

# Subjective refraction

OPTICS OF HUMAN EYE & REFRACTIVE ERRORS

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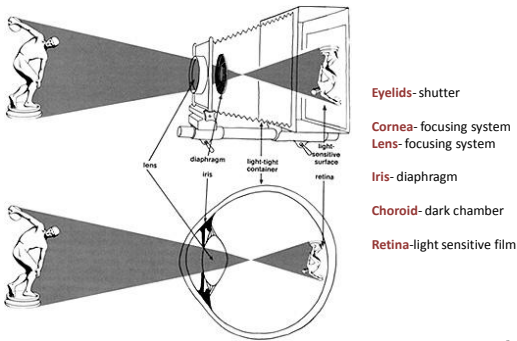
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## Optics of human eye

- Eye as a camera
- Components
- Schematic eye and reduced eyes
- Axes and visual angles
- Optical aberrations

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### Eye as a camera



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### Components

- The cornea
- The anterior chamber
- The iris and pupil
- The crystalline lens
- The retina

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### Cornea

- Reasons of refraction:
  - Curvature.
  - Significant difference in refractive indices of air and cornea.

- Vertical diameter slightly less than horizontal
- Front apical radius 7.5 - 7.7 mm
- Back apical radius 6.4 - 6.8 mm
- Actual refractive index cornea= 1.376
- Power of cornea +43D (2/3 of total eye power)

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## Iris and Pupil

### The anterior chamber

- Cavity between cornea and iris
- Filled with aqueous humor.
- Depth of AC – about 2.5-4.0 mm
- Change in AC depth change the total power. 1mm forward shift of lens- increase about 1.4D in power
- Refractive index of aqueous humor= 1.336

- Regulate amount of light entering the eye
- At 2.4mm pupil size, best retinal image obtained, as aberration and diffraction are balanced.

**Average size:** • 2-4mm

**Small pupil** • depth of focus increases  
• Concept used as pin hole test in refraction

**Large pupil** • Retinal image quality improves

## The crystalline lens

Thickness

- Birth 3.5 – 4 mm
- Adult life 4.75 – 5 mm

Radius of curvature

- Ant surface 10 mm
- Post surface 6 mm

Refractive index of lens

- Nucleus 1.41
- Pole 1.385
- Equator 1.375

Total power

- 15 -18 d.

Accommodative power

- At birth- 14-16 D
- At 25yrs- 7-8D
- At 50yrs- 1-2D

- Lens accounts for about one third of the refraction of the eye.

### ACCOMODATION

- Provides a mechanism of focusing at different distances.

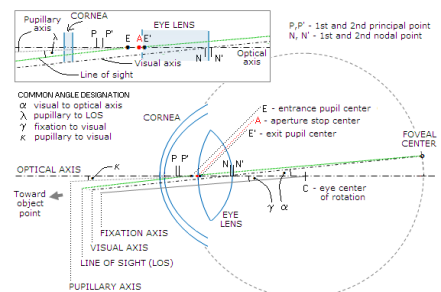
### OPTICAL CHANGES IN CATARACTOUS LENS

- Visual Acuity reduction.
- Myopic shift.
- Monocular diplopia.
- Glare.
- Color shift.

## Retina

- Maximum resolving power at fovea.
- A concave spherical surface with  $r = -12$  mm.
- Advantages of curvature of retina over plane image forming surfaces of cameras and optical instruments:
  - The curved images formed by the optical system is brought in the right order.
  - A much wider field of view is covered by the steeply curved retina

## Axes and visual angles



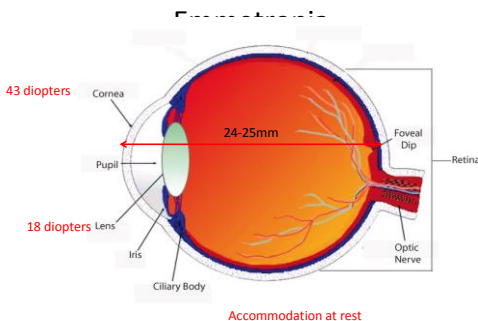
## Optical aberrations

- **OPTICAL AXIS:** line passing through centre of cornea, lens and meets retina on nasal side of fovea
- **VISUAL AXIS:** line joining fixation point, nodal point and fovea
- **FIXATION AXIS:** line joining fixation point and centre of rotation

- Diffraction of light
- Spherical aberrations
- Chromatic aberrations
- Decentering
- Oblique aberrations
- Coma

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## REFRACTIVE ERRORS

- **Ametropia:** a refractive error is present
- **Myopia:** Near sightedness
- **Hyperopia (Hypermetropia):** Far sightedness
- **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

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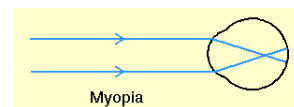
## REFRACTIVE ERRORS

- **Anisometropia:** a refractive power difference between the 2 eyes (> 2D)
- **Aniseikonia:** a difference of image size between the 2 eyes as perceived by the patient
- **Aphakia:** (Phakos=lens), aphakia is no lens
- **Pseudophakia:** artificial lens in the eye

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## Myopia

- A form of refractive error in which parallel rays of light entering the eye are focused in front of retina with accommodation being at rest.



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## Etiological types

- Axial(MC)-increased AP length of eyeball
- Curvatural-increased curvature of cornea, lens or both
- Index-increased refractive index of lens with nuclear sclerosis
- Positional-anterior placement of lens
- Myopia due to excessive accommodation

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## Clinical types of myopia

- Congenital
- Simple or developmental
- Degenerative or pathological
- Acquired

### Assignment:

- write an essay about clinical types of myopia discussing the difference between these types and mechanism of each type

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## Clinical features - Symptoms

- Distant blurred vision
- Half shutting of eyes
- Asthenopic symptoms
- Night blindness
- Divergent squint

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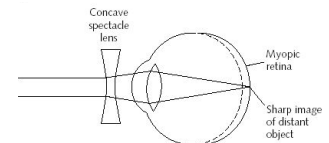
## Signs

- Prominent eyeballs
- Large cornea
- Anterior chamber is deep
- Large & sluggishly reacting pupil
- Fundus examination-changes seen only in pathological myopia

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## Optical treatment

- Concave lenses
- (Minus lens)



- Contact lenses

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## Optical treatment

### ✓ Adults:

- ✓ <30years-full correction
- ✓ >30years-less than full correction with which patient is comfortable for near vision.

### HIGH MYOPIA

- ✓ under correction is done to avoid near vision problem
- magnification of images
- contact lenses are better(to avoid image magnification)

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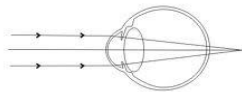
## Surgical treatment

- Radial keratotomy
- Lamellar corneal refractive procedures
- Laser based procedures
  - PRK
  - LASIK
  - LASEK
  - C-LASIK
  - E-LASIK

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## Hypermetropia

- It is the refractive state of eye where in parallel rays of light coming from infinity are focused behind the sensitive layer of retina with accommodation being at rest



Refraction in a hypermetropic eye.

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## Etiological types

- Axial(m.c)-decreased AP diameter of eyeball
- Curvatural-flattening of cornea, lens or both
- Index –old age, diabetics under treatment
- Positional-posteriorly placed lens
- Absence of lens-aphakia

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## CLINICAL TYPES

- SIMPLE HYPERMETROPIA
- PATHOLOGICAL
- FUNCTIONAL HYPEROPIA

### Assignment:

- write an essay about clinical types of hyperopia
- discussing the difference between these types and mechanism of each type

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## TOTAL HYPERMETROPIA

- It is the total amount of refractive error, estimated after complete cycloplegia with atropine
- Divided into latent & manifest

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## LATENT HYPERMETROPIA

- Corrected by inherent tone of ciliary muscle
- High in children
- Decreases with age
- Revealed after abolishing tone of ciliary muscle with atropine

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## MANIFEST HYPERMETROPIA

- Remaining part of total hypermetropia
- Correct by accommodation and convex lens
- Consists of facultative & absolute

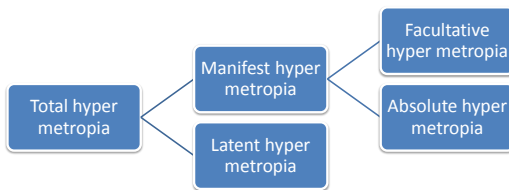
### FACULTATIVE HYPERMETROPIA

- Corrected by patients accommodative effort

### ABSOLUTE HYPERMETROPIA

- Residual part not corrected by patients accommodative effort

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## NORMAL AGE VARIATION

☞ At birth +2+3D HM

- ▶ Slightly increase in one year of life,
- ▶ Gradually diminished by the age 5-10 years

☞ In old age after 50 year again tendency to HM

- Tone of ciliary muscle decreases
- Accommodative power decreases
- Some amount of latent HM become manifest
- More amount of facultative HM become absolute

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## SYMPTOMS

- Principal symptom is blurring of vision for close work
- Symptoms vary depending upon age of patient & degree of refractive error
- Asymptomatic
- Asthenopic symptoms
- Defective vision only (particularly near vision)

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## TREATMENT

### BASIS FOR TREATMENT

- No Treatment
- Error is small
- Asymptomatic
- Visual acuity normal
- No muscular imbalance

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### Young children(<6 or 7yrs)

- ❑ Some degree of hypermetropia is physiological so no correction
- ❑ Treatment required if error is high or strabismus is present
- ❑ working in school small error may require correction
- ❑ In children error tends normally to diminish with growth so refraction should be carried out every six months and if necessary the correction should be reduced, otherwise a lens which is overcorrecting their error may induce an artificial myopia
- ❑ No deduction of tonus allowance in strabismus

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### Adults

- ❑ If symptoms of eye-strain are marked, we correct as much of the total hypermetropia as possible, trying as far as we can to relieve the accommodation
- ❑ When there is spasm of accommodation we correct the whole of the error
- ❑ Some patients with hypermetropia do not initially tolerate the full correction indicated by manifest refraction so we under correct them

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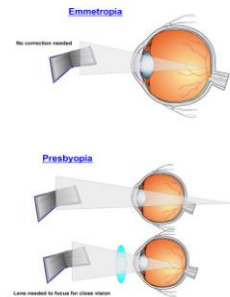
## MODE OF TREATMENT

- SPECTACLES
- CONTACT LENS
- SURGICAL

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## PRESBYOPIA

The physiologic loss of accommodation in the eyes in advancing age



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- Physiologic loss of accommodation in advancing age
- deposit of insoluble proteins in lens in advancing age-->elasticity of lens progressively decrease-->decrease accommodation
- around 40 years of age , accommodation become less than 4.00 D, causing difficulty with reading fine print , headache , visual fatigue

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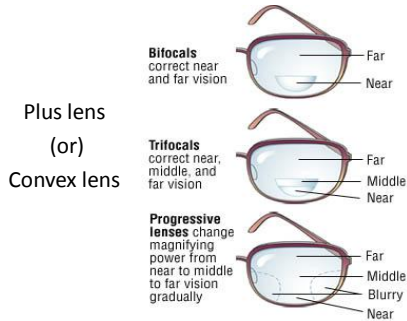
## SYMPTOMS

- The need to hold reading material at arm's length.
- Blurred near vision
- Headache
- Fatigue
- Symptoms worse in dim light.



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## SPECTACLES



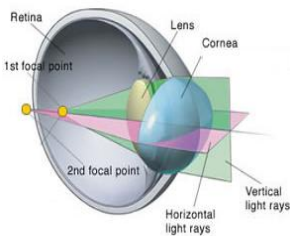
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## Surgery

- Monovision LASIK
- Monovision & CK
- IntraCor
- Refractive lens exchange
- Corneal Inlays & Onlays

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## ASTIGMATISM



A defect of an optical system causing light rays from a point source to fail to meet in a focal point resulting in a blurred and imperfect image.

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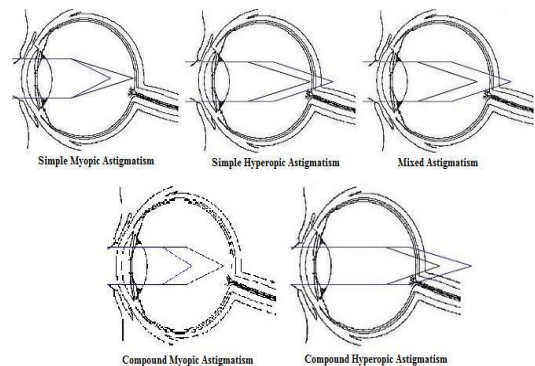
### Types

- Regular astigmatism – change in refractive power is uniform from one meridian to another
  - With-the-rule astigmatism
  - Against-the-rule astigmatism
  - Oblique astigmatism
  - Bi-oblique astigmatism
- Irregular astigmatism – Irregular change of refractive power in different meridians

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- Types of regular astigmatism
- Simple astigmatism
  - Simple hyperopic astigmatism
  - Simple myopic astigmatism
- Compound astigmatism
  - Compound hyperopic astigmatism
  - Compound myopic astigmatism
- Mixed astigmatism

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## Regular Astigmatism :

- Correctable by Spherocylindrical lenses
- Etiology :**
  1. Corneal - abnormalities of curvature [common]
  2. Lenticular is rare. It may be:
    - i. Curvatural - abnormalities of curvature of lens as seen in lenticonus.
    - ii. Positional - tilting or oblique placement of lens , subluxation.
  3. Retinal - oblique placement of macula [rare]

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### • Symptoms :

- Blurring of vision
- Asthenopic symptoms
- Tilting of head
- Squinting [Half closure of eyelid]



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## Investigations:

- Retinoscopy
- Keratometry
- Computerized corneal Tomography
- Astigmatic fan test
- Jackson cross cylinder

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## Treatment

- Optical treatment
  - Spectacles
  - RGP contact lenses
  - Toric contact lenses
- Surgical correction

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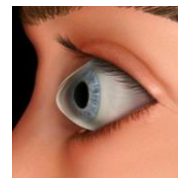
## Guidelines for optical treatment

- *Small astigmatism*- treatment is required
  - In presence of asthenopic symptoms
  - Decreased vision
- *High astigmatism*- full correction
- Better to avoid new astigmatic correction in adults because of intolerable distraction

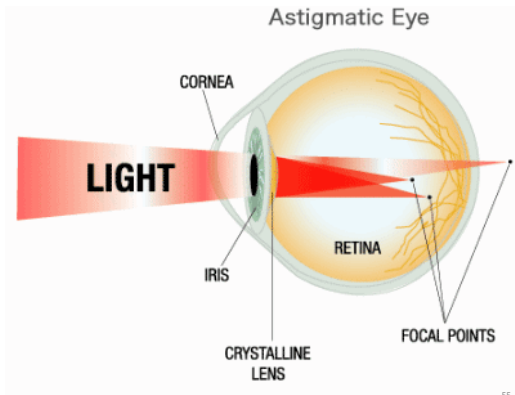
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## Irregular Astigmatism

- **Etiology :**
  - Corneal* -[ Scars , Keratoconus , flap complications, marginal degeneration ]
  - Lenticular* -[Cataract maturation]
  - Retinal* -[scarring of macula,tumours of retina,choroid]



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### Treatment :

- Optical treatment :
  - RGP contact lenses
  - Hybrid contact lenses
  - Scleral lenses
- Surgical treatment:
  - penetrating keratoplasty

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## Anisometropia

- Difference in refractive power between eyes
- refractive correction often leads to different image sizes on the retinas( aniseikonia)
- aniseikonia depend on degree of refractive anomaly and type of correction

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## Anisometropia

- Glasses : magnified or minified 2% per 1 D
- Contact lens : change less than glasses
- Tolerate aniseikonia ~ 5-8%
- Symptoms : usually congenital and often asymptomatic
- Treatment
  - anisometropia > 3-4 D-->contact lens
  - unilateral aphakia-->contact lens or intraocular lens

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## What is Refraction?

It is Determination of the refractive status (prescription) of the eye.

- Refraction could be performed Objectively (using Retinoscope or Autorefractometer) or subjectively.

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## Subjective Refraction

To determine by subjective means the combination of spherical and cylindrical lenses necessary to provide best visual acuity. (with accommodation relaxed)

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## Principles of Refraction

- 1. Accommodation-relaxed state
- 2. Maximum PLUS, minimum minus
- 3. Always trial frame before prescribing
- 4. Take into account vertex distance especially for high prescription individuals

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## How to ensure accommodation is relaxed?

- Use PLUS lens to FOG
- Ensure image is located in front of retina
- This causes image / VA to become worse if eye attempts to accommodate (Image point becomes further away from the fovea)

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