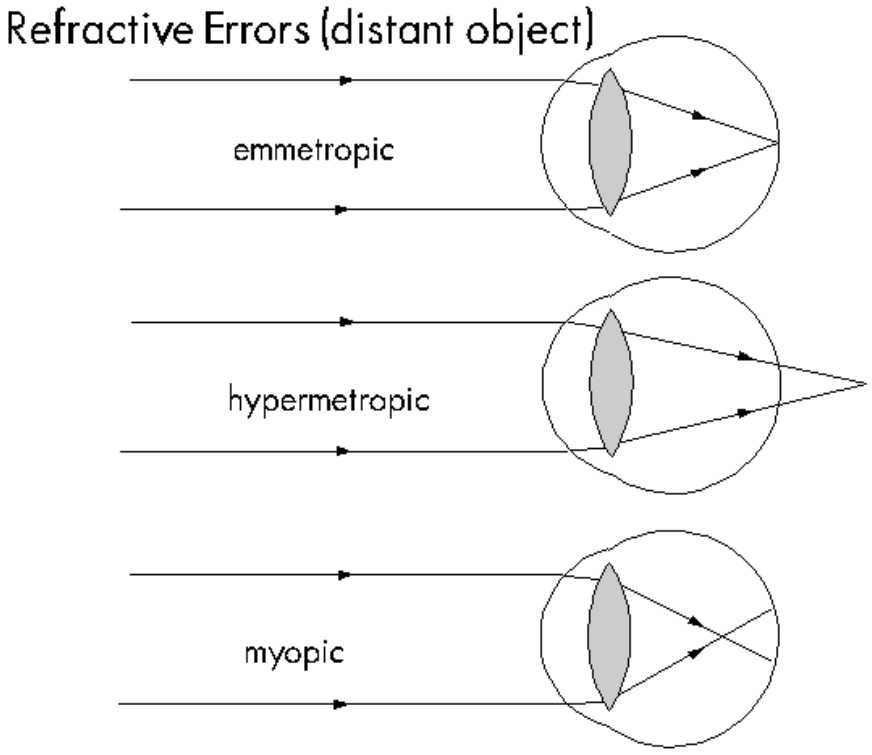
It is the ideal condition in which the incident parallel rays brought to perfect focus on the retina in a non-accommodated eye (eye at rest).

Ammetropia (errors of refraction)

The condition in which the parallel rays of light are not focused exactly on the retina when the accommodation is at rest. Ammetropia are of three types;

- Hypermetropia: when principal focus is formed behind the retina.
- Myopia: when principal light focus is formed in front of the retina.
- Astigmatism: when the refractive system of the eye is unequal in different meridians, and no single point focus is formed on the retina.

Anisometropia: (Unequal refractive error) – When the refractive state of the two eyes are unequal by more than 1 dioptre.



Myopia or Short sightedness:

It is the type of refractive error in which parallel rays of light are brought to focus in front of the retina when the eye is at rest (relax accommodation).

Aetiology

1. **Axial** (long eye): when the antero-posterior diameter is longer than average (each 1 mm increases in axial length produces 3 dioptres of myopic refractive change).
2. **Refractive** (excess refraction): due to;
    a) Curvature (the most common type): increase in the curvature of the cornea, and hence increase in its refractive power (Each 1 mm increase curvature produces 6 dioptres of myopic refractive change).
    b) Index: increase in refractive index of the lens (in nuclear sclerosis cataract).
    c) Anterior displacement of the lens.

Clinical classification of Myopia

1- Simple (Physiological) Myopia: represents physiological variation of normal eye, small degree less than 6 dioptres. Usually starts at early puberty and stabilizes at age of 21 years.

2- Degenerative (Pathological) Myopia: inherited as AR, large degree more than 6 dioptres. Rapidly progress during puberty and may continue to advance throughout life. It is associated with degenerative changes in the retina that may irreversibly impair the vision.

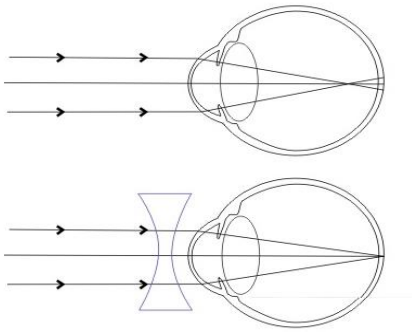
Symptoms of myopia

1. Blurring of distance vision.
2. Eye strain and headache, only with small degree of error
3. Divergent squint, due to no accommodation effort with less convergence leading to exoptropia.
4. In case of pathological myopia, sudden loss of vision due to retinal detachment, sever loss of the central vision may occur, black floaters due to vitreous degeneration.

Signs

1. Large prominent eyeball
2. Larger cornea, deep AC.
3. Dislocated lens.
4. In case of pathological myopia, the retina may show areas of atrophy, retinal break and retinal detachment, optic disc is large with myopic crescent, degenerative (liquefaction) of the vitreous.

Treatment



1. Optical correction:

a. Glasses: concave spherical lens (negative lens)

b. Contact lens.

2. Laser:

a. LASIK (Laser Assisted Stromal In situ Keratomileusis).

b. PRK (Photo Refractive Keratectomy).

3. Surgical:

a. Intracorneal rings (ICL) for low degrees.

b. Clear lens extraction for high myopia (more than -18 dioptres).

c. Minus phakic intraocular lens (IOL) implantation.

Hypermetropia (Hyeropia) or Far sightedness:

It is the type of refractive errors in which the parallel rays of light are brought to focus behind the retina when the eye is at rest (relax accommodation).

Aetiology:

1. **Axial** (short eye): when the axial length of the eye is shorter than average (Each 1 mm of shortening represents 3 dioptres of hyermetropic refractive change).
2. **Refractive** (deficient refraction):
   a) Curvature (most common type): due to decrease in the curvature of the cornea, and hence decrease in its refractive power (Each 1 mm decrease in curvature produce 6 dioptres of hypermetropic refractive change).
   b) Index: due to decrease in the refractive index of the lens (in cortical cataract).
   c) Posterior displacement of the lens.
   d) Aphakia: absence of the lens.

Clinical Classification of Hypermetropia

1. Manifest: amount of hypermetropia observed in a non cycloplegic refraction.

2. Latent: amount of hypermetropia which is masked by tone of ciliary muscle and involuntary accommodation.

3. Total: total amount of hypermetropia which is the sum of both manifest and latent hypermetropia. It is observed when accommodation is paralyzed in cycloplegic refraction using atropine or cyclopentolate.

Symptoms:

According to the amount of hypermetropia and the age of the patient.

1. Blurred vision – more for near than for distance vision.

2. Eye strain, headache.

3. Convergent squint – due to continuous effort of accommodation.

4. Early onset of presbyopia.

Signs:

1. small eyeball.

2. smaller cornea.

3. shallow anterior chamber – predispose to angle closure glaucoma.

4. Ophthalmoscopy – Optic disc is smaller with less defined edges, Blood vessels undue tortuosity and abnormal branching.

Treatment:

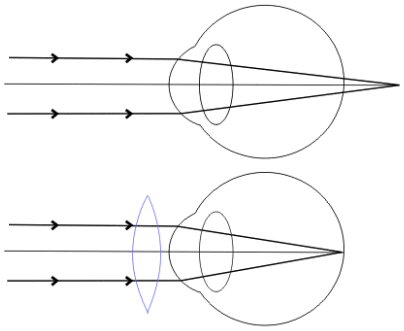
Mild hypermetropia without any definite symptom requires no treatment, especially for young individual. Treatment is required in:

- Symptomatic patient
- Middle aged patient
- In high hypermetropia

1. Optical:

a. Glasses: convex lens (positive lens) prescribed after full cycloplegic refraction particularly in children.

b. Contact lens.



2. Laser: using excimer laser surgery:

a. Lasik

b. PRK

3. Surgical:

a. Conductive keratoplasty.

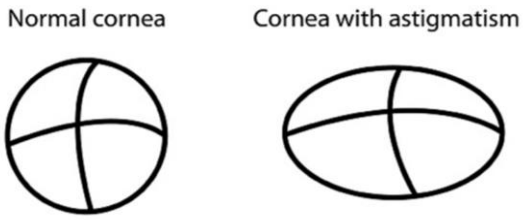
b. Plus phakic IOL implantation.

Astigmatism:

Unequal refraction of light in different meridians.

Aetiology

1. Curvature: due to an error of curvature mainly of the cornea (unequal curvature in different meridians).



a. Congenital or developmental, e.g. Keratoconus.
b. Acquired; after disease or trauma to cornea.

2. Index: due to presence of cataract in one meridian.

3. Decentring of lens: e.g. sublaxated lens after trauma.

Clinical Classification of Astigmatism

1- Regular: the two principal meridians are at right angle (at 90^{o} and 180^{o}).

a. Simple astigmatism: one of foci falls on retina (emmetropic), while the other may fall in front (simple myopic) or behind retina (simple hypermetropic).
b. Compound astigmatism: both foci fall in front (compound myopic) or behind retina (compound hypermetropic).
c. Mixed astigmatism: one focus falls in front and the other falls behind retina.

2- Oblique: when the two principal meridians are not at right angle to each other (not at 90^{o} and 180^{o}).

3- Irregular: the refraction in different meridians is irregular, where the surface of cornea is irregular and no principal meridian can be observed, e.g. severe keratoconus or corneal scarring.

Treatment

1. Optical:

a. Glasses: using cylindrical lenses according to the type of astigmatism.
b. Contact lens.

2. LASIK.

Presbyopia:

The amplitude of accommodation declines steadily with age. This is due mainly to sclerosis of the fibres of the crystalline lens and also due to ciliary muscle itself becomes less efficient with advancing age (after 40 years).

At birth, the eye is capable of 20 dioptres accommodation and this will gradually decrease. By the age of 45 years this has fallen to about 4 D and after the age of 60 years only 1 D or less.

In order to focus on an object at a reading distance of 25 cm, the emmetropic eye must accommodate by 4 dioptres. Therefore, the patient will begin to experience difficulty or discomfort for near vision at 25 cm when his accommodation has decayed to 4 D.

Symptoms

The onset of presbyopia differs according to the patient pre-existing refractive power;

a. Hypermetropic patient: early presbyopia onset.
b. Myopic patient: later presbyopia onset.

1. Blurring of the near vision.

2. Eye strain, headache.

3. The need to pull objects backward in order to see them clearly (increase the near point).

Treatment

Reading glasses: convex lens (plus lens) .