

# Ophthalmology

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Section 1

# OPTICS

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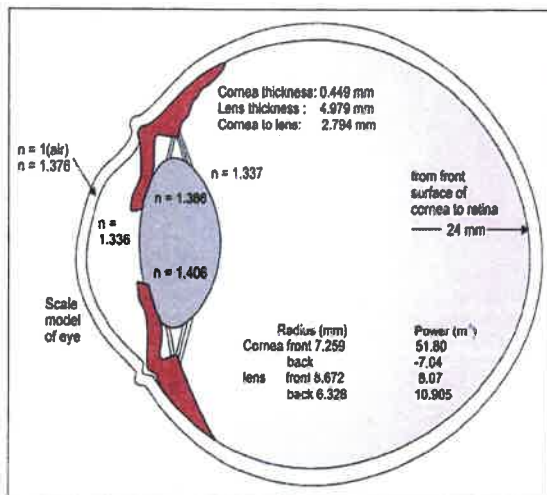
# 1.1

## Chapter

# OPTICS OF EYE AND REFRACTIVE ERRORS- MYOPIA

- Total power of eye - 58-60 D
- 3/4 is by cornea (45-50D)
- Rest is by the lens (16-17D)
- Refractive index of air =1.00
- Anything lighter than air =lower RI and anything denser = higher RI
- Cornea - 1.376
- Aqueous -1.336
- Lens - 1.396 (nucleus- 1.4; cortex- 1.39)
- Vitreous - 1.336

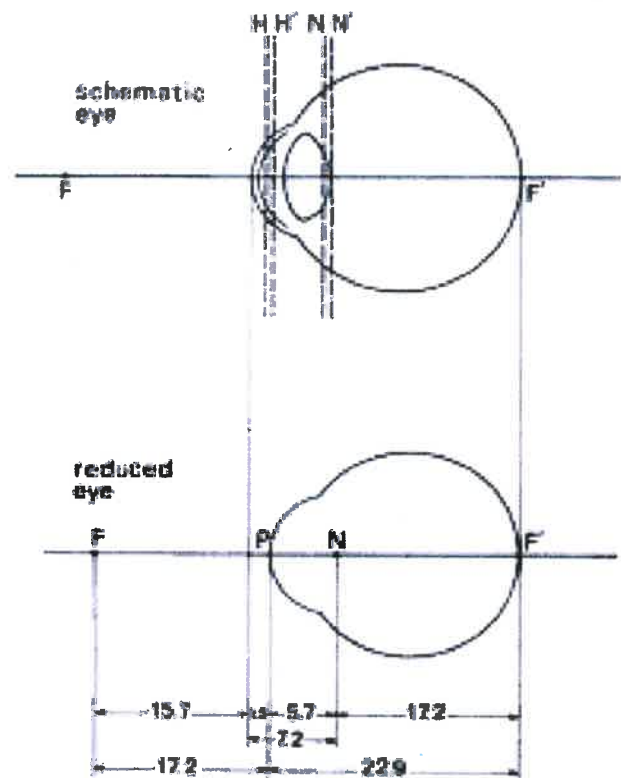
- Any opacity here is most significant. That is why a PSC is visually most significant



- Lens contributes less to the overall power of eye than the cornea.
- The most important refractive surface - anterior surface of cornea

## SCHEMATIC EYE / REDUCED EYE

- Simpler model of the complex optics of the eye.
- Rays pass from cornea to retina through the nodal point, present just in front of the posterior capsule in the lens.

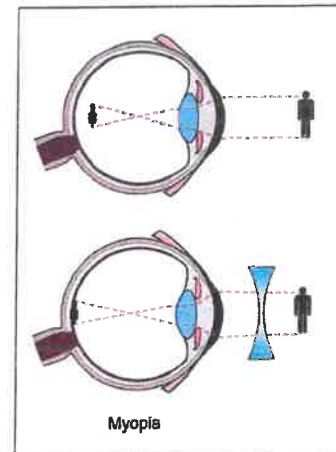
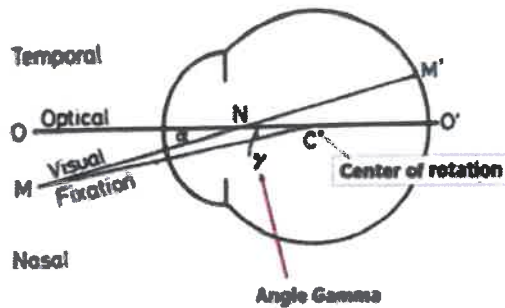


## Other models:

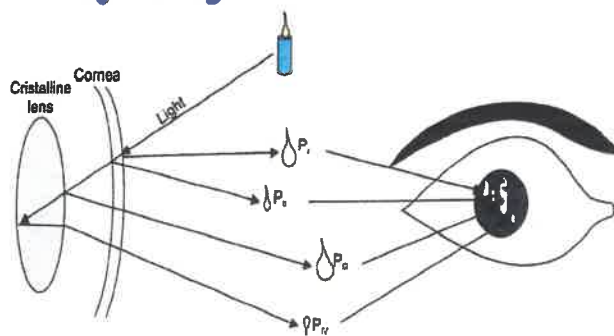
1. Donders
2. Gullstrand's

## Axes and Angles of Eye

- VAO - Visual  $\alpha$  optic
- FOG - Fixation  $\gamma$  optic
- KVOP - Visual  $\kappa$  pupillary plane



### Purkinje Images



- A concave (negative) lens is used to correct it

### Etiological classification

1. Axial myopia
  - Commonest form
  - Increase in antero-posterior length of the eyeball
2. Curvatural myopia
  - Increased curvature of cornea, lens or both
3. Positional myopia
  - Produced by anterior displacement of crystalline lens in eye, eg, Weil Marchesani Syn.
4. Index myopia
  - Increase in the refractive index of crystalline lens, associated with nuclear sclerosis (2<sup>nd</sup> sight of old age)
5. Myopia due to excessive accommodation
  - Spasm of accommodation

### REFRACTIVE ERROR

- Absence of RE - Emmetropia
- Presence of any RE - Ammetropia
- Ametropia can be classified into -
  1. Myopia
  2. Hypermetropia
  3. Astigmatism

Metropia = Measure of eye

### MYOPIA

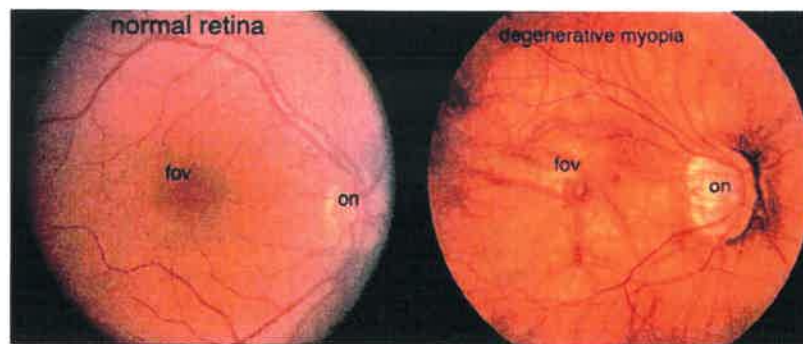
- Short-sightedness
- Person can see short distant objects without glasses

### Symptoms:

- Short sightedness
- Often leads to exophoria
- Floaters- in high myopia
- Simple Myopia <-6D
- High Myopia >-6D

### Pathological Myopia -

- a/w pathological changes in the eye.
- Due to increase in axial length and curvature of the eyeball, causing stretching of the coats of the eyeball
  1. Sclera - **posterior staphyloma**
  2. Choroid - **lacquer cracks** (tears or breaks in the Bruch's membrane). Through these cracks, new vessels grow called **CNVM** (choroidal neovascular membrane)
  3. Retina - when the coat of retina is stretched, there are peripheral retinal degeneration like **lattice /paving stone degeneration**, holes are formed in these degenerated areas can lead to retinal detachment and in the central part there are **foster fuch's spots**
  4. **Tigroid Fundus**
  5. Other changes- pseudo proptosis, divergent squint, open angle glaucoma, complicated cataract, spontaneous subluxation of lens



### T/t:

- Spectacles/ contact lens (concave lens)
- -1D minifies image by 2%

### PINHOLE

To differentiate refractive error and pathological cause for decreased vision

- If vision improves- Refractive error
- If vision doesn't improve- foveal pathology/ central media opacity

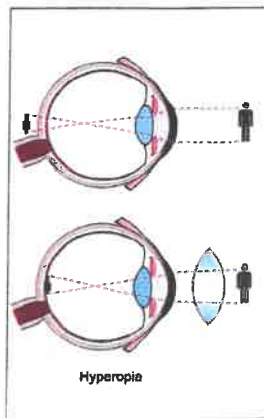
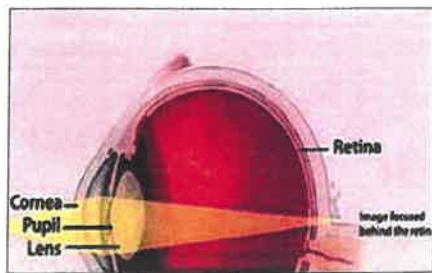


# 1.2

## Chapter

# REFRACTIVE ERRORS – HYPERMETROPIA, APHAKIA, ASTIGMATISM, RETINOSCOPY

## HYPERMETROPIA



- Known as Long sightedness
- Rays are focused behind the retina
- Distant objects can be seen more distinctly than near ones

### During accommodation:

- Ciliary muscles constrict.
- Ciliary zonules relax.
- Lens becomes thicker.
- In hypermetropia, the rays pass beyond the retina.
- Thus, accommodation used to see distant objects clearly, but, no accommodation left for near objects.

### Etiological Classification

- Axial- axial length ↓
- Curvatural- ↓curvature
- Index- Cortical sclerosis
- Positional- posterior dislocation of lens

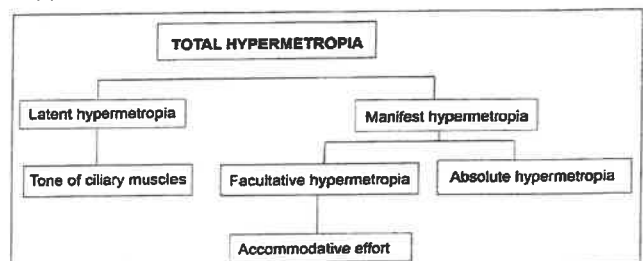
### Symptoms:

- Asthenopia (Tired eyes, headache, watering, mild redness)
- Frontal headaches
- Avoidance of visual tasks, especially at near
- Blurry vision at near
- Intermittent blurring of vision
- Recurrent styel/ chalazion

### Signs:

- Eye is shorter than normal
- Shallow anterior chamber
- Predisposed to acute angle closure glaucoma
- Retina appears like silk shot retina
- Optic nerve - pseudo papillitis/pseudo-papilledema
- Retina shows degenerative retinoschisis (splitting of the retina)

### Types:



**1. Latent hypermetropia:**

- Overcome physiologically by the tone of ciliary muscle
- Amounts to only one diopter
- Can be revealed only after cycloplegia

**2. Manifest hypermetropia:**

- Facultative hypermetropia can be overcome by an effort of accommodation
- Absolute hypermetropia cannot be overcome by an effort of accommodation

**T/t-**

- Spectacles/ contact lens (convex lens)
- 1D magnifies by 2%

**ANISOMETROPIA-** difference in refractive error of 2 eyes

**ANISEIKONIA-** diff in image size seen by 2 eyes.

**APHAKIA**

- Causes hypermetropia by 16D
- Aphakia is the absence of crystalline lens in normal anatomical position

**Causes of aphakia:**

- Post-surgical: signs are limbal scar, AC deep, iridodonesis, jet black pupil, hypermetropic refractive error, hypermetropic disc - Corrected by positive lens of + 10-11D
- Post traumatic
- Spontaneous subluxation
- Congenital

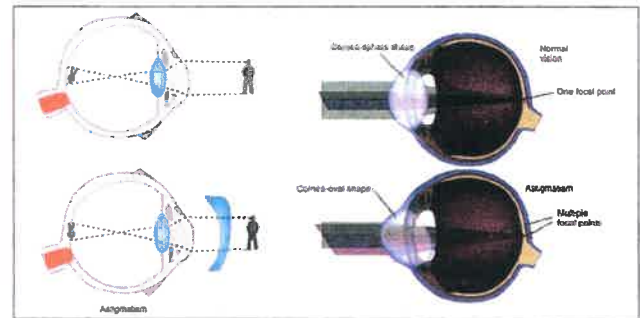
**Features**

- Anterior chamber deep
- Purkinje images- 2
- Iridodonesis
- Zero accommodation

**Correction-** Spectacles/ lens/ IOL

**Disadvantages of spectacles (16D)-**

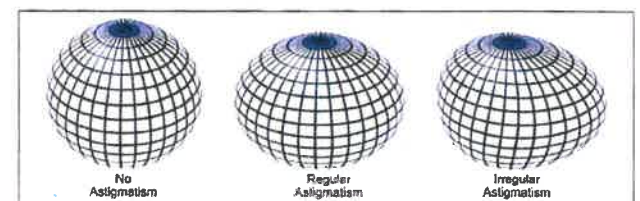
- Image magnification
- **Spherical aberration-** pin cushion distortion
- **Prismatic aberration-** causes Roving ring scotoma/ jack in the box phenomenon

**ASTIGMATISM**

- If the refractive index is different in different meridians, then it is called Astigmatism

**Types:**

- There are two types of astigmatism
  1. **Regular astigmatism:** has two primary meridians, one is flattest and other is steepest
  2. **Irregular astigmatism:** no 2 primary meridians, seen in a scar, keratoconus, lenticulus, immature cataract



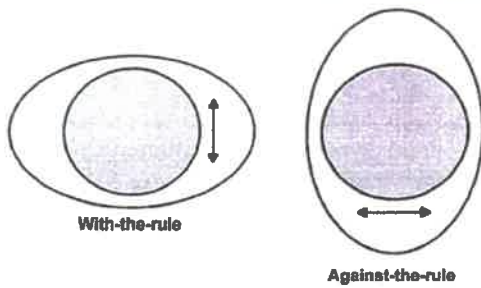
- Regular astigmatism can be further classified into:

**With the rule (vertical steeper)**

- The two principle meridians are at right angle to one another and **Vertical meridian** is more curved than Horizontal meridian.

**Against the Rule (horizontal steeper)**

- The two-principle meridians are at right angle to one another but **Horizontal meridian** is more curved than Vertical meridian.



**Correction**

- Cylindrical lens used. It acts perpendicular to placement

**1. Simple Astigmatism:**

- One focal point on the retina and the other in front or behind
- Of 2 types - simple myopic and simple hyperopic

**2. Compound Astigmatism:**

- Both the 2 focal points are in front or behind the retina
- Of 2 types - compound myopic and compound hyperopic

**3. Mixed Astigmatism:**

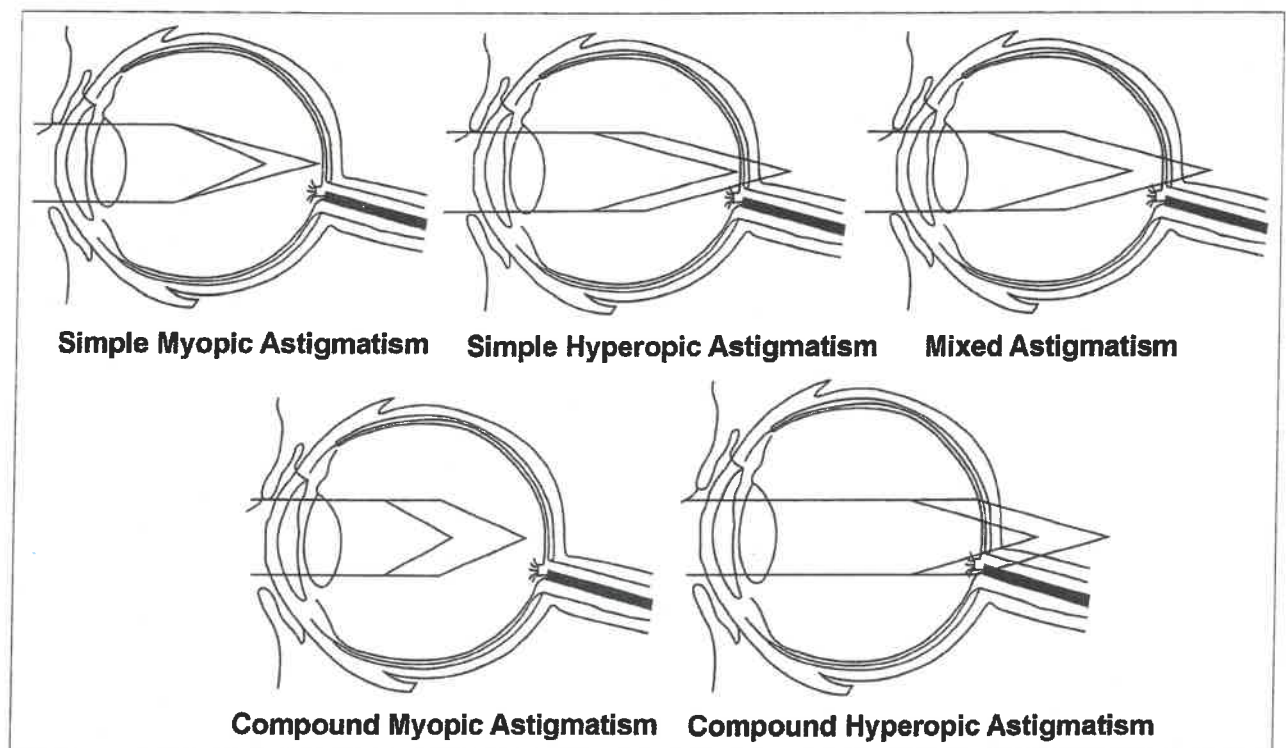
- One focal point in front of the retina and other behind the retina

**Oblique**

- The axes are right angles to each other, but lie in neither Horizontal meridian nor vertical meridian

**Bioblique**

- The axes are both acute and obtuse, but lie in neither horizontal meridian nor vertical meridian



**Simple Myopic Astigmatism**

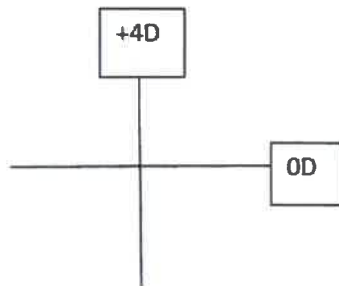
**Simple Hyperopic Astigmatism**

**Mixed Astigmatism**

**Compound Myopic Astigmatism**

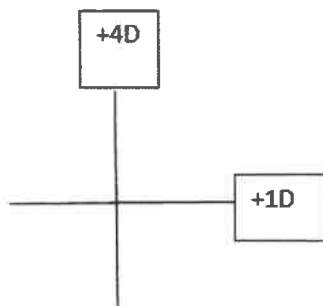
**Compound Hyperopic Astigmatism**

Eg, refractive error: (retinoscopy values)



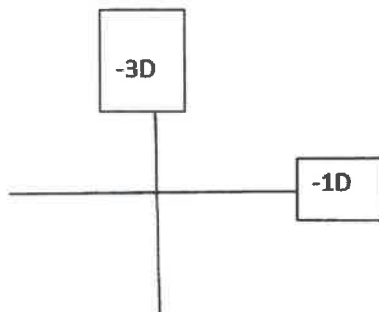
Simple hypermetropic astigmatism  
(since horizontal axis is steeper-  
Against the Rule astigmatism)

Eg-



compound hypermetropic astigmatism  
(since horizontal axis steeper- against  
the Rule)

Eg-

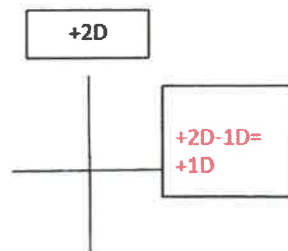


compound myopic astigmatism (since  
vertical axis steeper- with the rule)

Eg, +2D sphere with -1D cylinder at 90°

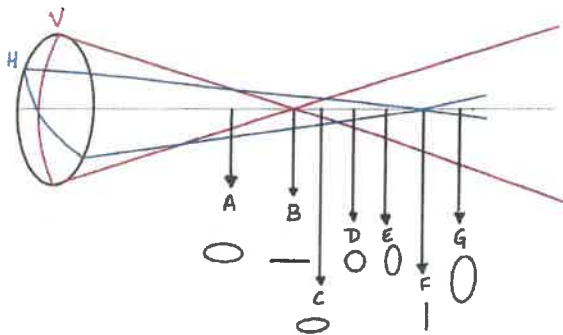
Answer-

- Cylinder works perpendicular to axis



- Due to cylinder placed in vertical axis, power of horizontal axis changes.
- Hence, it is compound hypermetropic astigmatism (against the rule)

## STRUM'S CONOID



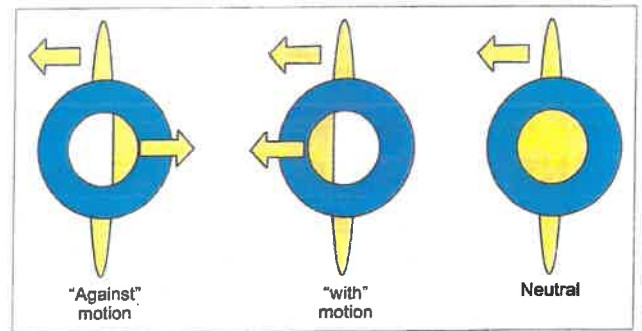
- Point A- compound hypermetropic astigmatism
- Point B- simple hypermetropic
- Point C, D, E- mixed
- Point F- simple myopic
- Point G- compound Myopic

## RETINOSCOPY

- Also called skiascopy/ shadow testing
- A beam of light is thrown in the patient's eye and we see the movement of the beam of light in the patient's eye.
- The movement of light depends on the patient refractive error
- Movement against the motion- myopia
- Movement with the motion- hypermetropia
- For this, a hand-held instrument called Retinoscope is used
- It works on a trial and error method
- End point is the neutralization point



Fig: A hand held instrument called a retinoscope projects a beam of light into the eye during a retinoscopy



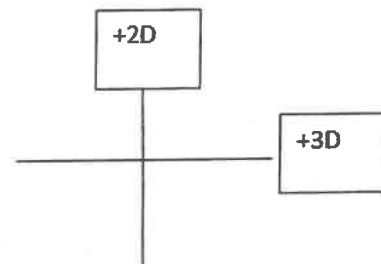
### 3 steps to calculate Refractive error of patient by retinoscopy

1. Neutralisation of reflex
  2. Distance correction
  3. Cycloplegia correction (atropine: 1D, Cyclopentolate 0.75 / Homatropine 0.5, tropicamide: 0.25D)
- Refractive error of patient = retinoscopy value - 1/distance - cycloplegic used
  - Cycloplegia - it is the paralysis of ciliary muscles

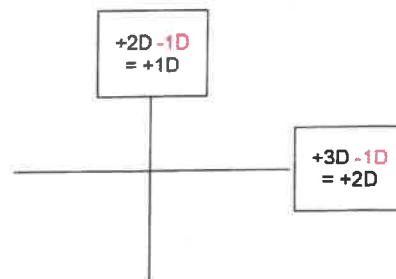
Q. Neutralisation of reflex- ie. Retinoscopy values are as follows when done from distance of 1m, no cycloplegic used. Calculate the refractive error.

Answer:

- Step1- write retinoscopy values



- Step2 - distance correction would be 1/distance= 1/1= 1D



- Step3 - since no cycloplegic used, no correction



- Hence, type of astigmatism is compound hypermetropic with the rule

### TRANSPOSITION OF EQUATIONS:

-2D sphere with -1D cylinder at 180°

Numerically add these with signs  
sign = cylinder power

= Sphere power

Answer = (-2-1D) Sphere with +1D Cylinder at 90°

= -3D S with +1D cylinder at 90°

SPHERICAL EQUIVALENT = Half of cylindrical value is added to spherical value

### FAR POINT

- In emmetropia- infinity
- In hypermetropia- behind the eye
- In myopia- in front of eye
- Far point =  $1/\text{power}$ ; eg, for -2D, far point =  $1/2\text{m} = 50\text{cm}$

### NEAR POINT

- NEAR TRIAD = Accommodation+convergence+ B/L Pupil constriction
- Ciliary body constricts - thus, zonules relax
- Changes in eye during accommodation:
  - Anterior lens curvature  $\uparrow$
  - Lens thickness  $\uparrow$
  - Equatorial thickness of lens  $\downarrow$
  - Anterior chamber becomes shallow
- With age, accommodation  $\downarrow$ , k/a presbyopia
- Range of accommodation = (far point - near point)
- Amplitude of accommodation = Power to focus at near - Power to focus at far
- Eg, -2D myopic with near point 10cm, amplitude =  $100/10 - 2 = 8\text{D}$
- Eg, +2D hyperopic with near point 10cm, amplitude =  $100/10 - (-2) = 12$  (NOTE: -2 taken because far point is behind the eye)

# 1.3

Chapter

## REFRACTIVE SURGERIES

### REFRACTIVE CORRECTION OPTIONS

- Cornea - keratorefractive procedures (RK, PRK, LASIK, FEMTOLASIK, SMILE, SILK)
- Lens - lenticular procedure (ICL, CLE)

### KERATOREFRACTIVE PROCEDURE:

- Radial keratotomy (RK)
- Photorefractive Keratectomy (PRK)
- Laser Assisted Insitu Keratomileusis (LASIK)
- Femtosecond Laser Assisted Insitu Keratomileusis (FEMTOLASIK)
- Small Incision Lenticule Extraction (SMILE)
- Small Incision Keratomileusis (SILK)

### 1. LASIK

#### Eligibility criteria for surgery:

- Age >18 years
- Refraction has to be stable for >1yr
- Corneal thickness >500 microns (residual corneal thickness after LASIK should be >270micron)

- Corneal curvature (keratometry) of 40-47D

#### Ophthalmic C/I:

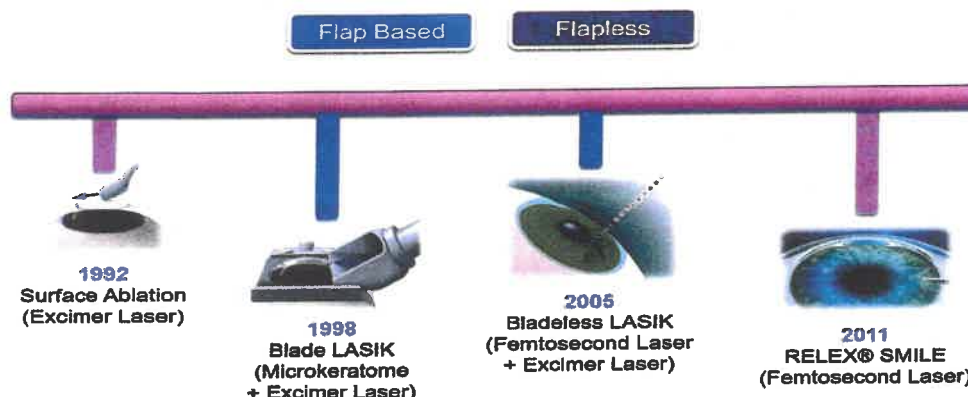
- Co-existing intraocular disease (uveitis, retinal pathology, glaucoma, corneal dystrophy, lenticular disease, dry eye)
- Systemic - diabetes (uncontrolled), joint related disease, antipsychotics, long term immunosuppressants / steroids

#### Mechanism of correction by surgery:

- **Flatten the curvature of the cornea** - refraction at the air corneal interface is delayed and thus, light is focussed at retina - myopia correction
- **Peripheral flattening** and central steepening of cornea - **hypermetropia correction**
- Axis based flattening - astigmatism correction

#### USFDA approved limit for refractive error correction:

- Myopia (0.5D-12D)
- Hypermetropia (+6D)
- Astigmatism (6D cylinder)



### Correction procedure:

- Corneal flap (90-130microns thick) created
- Laser done on the bed of the cornea (causes flattening and thinning of the cornea)
- Repositioning of flap
- It is required that 300 micron stromal bed is to be left behind
- 1D myopia correction - requires 12-15 microns tissue
- Thus, if 100-150 microns tissue available, correction of 10-12 D of myopia can be done
- If corneal thickness is less than 500 microns, then cornea-based surgeries avoided
- If corneal thickness is <470 microns, then it is absolutely C/I.

### Excimer LASER

- Used for LASIK.
- **193 nanometres** wavelength
- Stands for excited dimers (**argon and fluoride**); used in myopia, hypermetropia and astigmatism
- Myopia - laser applied on the central part
- Hypermetropia - laser applied on the periphery
- Astigmatism - the steeper axis is flattened

### FEMTOSECOND LASIK

- Flap is created by femtosecond laser
- is a Nd: glass laser
- Wavelength= 1054 nm, frequency = 10-15 second.
- Procedure- Photo bubble formation with the laser, lifting of the flap and correction by excimer laser

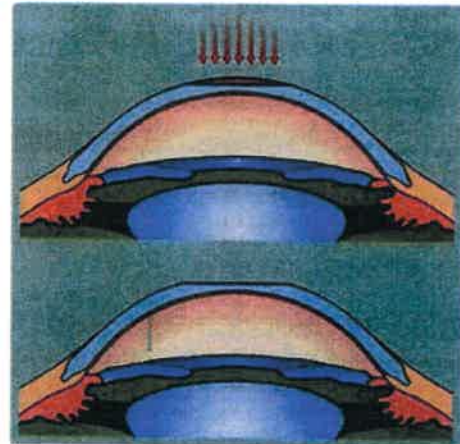
### SMILE

- Does not use excimer laser
- Stands for small incision lenticule extraction
- Bubbles are fired in two layers (superficial and deep layer).
- Lens shaped corneal tissue is then removed through a small cut in the cornea and is pulled out.
- Both the lasers are fired by femtosecond laser



### PRK SURGERY

- In thin cornea (<500 microns), instead of lifting a flap, direct excimer laser used on the surface - k/a surface ablation or photorefractive keratectomy or PRK surgery.
- Cornea then regenerates from the sides
- There is initial period of haze in the cornea and gradually is recovered.



### LENS BASED SURGERY

1. Implantable Collamer Lens / Implantable Contact Lens (ICL)
2. Clear Lens Extraction (CLE)

#### 1. ICL

- For Patients unfit for LASIK or high refractive error- ICL is done
- Lens is implanted over the normal crystalline lens, Also called as Phakic IOL

#### 2. CLE

- Patients unfit for ICL, high refractive errors - CLE
- Normal crystalline lens is removed and IOL is implanted in the capsular bag
- Also called FUKALA'S operation



Section 2

**LENS**

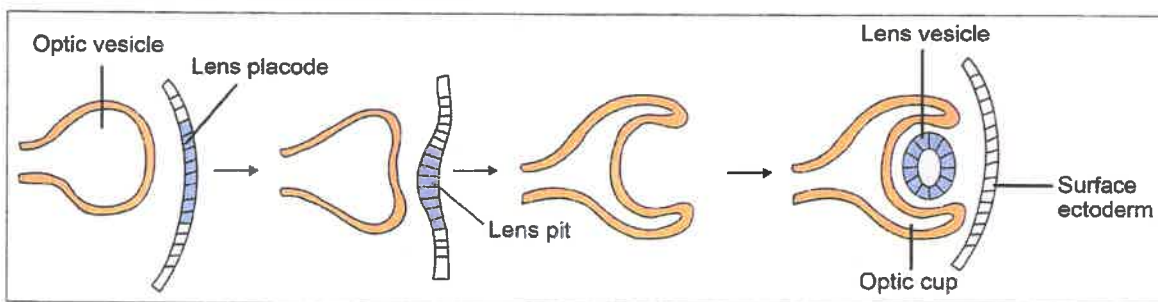
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# 2.1 Chapter

## LENS – EMBRYOLOGY, ANATOMY & PHYSIOLOGY

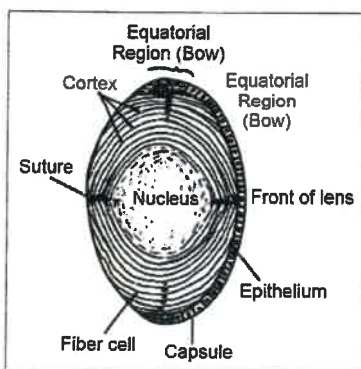
### EMBRYOLOGY

- Lens develops from **surface ectoderm**.



- From the forebrain- arises an **optic stalk**
- Optic stalk → **optic pit** → **optic vesicle** on the 21st day of gestation.
- Optic vesicle → forms thickening k/a **Lens placode** on the 27th day of gestation
- The optic vesicle invaginates to form **optic cup** and the lens placode starts to enter inside it k/a lens pit.
- Gets pinched off from the surface k/a lens vesicle.
- This separation of lens vesicle from surface ectoderm happens on 33rd day of gestation.
- Biconvex shape
- Anterior surface (radius= 10mm) is flat
- Posterior surface (radius= 8mm) is more convex.
- Size of lens is **9-10 mm**.
- Refractive index - 1.376
- Nucleus of lens (centre) is denser ( $\mu = 1.40$ )
- Cortex (peripheral) is comparatively rarer ( $\mu = 1.39$ )
- The entire lens is covered by a capsule
- In the adult lens there is only **anterior epithelium present**, no epithelium in the posterior surface.
- The mitosis occurs at the equatorial region of the lens.
- The capsule- thickest (14 microns) at the pre-equatorial region and thinnest (4 microns) at **the posterior pole**.
- Capsule is thickest B.M of body

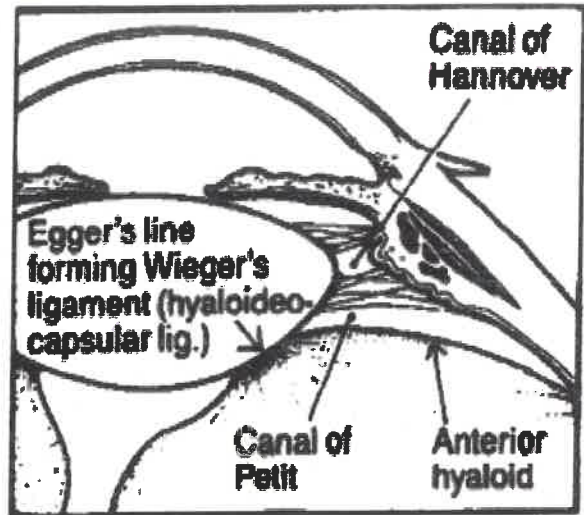
### ANATOMY OF LENS



#### Parts of the lens:

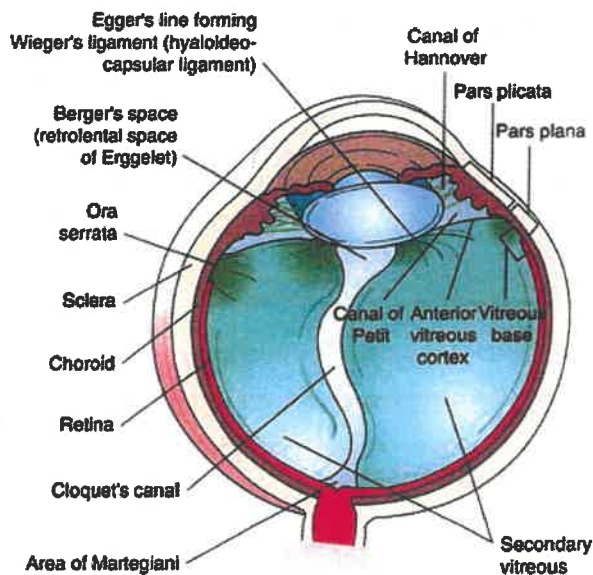
1. Capsule
2. Cortex
3. Nucleus -

- Embryonic nucleus (oldest fibres)- anterior erect Y and posterior inverted Y suture
- Fetal nucleus
- Infantile nucleus (birth to puberty)
- Adult nucleus (puberty to adulthood)
- Lens fibres are formed **throughout the life**
- Youngest fibres are in **cortex**
- Thinnest part of lens is **posterior pole**
- Lens is held in position by the zonules of Zinn/ suspensory ligaments.
- Position- lens is placed in the patellar fossa of vitreous.
- The potential space between the lens and the vitreous is called the Berger space.
- Between the posterior surface of lens and the anterior surface of vitreous is 'hyaloideo capulare ligament' aka '**weigerts ligament**'. This is strongest in childhood. So, **ICCE is contraindicated in children.**



### PHYSIOLOGY OF LENS

- Lens is an avascular structure.
- Metabolism is **anaerobic** (85%- Kreb cycle; 15%- HMP pathway; traces from sorbitol pathway)
- Nutrition- is from **aqueous humour**.
- Antioxidants - glutathione, super oxide dismutase, catalase, vit C and vit E.
- Lens is made up of 66% water, 33% protein (highest), 1% electrolytes.
- Na-K ATPase pump prevents hydration of the lens.
- Na<sup>+</sup> in aqueous is 144 mmols, K<sup>+</sup> is 4 mmols.
- Inside the lens Na<sup>+</sup> is 20 mmols and K<sup>+</sup> is 120 mmols



## 2.2 Chapter

# CLASSIFICATION OF CATARACT & CONGENITAL CATARACT

Cataract is any opacification of lens which may or may not affect the vision

### CLASSIFICATION OF CATARACT ON BASIS OF

1. Etiology
2. Position of cataract: at the nucleus, cortex, capsule or poles
3. Maturity -immature, mature and hyper mature

### ETIOLOGICAL CLASSIFICATION

- Congenital And Developmental Cataract
- Acquired Cataract
  - Senile Cataract
  - Traumatic Cataract : Blunt, Penetrating, Radiation, Electric Shock, Glass Blowers (Infra-Red)
  - Complicated Cataract (Uveitis - Induced)
  - Metabolic Cataract : Diabetes - Snowflake, Wilson's Disease - Sunflower
  - Drug induced Cataract: Corticosteroids, Miotics
  - Cataract Associated with Syndromes

### CONGENITAL AND DEVELOPMENTAL CATARACT

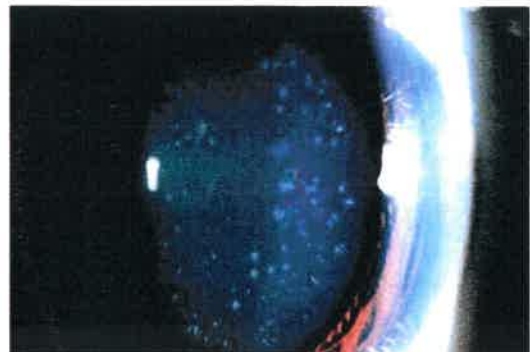
#### Causes of congenital cataract:

- Genetic- AD; genes responsible are: CRY gene (crystalline), CX gene (connexin), MIP gene (Major intrinsic protein)
- Infectious disease- TORCH
- Idiopathic

- Metabolic- Galactosemia, hypoparathyroidism, Lowe's syndrome, Fabry's disease

#### Types of congenital cataract:

- Punctate (Blue Dot) Cataract-
  - Most common type, aka **cataracta punctata cerulea**.
  - It is **stationary**
  - Does not affect vision



- Zonular (Lamellar) Cataract -
  - **Most common visually significant** cataract
  - Seen in **vit D deficiency**, hypocalcemia, rubella infection, autosomal dominant diseases
  - **Riders** are present on lens

