CHAPTER

1

Visual Acuity Assessment

COMPETENCY

OP1.1 DESCRIBE THE PHYSIOLOGY OF VISION

LONG ESSAY

1. A 22-year-old gentleman was tested for color vision as a requisite for his driver's license. He could not identify some plates in a standardized testing format.

A. Define color sense. Name the photoreceptors involved in color vision. (1+1 marks)

B. Explain the theories of color vision. (3 marks)

C. Enumerate 4 tests used to test color vision. (2 marks)

D. Compare and contrast congenital and acquired color blindness. (3 marks)

A. Color Sense/Color Vision and Photoreceptors

Color Sense/Color Vision

It is the ability of the eye to differentiate various colors as excited by light of varying wavelengths.

Photoreceptors Involved in Color Vision

Cones

B. Theories of Color Vision

1. **Young Helmholtz trichromatic theory**
   - According to this theory, there are three types of color receptors—one for each primary color
     i. Cones containing "erythrolabe" pigment are most sensitive to absorb the red color
     ii. Cones containing "çhlorolabe" pigment are most sensitive to absorb the green color
     iii. Cones containing "cyanolabe" pigment are most sensitive to absorb the blue color
   - Other colors are perceived due to a varying combination of stimulation of cones containing these pigments

2. **The opponent color theory**
   - This theory was proposed by Ewald Hering but has been updated by Hurvich and Jameson
   - According to this theory, one member of the color pair suppresses the appreciation of the other. So, they become mutually exclusive.
     i. Spectrally opponent receptors include red-green and blue-yellow
     ii. Aspectrally opponent receptors include those for black and white
   - Therefore, a color like greenish-red cannot exist
   - This theory explains the concept of after-images and color contrast
3. **Granit's polychromatic theory**
   - This theory believes that the cones have 7 types of receptors—one for VIBGYOR
   - It consists of modulators and dominators. The former is for hue detection and the latter has a wide spectrum for color detection

C. Tests Used for Color Vision

1. Ishihara's pseudoisochromatic charts (most commonly used)
2. Holmgren's wools test
3. Hardy–Rand–Rittler charts (used to detect congenital color blindness)
4. Farnsworth Munsell 100 hue test (most sensitive)

D. Congenital vs Acquired Color Blindness

Feature	Congenital	Acquired
Presentation	Asymptomatic, detected on screening	Maybe symptomatic due to associated ocular pathology
Pattern	Bilateral, symmetrical	It May be unilateral or bilateral Need not always be symmetric
Gender predilection	More in men (as the gene for red-green sensitive cones is present on the long arm of the X chromosome)	No such predilection
Color affected	Red-green is the most commonly encountered defect	Blue-yellow impairment is seen in macular disorders. Red-green impairment is seen in optic nerve diseases
Ocular findings	Visual acuity is usually normal except in rod monochromatism where the visual acuity is around 20/200	Visual acuity may be subnormal as the cause is either due to optic nerve or macular pathology
Fundus findings	Usually normal	It may be abnormal disc or macular findings may be there
Natural history	Stationary and permanent	May progress or improve depending on the pathology
Tests used	Isochromatic charts are most useful (Ishihara and HRR charts)	Farnsworth Munsell 100 hue test and Nagel's anomaloscope are most useful

SHORT ESSAYS

1. Explain phototransduction. (5 marks)

Phototransduction

- It is a process by which light energy is converted into electrical energy in the specialized cells of the retina called photoreceptors—rods and cones

- When light is absorbed by the photoreceptors in the form of photons, the reactions that follow are divided into three steps:

1. **Rhodopsin bleaching**
   - Rhodopsin is the visual pigment present in the rods. In the dark-adapted state, the opsin is coupled with retinine called 11-*cis*-retinol
   - When light falls on rhodopsin, the 11-*cis*-retinol is converted into *all-trans*-retinal. This is unstable and cannot remain associated with the opsin. This process is called "photodecomposition" (Fig. 1.1.1)
2. **Rhodopsin regeneration**
   - The 11-*cis*-retinal is generated from the *all-trans*-retinal and combines with vitamin A that is supplied by the blood
   - This process is independent of light
3. **Electrical changes**
   - The activated rhodopsin (metarhodopsin) is responsible for a cascade of biochemical reactions within the inner and outer segments of the photoreceptors that cause hyperpolarization
   - The inner segment of the photoreceptors passively pumps out sodium ions which are pumped back into the outer segment from the ECF
   - The activated rhodopsin causes a conformational change in opsin that causes the Na^+ channels in the outer segment to close because of which there is hyperpolarization
   - A receptor potential is set up

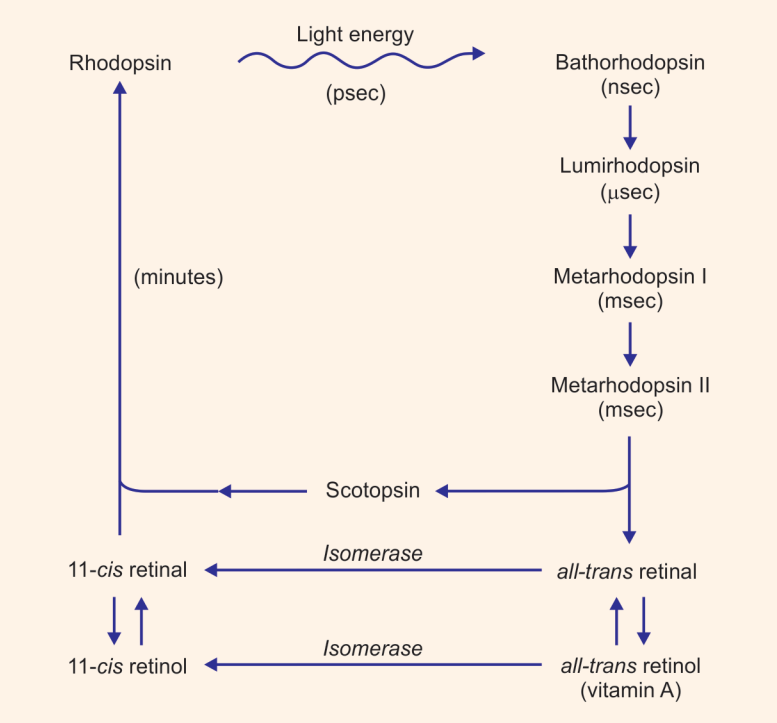


Fig. 1.1.1 Photodecompensation

2. Contrast between magnocellular and parvocellular pathways. (5 marks)

These pathways begin in the retinal ganglion cells and run through the entire visual pathway and are responsible for the parallel processing of an image

Feature	Parvocellular pathway	Magnocellular pathway
Diameter	Smaller	Larger
Cells	P cells	M cells
Location	Dominant in the macula	Dominant in the periphery
Layers of lateral geniculate body	3–6	1–2
Speed of conduction	Slower as the diameter is smaller	Faster as the diameter is larger
Color contrast	Yes	No
Spatial frequency	Higher	Lower
Temporal frequency	Lower	Higher
Part of cortex	Project into the primary visual cortex (4Cα of V1)	Project into the primary visual cortex (4 A and 4Cβ of V1)

3. A 14-year-old boy finds it difficult to walk in dim illumination.

A. Name 4 important causes for the same. (2 marks)

B. Explain the dark adaptation curve. (3 marks)

A. Causes of Night Blindness

- This condition is called nyctalopia or night blindness. It means the individual finds it difficult to see in the dark
- Causes are:
  1. Vitamin A deficiency
  2. Retinitis pigmentosa
  3. Miotic pupil
  4. Peripheral cataract

B. Dark Adaptation Curve

- Dark adaptation is the ability of an eye to adapt itself to decreasing illumination
- When an individual moves from a brightly illuminated area into a dimly illuminated region, the time taken for that person to be able to see the objects is called "dark adaptation time". It is around 20–25 minutes

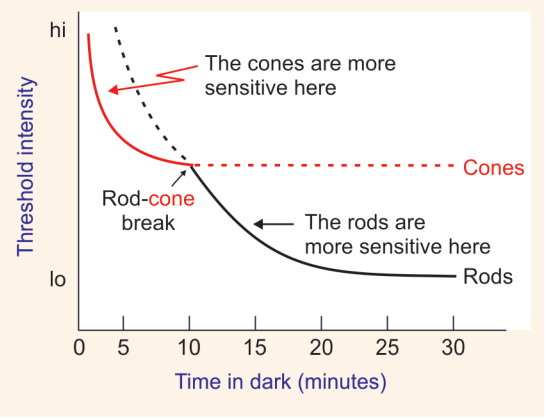


Fig. 1.1.2: Dark adaptation curve

- This curve is plotted by illuminating a certain portion of the retina that has both rods and cones (11 degrees from the fovea) (Fig. 1.1.2)
- There is an early cone adaptation seen as an increase in retinal sensitivity. It is smaller. This point is called the "cone threshold" and is about 5 minutes in duration
- This is followed by a longer, slower, and more sustained, and is formed by regeneration of rhodopsin in rods
- The point of a break between the two is called the 'alpha' point or rod-cone break
- When there is a delay in the dark adaptation time as described in the above-mentioned clinical situations, the curve is shifted higher

4. A predator animal has both eyes facing ahead whereas a prey has eyes on both sides of the face. Explain the advantages and disadvantages of each. Explain the requisites of a binocular singular vision. (2+3 marks)

A Predator has Both Eyes Facing Forward

Advantages

1. There is stereopsis, hence better localization of the object of interest (prey)
2. There is binocular coordination and hence, objects simulate corresponding retinal elements

Disadvantage

The visual field is not as great as when the eyes are on either side of the head.

A Prey has Eyes on Either Side of the Face

Advantage

They have an increased visual field and thus can anticipate attack from a predator more readily.

Disadvantage

It was initially thought that these animals have no depth perception until very recent studies have shown that these animals have an extra temporal fovea which is associated with stereopsis.

Requisites of Development of Binocular Singular Vision

1. Binocular singular vision is a state of simultaneous perception of a single image when light rays emanating from a single object are received by corresponding points of two retinae
2. Fixation
   - The eyes must have their optical axes aligned in such a way that the rays of the object of interest are focused onto the respective foveae
   - The axes of the eyes must be parallel
3. Overlap of visual fields to a large extent is necessary
4. The images formed in each eye should be of comparable sizes, shapes, and colors
5. The retinae must possess physiologically corresponding points
6. The reflex ocular movements must be well developed

5. Explain the grades of a binocular singular vision. (5 marks)

Grades of a Binocular Singular Vision (Fig. 1.1.3)

Conventionally, there are three grades of binocular singular vision and they are measured using a synaptophore

1. **Grade I/simultaneous macular perception**
   - Both eyes can see two dissimilar objects simultaneously
   - When two dissimilar objects are presented to both eyes through a synaptophore, there are fused. For example, when a cage is shown to the right eye and a parrot in the left eye, the binocular system perceives it as a bird in the cage
2. **Grade II/fusion**
   - The brain can fuse two incomplete similar objects to create the image of a single object. It has two components: sensory and motor

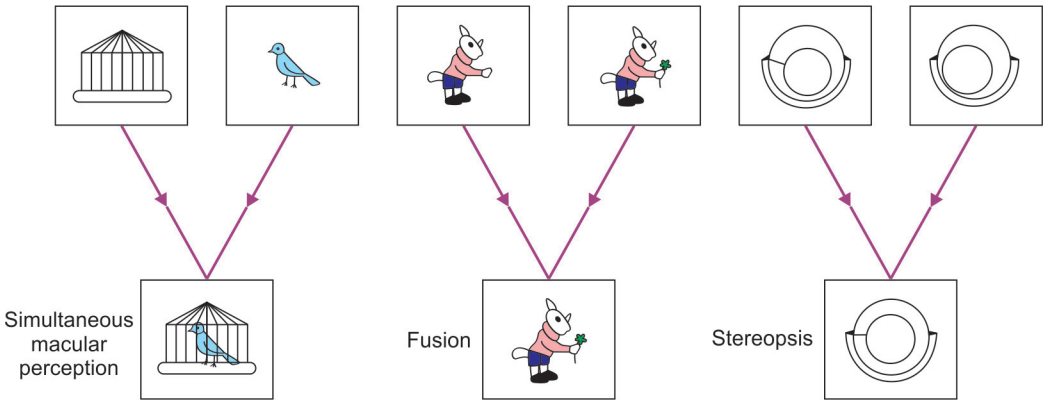


Fig. 1.1.3: Grades of binocular singular vision

- When two partial images are presented to each eye at the same time through a synaptophore, they are seen as a fused image.
- For example, when a rabbit is projected to the right eye and hands holding a bouquet in the left eye, they are seen as a rabbit holding a bouquet

3. **Grade III/stereopsis**
   - It is the most advanced form of binocular vision and it is the ability to perceive the third dimension, i.e. depth perception

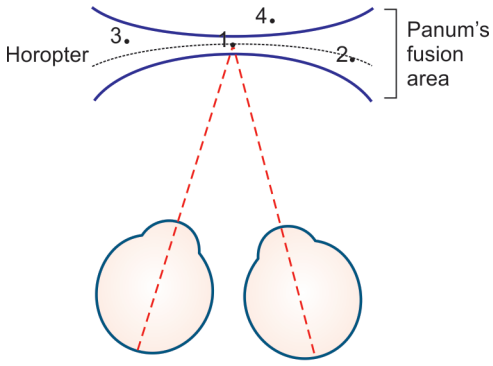
6. Define Panum's fusional area and its role in stereopsis. (1+4 marks)

Panum's Fusional Area

- A horopter is an imaginary circle that joins various points of fixation in the space formed by stimulation of corresponding retinal points in both retinae
- Objects that are placed in front or behind the horopter produce diplopia
- However, a small area straddling this horopter will not lead to the expected diplopia and this space is known as Panum's fusional space (Fig. 1.1.4)
- It is hyperbolic in shape and narrowest at fixation

Role in Stereopsis

- Any point on the horopter does not induce diplopia
- Any point outside the horopter, but within the Panum's fusional space causes the perception of depth or thickness. Thus, this concept of Panum's area helps in understanding stereopsis
- The synergy hypothesis of Panum states that stimulus on one retina can be fused with a range of similar stimuli on points very near the corresponding point on the other retina.
- So, there is fusion with retinal disparity giving rise to the perception of depth



1. Fixation
2. Point on horopter: No retinal disparity
3. Point in Panum's fusion area: Disparity induces stereopsis
4. Point outside Panus's fusion area: Induces diplopia

Fig. 1.1.4 Panum's fusional area

- As the Panum's area is smallest at fixation, fusion ability is the least.
- Therefore, stimuli that lie on either side of the horopter can cause diplopia that the points in the peripheral field of vision

SHORT ANSWERS

1. Anxious parents of a 4-week-old child present to you saying that their baby does not see the mother's face. Is this normal? Explain the development of vision in a child with clear ocular media and normal visual pathways. (1+2 marks)

- Yes. It is normal
  - When a child is born, her visual acuity is roughly 6/60 and is hypermetropic
  - The child is most interested in her close surroundings only, but cannot fixate with both eyes
  - Development of fovea or foveation takes a minimum of 6–8 weeks

Development of Vision in a Child with Clear Ocular Media and Normal Visual Pathways

- For normal visual development, the requisites are adequate light, normally aligned optical axes of both eyes, clear optical media (cornea, lens, and vitreous), and a normal nervous system
- Development of the visual system includes specialization of photoreceptors, maturation of synapses, myelination of the proximal visual pathways, and maturation of the ciliary body
- At birth, the child cannot fixate, and the ocular axis may seem non-parallel
- The first 6 weeks are extremely important as the process of "foveation" takes place
  - At around 6–8 weeks, the child steadily fixes on light or an object of interest held at 8–10 inches
  - At around 12–14 weeks, the child follows when the object is moved
  - At around 5–6 months, stereopsis, color vision, and eye-body coordination develop

2. A couple is planning for a child and wants to know if their child may develop color blindness as the father is color blind since birth. Describe the inheritance, and clinical features of congenital color blindness. (2+1 marks)

Congenital Color Blindness

Inheritance (Fig. 1.1.5)

- The gene for red and green pigments in cones is expressed on the X chromosome
- Congenital color blindness is acquired by X-linked recessive inheritance and is most commonly seen in boys
- If the mother is a carrier, there is a 50% chance of her son acquiring the disease and a 50% chance of her daughter carrying the disease. If the father is affected, all his daughters become carriers

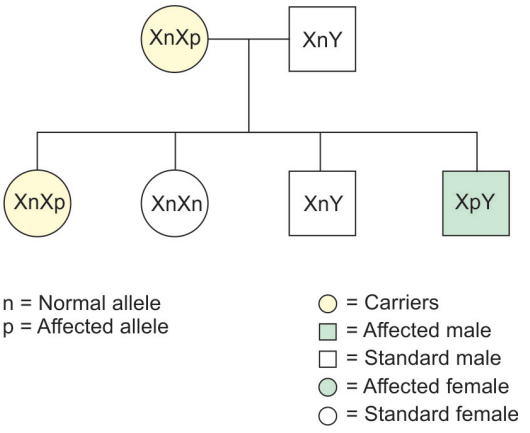


Fig. 1.1.5: Inheritance of congenital color blindness

Clinical Features

- Color-blind individuals appreciate various colors in shades of gray and thus are hardly aware of their defects
- Visual acuity, pupil, and fundus are normal
- Depending on which color they are unable to appreciate, they are categorized as
  - **Protanopia:** Cannot recognize red color
  - **Deuteranopia:** Cannot identify green color
  - **Tritanopia:** Cannot identify blue color

3. Name 3 electrophysiological tests used to test the integrity of the visual system. State their principles. (1+2 marks)

Test	Principle
Visually evoked potential	• It is an objective test that records impulses at the occipital cortex following stimulation of the retina by light • It tests the integrity of the visual system, more so of the macula
Electroretinogram	• The changes in resting potential in the eye upon stimulation by light are recorded through electrodes placed on the cornea
Electrooculogram	• The difference between the potential that exists between the cornea and the posterior aspect of the retina is recorded in a fully dark-adapted and a light-adapted state

4. Enumerate important milestones in the development of visual development. (3 marks)

- At birth: the child cannot fixate, and the ocular axis may seem non-parallel
- The first 6 weeks are extremely important as the process of "foveation" takes place
- At around 6–8 weeks, the child steadily fixes on light or an object of interest held at 8-10 inches
- At around 12–14 weeks, the child follows when the object is moved
- At around 5–6 months, stereopsis, color vision, and eye-body coordination develop

5. Cyclops is a character in Greek mythology who had one eye in the center of the forehead. Explain how, this concept is used in understanding binocular singular vision. (3 marks)

- The concept of the cyclopean eye arises from the concept of corresponding retinal elements
- When corresponding retinal elements of both eyes are stimulated, there is a sensory fusion that takes place
- Corresponding retinal elements create a single visual direction for a particular stimulus
- As a result, a mental impression of the visual direction of both eyes is formed such that an imaginary eye exists between the two eyes in the

forehead where the object is in exact line with the cyclopean eye (Fig. 1.1.6)

- As a result, there is a binocular singular vision and there is no diplopia

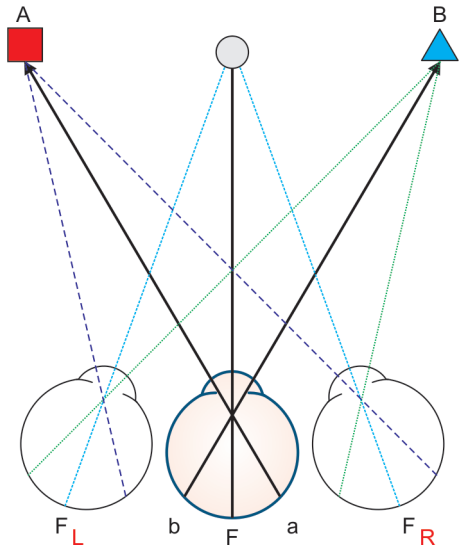


Fig. 1.1.6: Cyclopean eye

6. Explain the physiological basis for electro-retinogram. (3 marks)

- Electroretinogram is a recording of the changes of resting potential in the eye that is caused by light
- There exists a potential difference of 1mV between the cornea and the retina and is called the corneo-retinal potential
- When light falls on the retina, there is a change in this potential
- The resultant waveform generated by the action of a flash of light is called the electroretinogram or the ERG
- It is a composite recording of the activity of the Photoreceptors, Muller cells, and bipolar cells through which electrical activity flows
- A typical ERG consists of a negative 'a' wave followed by a large positive 'b' wave
- When light falls on the retina, there is hyperpolarization of the photoreceptors which become more positive when compared to the cornea
- Thus, a negative wave is generated and it represents the activity of the photoreceptors
- The Muller cells in connection with the photoreceptors and release of potassium ions by the photoreceptors cause electrical activity of the Muller cells and a positive wave is generated
- Finally, the 'b' wave is followed by a long positive 'c' which is due to the activity of retinal pigment epithelium (Fig. 1.1.7)

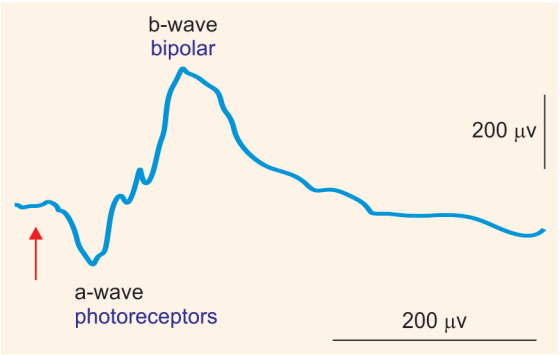
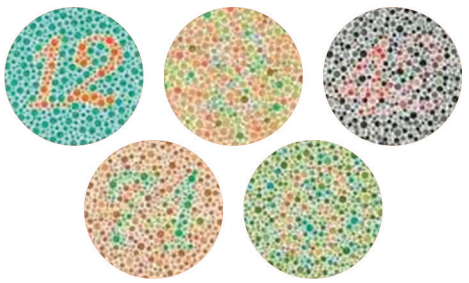


Fig. 1.1.7: Normal ERG

7. A. Identify the test shown in the image.
B. State its use.
C. Name two causes for acquired color blindness. (1+2=3 marks)

A. The Test Shown in the Picture

- The Ishihara color vision test



B. Use

- It is used to identify and diagnose congenital color blindness

C. Causes of Acquired Color Blindness

1. Optic neuritis
2. Diabetic macular edema

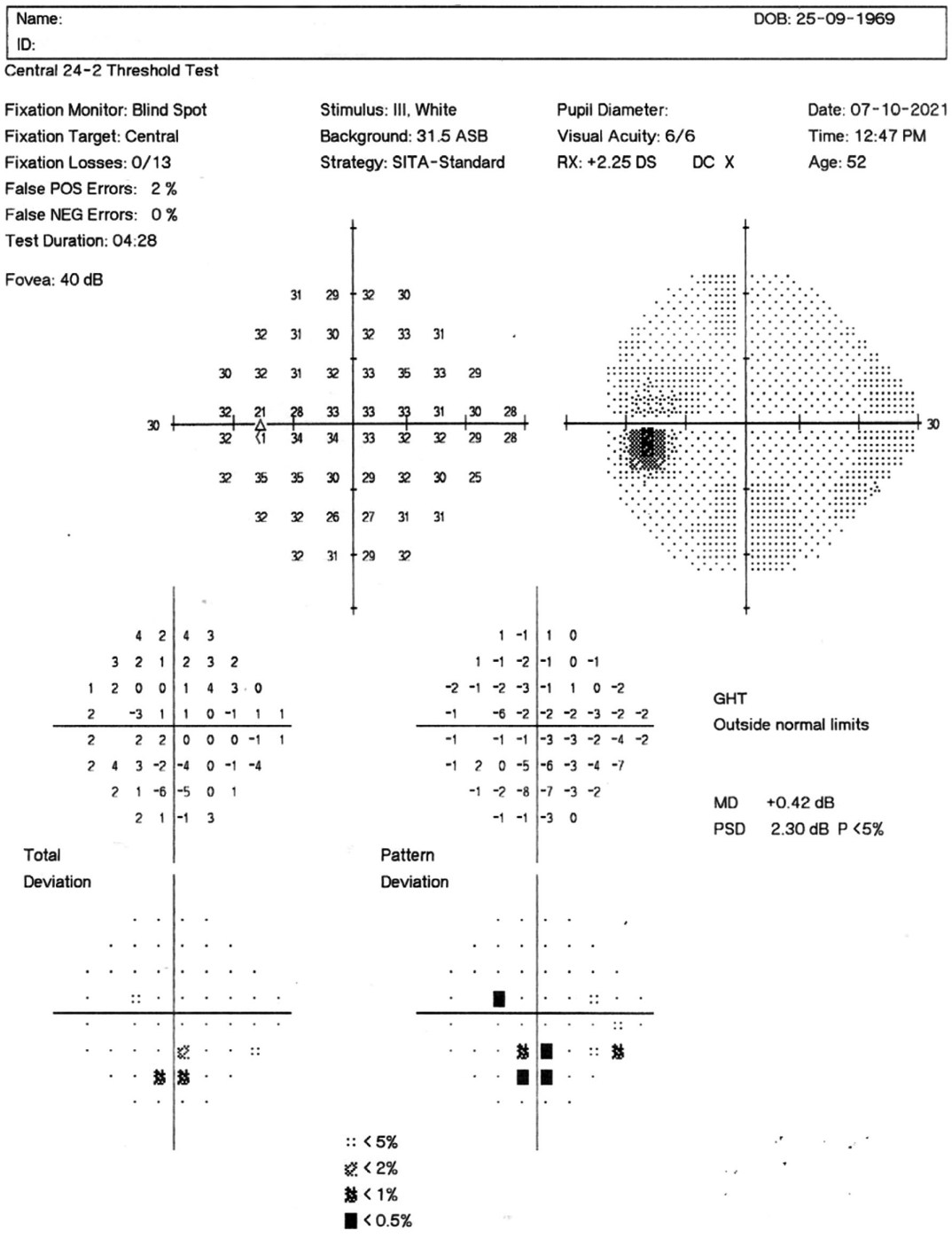
8. A. Identify the test by the report shown in the image.

B. Define a scotoma.

C. Differentiate between a positive and a negative scotoma. (1+1+1 marks)

A. The Image is a Report

- Visual field charting and hence, the test is called perimetry



B. Definition of Scotoma

- A non-seeing area within the visual field

C. Differentiation between a Positive and a Negative Scotoma

Feature	Positive scotoma	Negative scotoma
Definition	Perception of a non-seeing area within the visual field	Non-perception of a non-seeing area within the visual field
Symptoms	A black spot is seen by the patient	Usually asymptomatic
Causes	Neurological	Macular disorders like central serous retinopathy

9. There is a genetic disorder that predominantly affects the cones of the retina. State 2 components of vision that are affected due to cone dysfunction. Give an example of rod dysfunction. (2+1 marks)

Components of Vision that are Affected Due to Cone Dysfunction

- Cones are responsible for day vision and color vision
- So, the patient will experience hemeralopia (day-blindness) and dyschromatopsia (color blindness).
- The central vision is affected as most of the cones are concentrated in the macula which represents the center of the visual field

Example of Rod Dysfunction

Retinitis pigmentosa or pigmentary retinopathy

COMPETENCY

OP1.2 DEFINE, CLASSIFY AND DESCRIBE THE TYPES AND METHODS OF CORRECTING REFRACTIVE ERRORS

LONG ESSAYS

1. A defense personnel undergoes eye testing for vision and his visual acuity was found to be 6/6 in both eyes.

A. Define emmetropia and ametropia. (2 marks)

B. Describe the different types of refractive errors and their clinical features. (6 marks)

C. Enumerate the methods of treating each refractive error. (2 marks)

A. Emmetropia and Ametropia

Emmetropia

It is the state of the eye when parallel rays of light traveling from infinity are focused at a point on the retina with accommodation being at rest.

Ametropia

- It is a state of the eye when parallel rays of light traveling from infinity are not focused at a point on the retina with accommodation being at rest
- It is the presence of a refractive error

B. Different Types of Refractive Errors

1. Myopia

- It is a type of ametropia where light rays traveling from infinity are focused onto a point anterior to the retina. (Fig. 1.2.1)
- As a result, the image is formed in front of the retina
- Myopia is due to increased curvature of the cornea, increased curvature of the anterior surface of the lens, increased axial length of the eyeball, anteriorly displaced lens, or increased sclerosis of the lens
- Clinical features
  - The patients are usually in their school-going age
  - They present with an inability to see distant objects clearly and hence myopia is also known as "nearsightedness" in layman's terms
  - On examination, the eyeballs appear large, deep anterior chamber and fundus may be normal in lower degrees of myopia
  - In degenerative myopia, there are retinochoroidal degenerative features seen on fundoscopy
- Diagnosis by
  - Retinoscopy

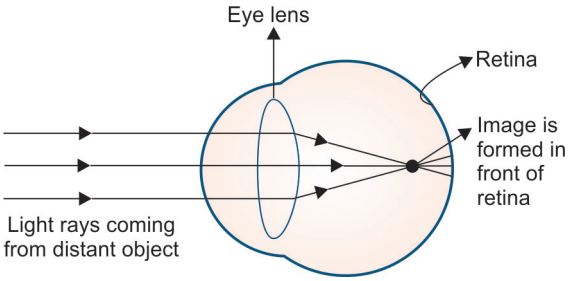


Fig. 1.2.1: Mechanism of myopia

2. Hypermetropia

- It is a type of refractive error where the light rays traveling from infinity are focused onto a point posterior to the retina (Fig. 1.2.2)
- As a result, the image is formed behind the retina
- Hypermetropia can result due to flat cornea, flat anterior surface of the lens, posteriorly displaced lens, short axial length, or sclerosis of the cortex
- Clinical features
  - The individuals usually complain of headaches in mild degrees of hypermetropia
  - The headache increases with near work and the end of the day
  - Asthenopia or tiredness of eyes and difficulty in seeing nearby objects or letters is a classical symptom
  - On examination, the eye may appear smaller, with a shallow anterior chamber and fundus has an appearance of 'silk shot retina' that is, increased reflexes on the retina with 'pseudo-papillitis' due to small optic nerve head may simulate disc edema
- Diagnosis by
  - Retinoscopy

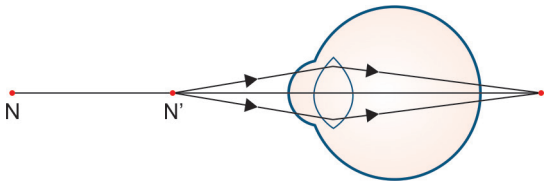


Fig. 1.2.2: Mechanism of hypermetropia

3. Astigmatism

- It is a type of ametropia where incident parallel rays of light traveling from infinity cannot be brought to focus on to one point on the retina with any spherical lens, rather focus onto multiple points along a line (Fig. 1.2.3)
- Astigmatism is most commonly due to irregular cornea, followed by lenticular astigmatism that can be seen in mild cases of subluxation and lenticonus.

- Clinical features
  - The individuals usually complain of headaches and may complain of distorted vision
  - Asthenopia or tiredness of eyes and difficulty in seeing nearby objects or letters is a classical symptom
  - On examination, the eye appears normal in small degrees of astigmatism
- Corneal scars may be present that cause larger degree of astigmatism

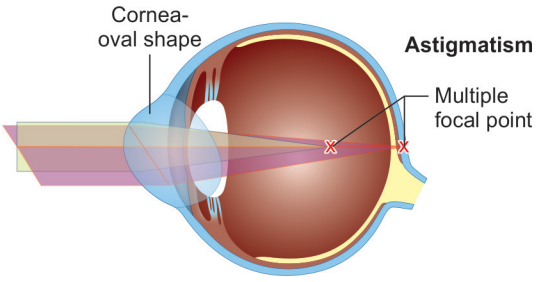


Fig. 1.2.3: Mechanism of astigmatism

C. Methods of Treating Each Refractive Error

1. **Myopia**
   - Concave lenses in the form of spectacles and contact lenses
   - Refractive surgeries like photorefractive keratectomy, LASIK, phakic IOL, and refractive lens exchange
2. **Hypermetropia**
   - Convex lenses in the form of spectacles and contact lenses
   - Refractive surgeries like hyperopic LASIK, conductive keratoplasty
3. **Astigmatism**
   - Cylindrical lenses in the form of spectacles and contact lens. Rigid contact lenses and toric contact lenses are preferred in higher degrees of astigmatism
   - Refractive surgeries include arcuate keratotomy and astigmatic LASIK

2. An 11-year-old girl presents with difficulty in seeing letters written on the blackboard.

A. Define myopia. **(1 marks)**
B. Classify myopia. **(3 marks)**
C. Enumerate two secondary causes of myopia. **(2 marks)**
D. Explain the principles of treatment and correction of myopia. **(4 marks)**

A. Myopia

A type of refractive error in which incident rays traveling from infinity are brought to focus on a point in front of the retina.

B. Classification of Myopia

Based on the clinical presentation

1. Simple myopia/school myopia: presents with a mild degree of myopia, usually not more than –6D
2. Developmental myopia: usually seen in infants born with a congenitally long eyeball and around –10D of non-progressive myopia
3. Degenerative myopia: a type of progressive myopia where there is degeneration of the choroid and the retina with an increasing axial length of the eyeball

C. Secondary Causes of Myopia

Cornea	Keratoconus
Lens	Nuclear sclerosis of the lens
	Hyperglycemia causes increased refractive index of the lens

D. Principles of Treatment

Optical Treatment

- In myopia, the converging power of the eye as an optical system is higher than normal, which is more than +60D
- A concave lens is used to diverge the converging lens so that the rays are made to converge onto the surface of the retina (Fig. 1.2.4)
- The concave lens can be used in the form of spectacles or contact lenses

Advantages of Spectacles

1. Easy to wear
2. Reversible

Disadvantages of Spectacles

1. May restrict the field of vision
2. Minification

Advantages of Contact Lenses

1. Placed over the cornea, hence more physiological
2. Minimal minification
3. Useful in unilateral high myopia

Disadvantages of Contact Lenses

1. Handling difficulty
2. Contact lens associated problems

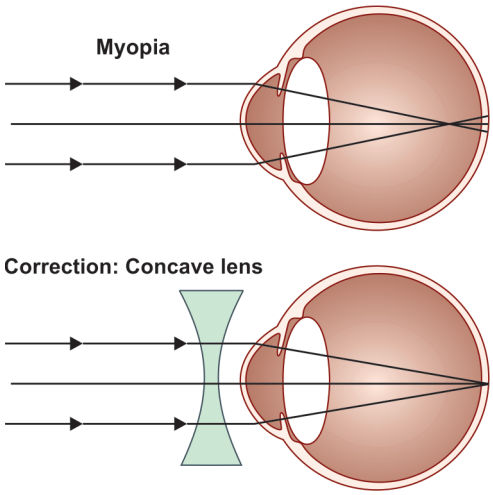


Fig. 1.2.4: Effect of concave lens in myopia

Surgical Correction for Myopia

- Corneal refractive procedures are based on the flattening of the cornea by various keratorefractive procedures or by lenticular procedures
- Flattening can be caused by incisions placed by using blades or using excimer LASER
- Lenticular procedures include refractive lens exchange and phakic IOL insertion

3. A motorist sustained an injury to the cornea following he underwent repair. He complains of distorted vision.

A. Define astigmatism and explain its types.
B. Draw a neat and labeled diagram of the Sturm's conoid.
C. Explain the clinical features and methods of correction of astigmatism.
D. Give two causes for distorted image formation. (3+3+3+1 marks)

A. Astigmatism

Definition

- It is a type of ametropia in which light rays incident on the eye do not get focused onto a point on the retina, instead get focused along a line
- This happens due to the difference in the power between two major meridia of the refracting surfaces

Types

1. **Regular astigmatism**
- In this type, the refractive power of the eye changes regularly from one meridian to another
- It is further divided into four types
  i. With the rule astigmatism (vertical meridian more curved than horizontal)
  ii. Against the rule astigmatism (horizontal meridian more curved than the vertical)
  iii. Oblique astigmatism (the two principal meridia are not vertical and horizontal, but perpendicular to each other
  iv. Bioblique astigmatism (the two meridia are neither vertical nor horizontal, also not perpendicular to each other)

2. **Irregular astigmatism**
- In this type, the refractive power of the eye changes irregularly from one meridian to another

B. Labeled diagram of the Sturm's Conoid

- Sturm's conoid (Fig. 1.2.5) is a pictorial representation of refraction at an astigmatic surface where the curvature of the horizontal meridian differs from the vertical meridian
- Various positions represent different clinical types of astigmatism:
  - A: Compound hypermetropic astigmatism
  - B: Simple hypermetropic astigmatism
  - C, D, and E: Mixed astigmatism
  - D: Circle of least diffusion
  - F: Simple myopic astigmatism
  - G: Compound myopic astigmatism

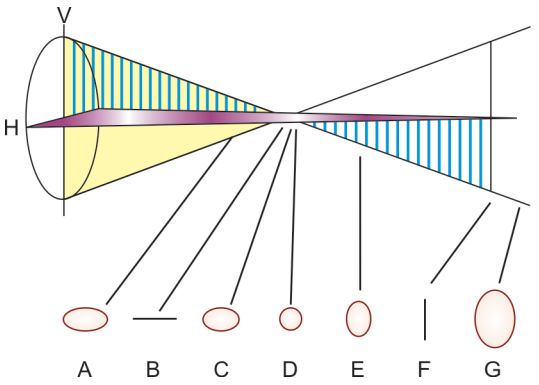


Fig. 1.2.5: Sturm's conoid

C. Astigmatism

Clinical Features

- Astigmatism causes asthenopia and headache more commonly than visual disturbances
- Blurred vision for near or distance depending on the type of astigmatism (hypermetropic or myopic)
- Patients may rarely perceive distorted shapes of objects
- Signs: Cornea may show scars that are responsible for astigmatism. The fundus may show an oblique disc
- Diagnosis is established by retinoscopy when two different powers are needed to neutralize two meridia. Autorefractometry, astigmatic fan, and Jackson's cross-cylinder can be used to confirm the power before prescribing

Methods of Correction

1. Spherocylindrical or cylindrical lenses are the most used form of treatment
2. Soft contact lenses with spherical correction can be useful in powers less than 0.75D
3. Rigid lenses are useful in slightly higher-powered lenses (2–3D)
4. Toric contact lenses are needed in higher powers
5. Astigmatic LASIK, arcuate keratotomy are corneal procedures

D. Causes for Distorted Image Formation

1. Astigmatism
2. Macular disorders

4. A 42-year-old tailor has trouble threading the needle of very recent onset. He never had any visual problems until now.

A. State the most probable diagnosis. (1 mark)
B. Enumerate the presenting features. (2 marks)
C. Explain the mechanism of accommodation. (4 marks)
D. Enumerate the methods of correcting this condition. (3 marks)

A. Most probable diagnosis

Presbyopia

B. Presenting Features of Presbyopia

- The tiredness of eyes or asthenopia
- Failing vision for near or blurred vision for proximal objects
- Headache, which increases more towards the day
- Intermittent diplopia due to a disturbed relationship between accommodation and convergence may be experienced by some

C. Mechanism of Accommodation

- The most accepted theory for accommodation is by Helmholtz. It is also called the relaxation theory (Fig. 1.2.6)
- According to this, the lens capsule is held taut under tension circumferentially by ciliary zonules that arise from the ciliary ring
- In an unaccommodated state, the lens is kept compressed by the tense zonules and the relaxed ring
- Following stimulation for accommodation, there is a contraction of the ciliary ring leading to shortening and relaxation of the zonules. As a result, the lens capsule relaxes
- This is followed by bulging of the anterior surface of the lens that increases the curvature and decreases the radius of curvature
- As a result, the converging capacity of the refracting surface increases
- A second theory is by Tscherning, according to which contraction of the ciliary ring, leads to contraction of zonules and tightening of the capsule at the equator. As a result, the capsule at the poles of the lens becomes lax and the anterior surface bulges forward

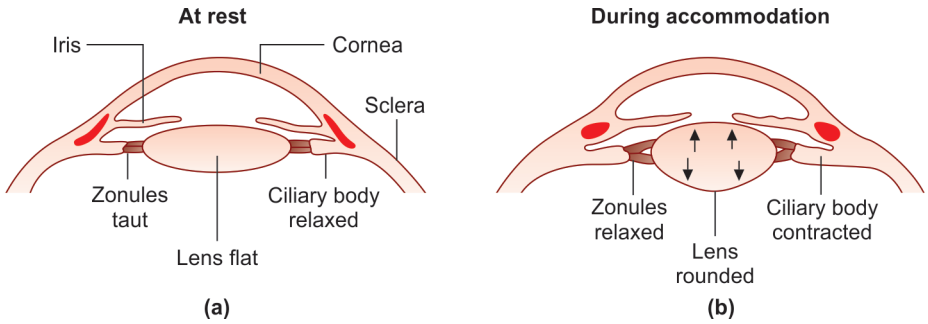


Fig. 1.2.6: Mechanism of accommodation

- This theory was further extended by Schachar. According to this, equatorial tension caused by the tension in the zonules leads to equatorial displacement of the lens and the central part of the lens bulges forward (Fig. 1.2.7)

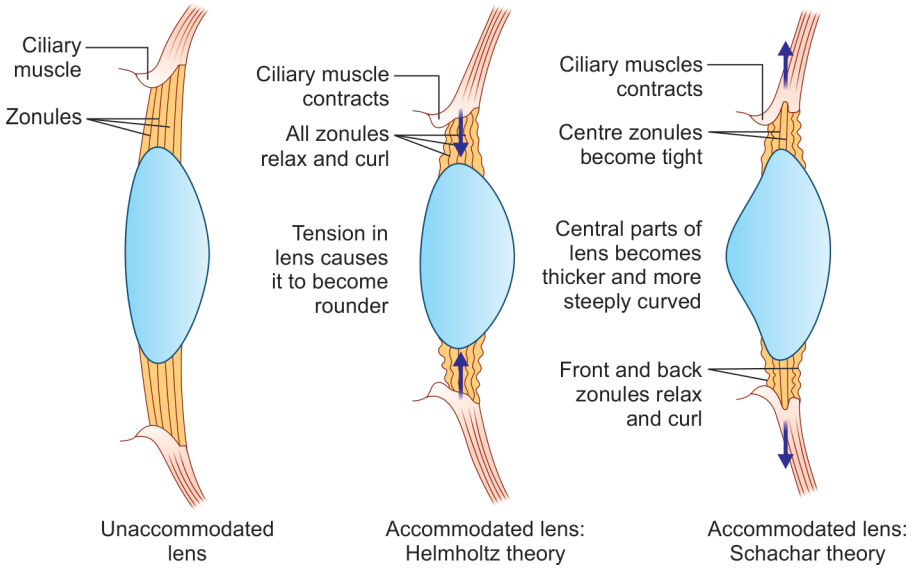


Fig. 1.2.7: Comparison between Helmholtz and Schachar theory

D. Methods of Correction

1. Optical Correction

- It is the simplest form of correction
- It is done using convex lenses in the form of spectacles or contact lenses
- The power of the glass is based on the need of the patient, his occupation, working distance, and most importantly preexisting refractive error
- It may range from +1.0D to +3.0D sphere
- The presbyopic correction can be provided in the form of monofocals, bifocals, or progressive glasses

2. Refractive Surgeries

- They are becoming more popular
- Monovision conductive keratoplasty
- Monovision LASIK
- Bifocal LASIK
- Presbyopic multifocal LASIK
- Corneal inlays
- Multifocal accommodating IOLs
- Monovision with IOLs
- Scleral based surgeries (Anterior ciliary sclerotomy, scleral expansion surgery)

SHORT ESSAYS

1. Enlist the components of hypermetropia. State the clinical importance of these components. (4+1 marks)

- Hypermetropia is a type of refractive error in which parallel rays traveling from infinity are brought to a point focus behind the retina
- It is also called 'long-sightedness in layman terms a poorer vision for near

Components of Hypermetropia

1. **Total hypermetropia:** Total hypermetropia after complete cycloplegia
2. **Manifest hypermetropia:** The amount of hypermetropia uncorrected by ciliary tone
3. **Latent hypermetropia:** The amount of hypermetropia that is corrected by inherent ciliary tone
4. **Facultative hypermetropia:** The amount of hypermetropia corrected by voluntary ciliary effort
5. **Absolute hypermetropia:** The amount of hypermetropia that remains uncorrected after accommodating effort

Clinical Importance

While providing an optical correction for hypermetropia, the value of manifest refraction + one-third of the latent refraction should be prescribed (Donder' law).

2. Describe the clinical features of hypermetropia. (5 marks)

Clinical Features of Hypermetropia

Symptoms

- Aesthenopic symptoms such as brow ache, headache, heaviness of eyes, and watering occur more commonly than with myopia as these patients have to use more of their accommodation to get a clear image of nearby objects. These are seen more towards the end of the day
- Recurrent styes, chalazia, and blepharitis. This is probably due to excessive rubbing of eyes due to eye strain
- High uncorrected hypermetropia in childhood can result in a convergent squint
- Amblyopia is more common in hypermetropia as younger children have more interest in nearby objects and when they are unable to do the same, develop amblyopia

Signs

- Short eyeballs, shallow anterior chamber
- The fundus may reveal a bright reflex simulating watered silk, also called shot-silk retina. The optic disc may seem crowded and mimic papillitis and thus the term "pseudopapillitis"
- Diagnosis is established by retinoscopy

3. Describe the features of pathological myopia. (5 marks)

Pathological Myopia/Degenerative Myopia

- Myopia associated with other pathologies of the eye especially the retina and choroid and is genetic in origin
- It is degenerative and progressive
- Usually begins around 5–10 years to progress up to the third decade

- Usually present with rapid fall in far vision which is uncorrectable with refractive correction
- They may also have a lot of floaters due to vitreous degeneration
- The power may go as high as –20 to –25D

Clinical Signs (Fig. 1.2.8)

- Long eyeball evidenced by long axial length around 28–33 mm
- Deep anterior chamber
- May be associated with a posterior subcapsular cataract
- Vitreous degeneration, posterior vitreous detachment
- Extensive retinal thinning and degeneration, peripheral cystoid degeneration
- Large and pale appearing disc with temporal crescent or peripapillary atrophy
- Nasal supertraction of the retina over the disc
- Prominent choroidal vessels due to thinning of the overlying retina
- Lacquer cracks (linear cracks in Bruch's membrane)
- Posterior staphyloma
- Foster Fuchs spot (sub-retinal bleed due to rupture of choroidal vessels at fovea) and myopic choroidal neovascular membrane
- Can be complicated with retinal detachment and vitreous hemorrhage

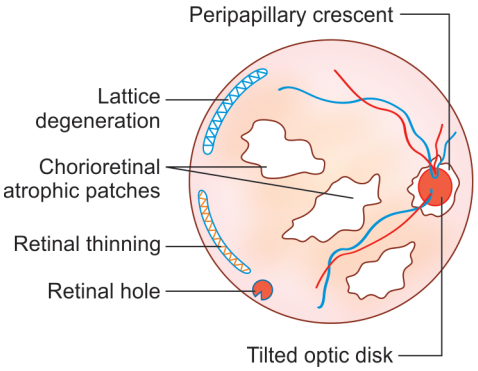


Fig. 1.2.8: Fundus features of degenerative myopia

4. Describe the etiology and clinical features of school myopia. (2+3 marks)

School Myopia

- School myopia or simple myopia is a common form of myopia where the power of the eye usually does not exceed –6D
- It is considered physiological as it occurs with the sudden increase in growth of the eyeball associated with puberty

Etiology

- Axial type:
  - Increase in the axial length of the eyeball causes the image to fall anterior to the retina. 1 mm increase in length of the eyeball causes myopia of roughly 3D
  - It is proposed to be associated with precautious neurological development
- Curvatural type: It is due to underdeveloped eyeball
- Genetics: Myopia is supposed to have a genetic inheritance
- Excessive near work: Myopia progresses more in children who do more near work, have less outdoor activity

Clinical Features

Symptoms

- Diminished vision for distance is usually the main complaint
- Asthenopia and headache may be there with smaller refractive errors
- In younger children, the parents may complain of the child viewing the television from a closer distance, failing to attain milestones, and disinterested in outdoor activities

Signs

- The eyeballs appear long and prominent
- The anterior chamber is deep
- The fundus is usually normal, but some may have a temporal crescent
- Some even may have peripheral retinal degenerations and atrophic holes

5. Define anisometropia? Explain its effects on a binocular singular vision.

(1+4 marks)

Anisometropia

Definition

- It is a condition in which both eyes have different refractive powers
- Clinical definition
  - A difference of more than 2.5D is taken as anisometropia, as up to 2.5D can be tolerated by the cortex
  - Up to 4D can be tolerated based on individuals, more than 4D cannot be tolerated

Effects on Binocular Singular Vision

Anisometropia can cause suppression, amblyopia, or loss of binocular function.

1. **Suppression and amblyopia**
   - Individuals with anisometropia described beyond the above-mentioned degrees cause diplopia or confusion and in a long-term can cause anisometropic amblyopia
   - The mechanism by which amblyopia develops is suppression
   - Even lower degrees of anisometropia can cause a decline in binocularity which is evident on the Worth four dot test
2. **Loss of binocular function**
   - There is a loss of stereoacuity beyond 1 Diopter difference in the sphere
   - The probable mechanism by which stereoacuity is affected is by foveal suppression
   - With an anisometropia of 1D, a clinically acceptable level of stereopsis can be maintained. But with an anisometropia of 4D, only 20% of individuals can maintain a moderate amount of stereopsis
   - Also, the amount of decline in binocularity is more in spherical anisometropia
   - In cases of mixed anisometropia, there is an alternate vision
   - For example, if one eye is moderately hypermetropic and the other eye is myopic, amblyopia does not develop. But there is no binocularity
   - Due to the aforementioned reasons, anisometropia should be appropriately corrected in the pediatric age group

6. Define accommodation and describe the anomalies of accommodation.

(1+4 marks)

Accommodation

Definition

Defined as a process by which divergent rays coming from a near object are converged at a point on the retina with the help of the ciliary body, zonules, lens, and the pupillary aperture.

Anomalies

1. **Presbyopia**
   - It is an age-related decrease in accommodating power of the ciliary body and the lens, resulting in an inability to focus on the nearby objects
2. **Insufficiency of accommodation**
   - It is a condition in which accommodation is less than the age-matched normal population. They present with asthenopia and blurred vision for near. It is not ametropia. It is due to a decrease in the amplitude of accommodation
3. **Paralysis of accommodation**
   - It is total paralysis of accommodation
   - Causes can be drug-induced, third nerve palsy, internal ophthalmoplegia due to ciliary ganglionitis
4. **Spasm of accommodation**
   - When the accommodation is abnormally excessive, it is called a spasm of accommodation
   - They usually present with browaches and aesthenopic symptoms
   - They can have blurred vision due to induced myopia
   - Diagnosis is established by atropine retinoscopy
   - Treatment is in the form of cycloplegia with atropine and correction of associated refractive error
   - Avoidance of near work is advised

7. Explain the optics of aphakia. (5 marks)

- Aphakia is an absence of a crystalline lens
- The lens contributes to around 18–20D of the total 60D of the eye

Changes in Cardinal Points of the Eye (Fig. 1.2.9)

- The total power of the eye is reduced to around 40–45D. the eye becomes extremely hypermetropic
- The anterior focal point becomes 23.2 mm in front of the cornea and the posterior focal point is shifted to 31 mm behind the cornea
- The two principal points are at the anterior surface of the cornea. The nodal points are close to each other and about 7.75 mm behind the cornea
- An aphakic eye has very poor vision unless the eye is highly myopic. Also, there is against the rule of astigmatism
- There is a loss of accommodation

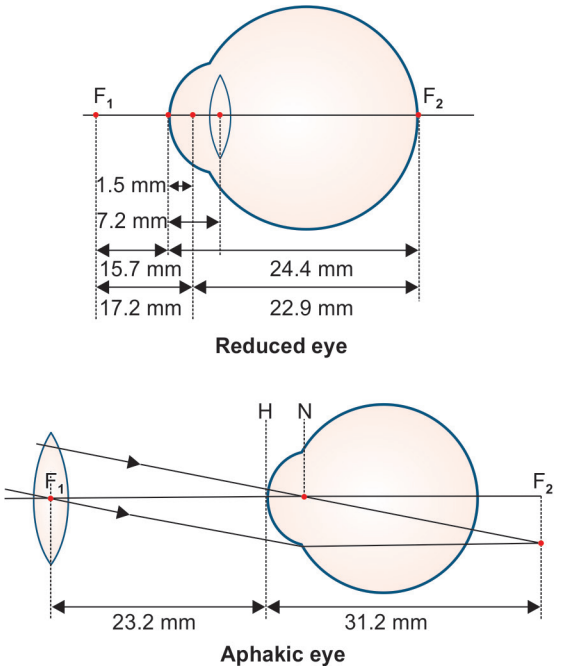


Fig. 1.2.9: Optics of aphakia

8. Describe various methods of correcting aphakia with the pros and cons of each type. (5 marks)

Methods of Aphakia Correcting

Method	Pros	Cons
• Spectacles • Using highly plus lenses to correct aphakia was the commonest method used in the past • Around +10D power, glasses are used	• Low cost • Easy handling	• Heavy • Magnification up to 30%, can cause diplopia if unilateral • Chromatic and spherical aberration. Spherical aberration causes the pincushion effect • Decreased field of vision • Jack in the box phenomenon • Cosmetically not acceptable
• Contact lenses	• There is no magnification. • No spherical, chromatic aberrations • The field of vision is bigger • No roving ring scotoma	• Difficult to handle as vision is very low • Cost and contact lens-related issues
Surgical correction 1. The PC IOL can be placed in the capsular bag if it is present. 2. Or iris-claw lenses can be used. 3. ACIOL (anterior chamber IOL) which is angle supported was a good option, now they are slowly becoming obsolete. 4. Scleral fixated lenses are also a good option	• More physiological	• Need for a second surgery • Risk of intraoperative procedures • Further decline in endothelial health (especially in ACIOL use)
• Refractive corneal procedures: keratophakia and epikeratophakia (obsolete) • Hyperopic LASIK can be tried	• No intraocular manipulation • Can correct astigmatism	• Cost and availability

9. Compare various types of contact lenses. (5 marks)

Types of Contact Lenses

- Depending on the nature of the material used, contact lenses are divided into three types

Feature	Hard lenses	Rigid gas permeable lenses	Soft lenses
Material	Made of PMMA	Silicone acrylate	HEMA
Special properties		Permeable to oxygen	1–2 mm larger than the corneal diameter
Optical quality	High	High	Lesser
Durability	Durable and cost effective	Durable and cost effective	Expensive

Contd.

Feature	Hard lenses	Rigid gas permeable lenses	Soft lenses
Disadvantages	Impermeable to oxygen, so difficult to tolerate, can cause abrasions		Protein deposits are more common, cannot correct astigmatism >2D
Present-day use	Uncommon	A high degree of astigmatism, keratoconus	Commonly used due to comfort

- Depending on the ionic charge and water content, soft contact lenses are grouped into 4 categories

Group 1	Low water content Nonionic polymers
Group 2	High water content Nonionic polymers
Group 3	Low water content Ionic polymers
Group 4	High water content Ionic polymers

SHORT ANSWERS

1. Mr. J went to an ophthalmologist and was given the following prescription.

Eyecare Hospital, Mumbai

Name Mr. 1 Date: 02/04/2021

Age 55 years

Address: Maharashtra

	Right eye			Left eye		
	Sphere	Cylinder	Degrees	Sphere	Cylinder	Degrees
Distance	+2.0D	+0.5D	180	+1.5D	+0.75D	180
Near	+4.5D	+0.5D	180	+4.0D	+0.75D	180

Remarks: Bifocals for constant use

Signature

A. State the type of refractive error. (2 marks)

B. Define presbyopia. (1 mark)

A. Type of Refractive Error

Compound hypermetropic astigmatism in both eyes (with against the rule astigmatism) along with presbyopia.

B. Definition of Presbyopia

A physiological age-related decrease in the accommodative power of the crystalline lens leading to difficulty perceived by the individual in seeing clearly at proximity.

2. Explain how each component of the eye contributes to the refractive status with appropriate examples. (3 marks)

Ametropia or refractive error may be due to one or more of the following:

1. **Axial length**
   - Cause of ametropia is the abnormal axial length of the eyeball
   - A long eyeball leads to myopia, whereas a short eyeball leads to hypermetropia
   - 1mm of difference in length causes a difference of 3D in refractive error
2. **Curvature of the cornea and the lens**
   - Cause of ametropia is due to increase or decrease in the radius of curvature of the anterior surface of the cornea and lens
   - 1 mm difference in the radius of curvature produces ametropia equivalent to 6D
   - Thus, steep cornea leads to myopia and flattening of cornea causes hypermetropia
3. **Refractive index**
   - Change in the refractive index of cornea, aqueous, lens, or vitreous leads to ametropia
   - An increase in the refractive index of the lens as in senile sclerosis causes a myopic shift, whereas an increase in the refractive index of the cortex causes a hypermetropic shift
4. **Position of the lens**
   - The nodal point in the eye is the posterior pole of the lens
   - Hence any change in the position of the lens produces a refractive error
   - A forward displacement of the lens leads to myopia and backward displacement of the lens leads to hypermetropia

3. Describe the causes, clinical features, and treatment of irregular astigmatism. (1+2+2 marks)

Irregular Astigmatism

- A type of astigmatism in which the refractive power changes irregularly from one meridian to the other
- It is usually curvatural

Causes

Scarred cornea, subluxated lens due to varying laxity of zonules at different parts of the lens.

Clinical Features

Symptoms

Patients present with distortion of objects, blurred vision, and sometimes polyopia

Signs

- Corneal surface may appear irregular and scarred
- If associated with subluxated lens, there is iridodonesis, phacodonesis, and uneven anterior chamber
- Distortion of mires on placido disc and photokeratoscopy

Treatment

- Rigid contact lenses
- Photorefractive keratectomy
- Penetrating keratoplasty as a last resort

4. Define aniseikonia. State its types. (1+2 marks)

Aniseikonia

Definition

A condition in which the images projected onto the visual cortex by two retinae are of different sizes and shapes.

Types

1. Optical aniseikonia due to anisometropia
2. Retinal aniseikonia may occur due to retinal stretching due to edema
3. Cortical aniseikonia

5. Name the types of anisometropia. (3 marks)

1. **Simple**
   - When one eye is normal and the other is either myopic/hypermetropic/astigmatic
2. **Compound**
   - When both are myopic/hypermetropic/astigmatic of unequal degrees
3. **Mixed**
   - When one is myopic and other is hypermetropic

6. Explain the terms (1 mark each)

A. Far point
B. Near point
C. Amplitude of accommodation

A. Far Point

- Punctum remotum: or far point is the farthest point that is visible
- It is taken as infinity for emmetropic eye, is a real point in front of the retina in myopic eyes, and a virtual point behind the retina in a hypermetropic eye

B. Near Point

- Punctum proximum or near point is the nearest point which is visible to the naked eye
- Its value changes with age

10 years	7 cm
40 years	25 cm
45 years	33 cm

C. Amplitude of accommodation

- The difference between dioptric power needed to focus near point and the far point is called the amplitude of accommodation
- A = P–R

7. Explain how the near point is measured? (3 marks)

- The near point is the nearest point that is visible to the naked eye
- It is measured using the RAF rule (Royal Airforce) (Fig. 1.2.10)
- During the test, the patient must wear his full optical correction
- The instrument consists of a specially designed rule on which centimeters and inches are marked on two sides
- The third side is marked with diopters for measuring NPA, and the fourth side is marked by the appropriate age
- A wing-like structure is present on one end that fits over the nose and rests over the maxillary region
- A mobile rider is present that moves along the length of the rule
- The wing-like end of the instrument is placed on the nose and the rider is moved closer to the eyes till the closest point till which the 6/9 letters on it are clear
- The distance is measured by the markings at which the rider coincides and it is the NPA

Fig. 1.2.10: RAF rule

8. Explain progressive spectacles. (3 marks)

- Progressive power lenses are also called Varifocal lenses
- They have a progressive increase in the power of the lens from the upper part downwards
- A standard progressive power adds lens is designed to have four zones (Fig. 1.2.11)
  1. Distance vision zone in the upper part
  2. Near vision zone in the lowermost part
  3. Progressive corridor connecting the above two
  4. Blending region on either side.

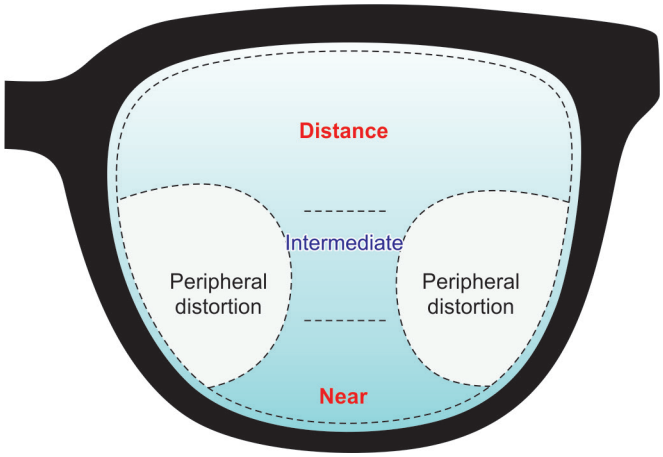


Fig. 1.2.11: Progressive glasses

9. Enumerate the types of contact lenses. (3 marks)

1. Hard contact lens
2. Rigid gas permeable lens
3. Soft lens

10. Enumerate the disadvantages of using aphakic glasses. (3 marks)

- Using highly plus lenses to correct aphakia was the most common method used in the past in developing countries
- It has many disadvantages
  1. Heavy
  2. Magnification up to 30%, can cause diplopia if unilateral
  3. Chromatic and spherical aberration. Spherical aberration causes the pincushion effect
  4. Decreased field of vision
  5. Jack-in-the-box phenomenon or roving ring scotoma
  6. Cosmetically not acceptable by many

11. Enumerate the indications for low vision aids. (3 marks)

Low Vision Aids

A. Macular Disorders: Magnifiers and Telescopes are Useful

1. Albinism
2. Age-related macular degeneration
3. Heredomacular dystrophies
4. Diabetic maculopathy
5. Chorioretinitis
6. Myopic macular degeneration

B. Retinal Dystrophies: Magnifiers with Increased Illumination are Useful

1. Retinitis pigmentosa
2. Choroideremia

12. A patient has been prescribed the following prescription for spectacles.

Right Eye	Left Eye
–3.0D sphere –0.75D cylinder @ 90 degrees	–2.25D sphere

A. State the types of refractive errors in both eyes. (1+1 marks)

B. Define hypermetropia. (1 mark)

A. Types of Refractive Errors in Both Eyes

1. **Right eye:** Compound myopic astigmatism (against the rule)
2. **Left eye:** Myopia

B. Definition of Hypermetropia

A type of refractive error where the light rays traveling from infinity are focused onto a point posterior to the retina. As a result, the image is formed behind the retina.

13. A 14-year-old boy playing cricket gets an injury to his right eye. His lens is subluxated. State the type of refractive error induced and explain its mechanism. (1+2 marks)

Type of Refractive Error

Subluxation of the lens causes myopic astigmatism and is usually irregular.

Mechanism

- Normally, the lens is held tightly by the zonules and the anterior surface (that determines the refractive error) is even, and thus, there is no or minimal astigmatism
- In subluxation (partial loss of zonules), a part of the zonular ring is disrupted

14. Explain the optical phenomenon indicated by the image. (3 marks)

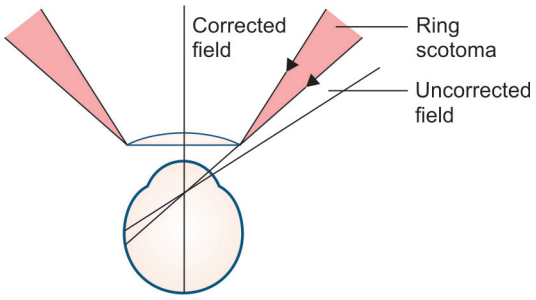


Fig. 1.2.12: Jack-in-the box phenomenon

- The image shows a Jack-in-the-box
- Jack-in-the-box phenomenon or roving ring scotoma: a ring-shaped relative scotoma in the midfield between the central field and peripheral field (50–65°) (Fig. 1.2.12)
- Objects in this area are not visible but appear suddenly out of nowhere when the patient moves his eye towards the object or it enters his central or peripheral field
- It happens due to the prismatic effect of the convex lenses

COMPETENCY

OP1.3 DEMONSTRATE THE STEPS IN PERFORMING THE VISUAL ACUITY ASSESSMENT FOR DISTANCE VISION, NEAR VISION, COLOR VISION, THE PINHOLE TEST, AND THE MENACE AND BLINK REFLEXES

SHORT ESSAYS

1. Explain the steps in visual acuity assessment. (5 marks)

Visual acuity assessment includes the following steps:

1. **Objective refraction**
   - In this method, the amount of refractive error is assessed by either manual or automated methods
   - The manual method is done by a hand-held retinoscopy
   - Retinoscopy is a procedure for objective refraction where a beam of light emanating from a source is shone into the pupil of an individual and moved from one side to the other in both meridia
   - Based on the movement of the reflex within the pupil, certain inferences can be drawn
   - These inferences are based on the presumption that the examiner is seated at 1 m far from the patient

- Once the type of refractive error is determined, the degree of the refractive error should be calculated
- It is done by placing progressively higher 'minus' lenses in front of the eye when the reflex is moving against the movement till the movement is neutralized or reversed
- In cases of 'with-the-movement' of the reflex, 'plus' lenses are placed in ascending progression, till there is the reversal of movement
- Automated refraction is done by using an autorefractometer

2. **Subjective refraction**
   - This is done by the trial and error method
   - A trial frame is used to place lenses and the distance and near vision based on the readings obtained by objective refraction
   - The patient is asked to read out the Snellen's chart placed at a distance of 6 m
   - Snellen's chart has letters or numbers with decreasing size.
   - The biggest of the character is denoted as 6/60; meaning what the patient has to view at 60 m, can be viewed by him at 6m (indicating subnormal vision)
   - Thus, there are various grades like 6/36, 6/24, 6/18/6/12, 6/9, and 6/6
   - This is followed by a near vision assessment with a near vision chart (Jaeger)
3. **Refinement of refraction**
   - Refinement of a sphere is done by Fogging method and Duochrome test
   - Refinement of the cylinder is done by Jackson's cross-cylinder and Astigmatic fan test
4. **Binocular balancing**
   - This refers to finding any oculomotor imbalances like manifest deviation, convergence insufficiency, etc

2. Describe the principles and procedure of retinoscopy. (2+3 marks)

Retinoscopy

Principles

- In the determination of refraction, the first objective refraction is done to determine the type of refractive error—myopia, astigmatism or astigmatism or a combination and then their magnitude
- This is performed manually by retinoscopy or skiascopy. It is based on the principle that when light is shone into the eye, the direction of movement of the reflex depends on the refractive status of the eye

Results of Retinoscopy (Fig. 1.3.1)

If the shadow moves in the opposite direction, then the refractive power is >1D myopia
In such cases, minus lenses are placed in front of the eye till the movement changes in the same direction
If the shadow moves in the same direction, then it is either emmetropia or hypermetropia or myopia of less than 1D
In such cases plus lenses are placed in front of the eye till there is a change of movement to the opposite direction
If the shadow does not move, then it is the myopia of 1D

Procedure

- The patient is seated in a dark room and asked to focus on Snellen's chart
- The examiner sits 1m in front of the patient and shines light into the patient's eye in one direction and noted the movement of the shadow

- Once the type of refractive error is determined, the degree of the refractive error should be calculated
- It is done by placing progressively higher 'minus' lenses in front of the eye when the reflex is moving against the movement till the movement is neutralized or reversed
- In cases of 'with-the-movement' of the reflex, 'plus' lenses are placed in ascending progression, till there is a reversal of movement

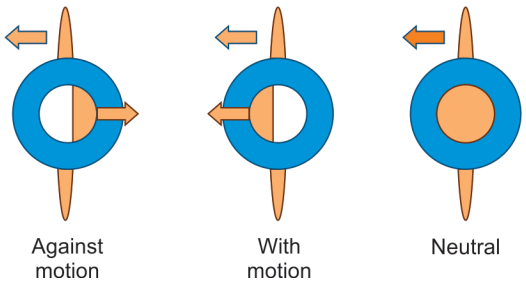


Fig. 1.3.1: Results of retinoscopy

- If there is a requirement of use of cycloplegic, a cycloplegic is used

SHORT ANSWERS

1. Demonstrate the ability to identify refractive errors based on retinoscopy findings. (3 marks)

- Retinoscopy is a procedure for objective refraction where a beam of light emanating from a source is shone into the pupil of an individual and moved from one side to the other in both meridia
- Based on the movement of the reflex within the pupil, certain inferences can be drawn.
- These inferences are based on the presumption that the examiner is seated at a distance of 1m from the patient
- If the shadow moves in the same direction, then it is either emmetropia or hypermetropia or myopia of less than 1 D (Fig. 1.3.2)
- If the shadow moves in the opposite direction, then the refractive power is >1D myopia (Fig. 1.3.3)
- If the shadow does not move, then it is a myopia of 1D (Fig. 1.3.4)
- Once the type of refractive error is determined, the degree of the refractive error should be calculated
- It is done by placing progressively higher 'minus' lenses in front of the eye when the reflex is moving against the movement till the movement is neutralized or reversed
- In cases of 'with-the-movement' of the reflex, 'plus' lenses are placed in ascending progression, till there is a reversal of movement

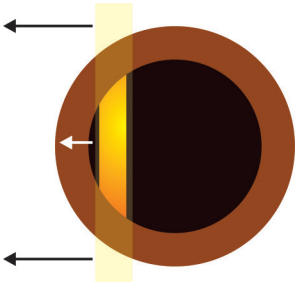


Fig. 1.3.2: With movement

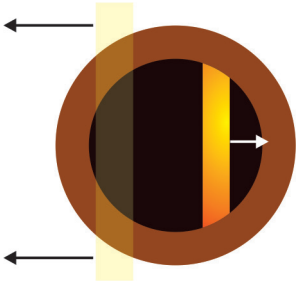


Fig. 1.3.3: Against movement

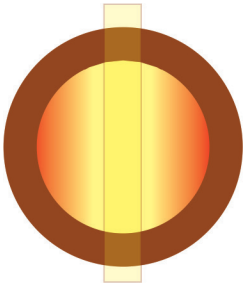


Fig. 1.3.4: Neutralization of reflex

2. Describe refinement of the cylinder after the trial-and-error method. (3 marks)

Refinement of the cylinder is performed using an astigmatic fan and Jackson's cross cylinder

1. **Astigmatic fan (Fig. 1.3.5)**
   - The astigmatic fan consists of a set of radiating lines spaced at 10° apart, with a central panel that contains a 'V' and a set of perpendicular lines.
   - After obtaining the best-corrected visual acuity, a positive sphere is added to the trial frame to induce simple myopic astigmatism
   - Then, the patient is instructed to point out the group of lines that appear clearest and darkest. This gives an idea about the probable axis

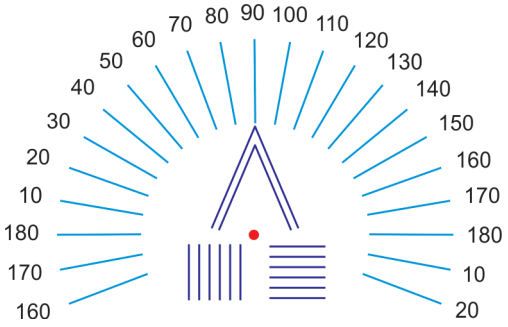


Fig. 1.3.5: Astigmatic fan

2. **Jackson's cross-cylinder**
   - It is a combination of two cylinders of equal strength but in perpendicular meridia (Fig. 1.3.6)
   - The commonly used powers are ±0.25 and ±0.5
   - The patient's best-corrected visual acuity with the sphere is found and placed in the trial frame
   - The cross-cylinder is placed with the 'plus' mark at 90° and followed by 180°
   - If there is an improvement of visual acuity with any of the positions, there is a requirement of a cylinder in that particular axis
   - To refine the axis, the cross-cylinder is placed in a way such that both axes are 45° to the assumed axis.
   - This is followed by flipping the cross-cylinder
   - If the patient notices improvement in either position, the plus cylinder is rotated towards the plus sign of the cross-cylinder and the minus is rotated towards the minus

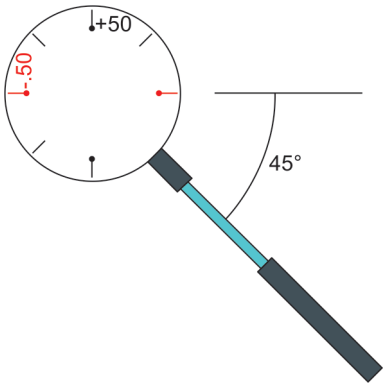


Fig. 1.3.6: Jackson's cross-cylinder

3. Explain the role of a pinhole in refraction? (3 marks)

- The pinhole is a very useful instrument in refraction
- It is nothing but an occluder with a central point-sized opening

Principle

- It is based on the principle that smaller pupils give a good depth of focus and clarity due to smaller aperture
- So, when light rays are made to pass through the pinhole, the central rays only pass through. These rays are not affected by refractive errors which arise due to the curvature of the refractive surfaces (Fig. 1.3.7)

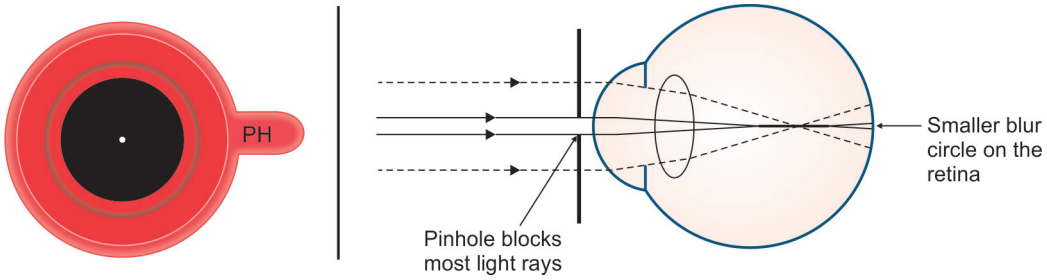


Fig. 1.3.7: Principle of pinhole

Use in Refraction

- When the uncorrected visual acuity is less than 6/6, a pinhole is placed in the trial frame. If the visual acuity improves to 6/9 or 6/6/, then we know the cause for blurred vision is a refractive error
- If the visual acuity does not improve with the use of a pinhole, it is more probable that the cause for diminution of vision is some other pathology

4. Explain how menace reflex is elicited? State its clinical implication. (1+2 marks)

Menace Reflex Elicitation

- To perform this test, the patient is seated comfortably and instructed to occlude one eye
- Menace reflex is elicited by suddenly bringing an object/examiner's hand close to the eye of the patient
- The patient with moderately fair vision blinks as a protective response (both the eyelids close)

Clinical Implication

- Menace reflex is a frequently used bedside test for testing visual acuity in patients who cannot take part in conventional visual acuity testing
- It is a type of blink reflex that leads to reflex blinking in response to a fast-approaching object towards the eye
- It is absent in damage to the visual cortex
- It is useful in the rough assessment of vision in children, mentally challenged, and malingerers

5. Explain how blink reflex is elicited? State its clinical implication. (1+2 marks)

Blink Reflex Elicitation

- To elicit it, the examiner stands beside the patient and the patient is advised to look straight ahead
- With a wisp of cotton, the examiner touches the corneal limbus without bringing the cotton wisp into the patient's field of vision (otherwise menace reflex gets elicited)
- This causes bilateral blinking
- The same procedure is repeated on the other side. It can be quantified by using an aesthesiometer

Clinical Implication

- It is an involuntary reflex characterized by blinking of the eyelid followed by corneal stimulation
- It is a bilateral response; the afferent pathway is through the ophthalmic division of the trigeminal nerve and the efferent is through the zygomatic branch of the facial nerve
- The time taken is 0.1 seconds
- It is a defensive mechanism to protect the eye from injury. It forms the basis for testing corneal sensations
- Absent blink reflex is seen in several cases where trigeminal nerve endings are damaged
- Asymmetric blink reflex is seen in facial palsy

6. A 4-year-old was found to have a refractive error of +3D. But he cannot be prescribed glasses right away. Justify the use of cycloplegics in refraction. (3 marks)

- A 4-year-old child with hypermetropia of 3D has been examined in this case.
- Glasses should not be prescribed right away as children have a ciliary tone that masks the actual refractive error
- Cycloplegics are drugs that cause paralysis of accommodation leading to uncovering the actual refractive error that has been corrected by ciliary tone
- They are especially indicated in children, hypermetropes and severe astigmatism to confirm the axis.
- Retinoscopy performed after cycloplegics is called wet retinoscopy

Cycloplegic	Age for use	Dosage	Time of retinoscopy	PMT performed
Atropine (1%)	<5 years	Given as ointment BID for 3 days	3 days	After 3 weeks
Homatropine (2%)	5–8 years	1 drop every 10 minutes for 60 minutes	90 minutes	3 days
Cyclopentolate (1%)	8–13 years	1 drop every 15 minutes, 3 applications	90 minutes	3 days
Topricamide (1%)	Only as a mydriatic	1 drop every 15 minutes, 3 applications	40 minutes	Next day

- After doing a retinoscopy in a cycloplegic state, a post-mydriatic test subjective refraction is performed after the prescribed period
- Correction is only prescribed instead of performed after this test.

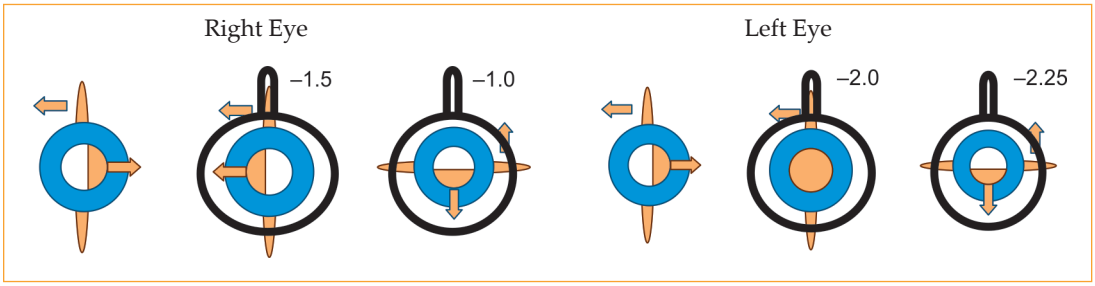
7. Describe the method of using Ishihara's chart. (3 marks)

Method of Using Ishihara's Chart

- It was designed by a Japanese scientist and is designed to identify congenital color blindness
- Individuals with color blindness are asymptomatic and see all colors in various shades of grey
- In the Ishihara chart, there are various colored circles that are of various intensities of the same hue within which a number is hidden. Also, the number is made of colored circles of different shades of the same hue

- This is called pseudo-isochromatism—a false impression of being of the same color
- To perform this test, the individual is asked to cover one eye and identify the numbers in the chart. The examiner notes the readings by the individual. This is followed by an assessment of the other eye
- A table is provided at the end of the chart that helps to categorize the type of color blindness

8. A 29-year old man presents with blurred vision for distance. On performing dry retinoscopy at 1m, the following results are seen. Draw a power cross for the same and deduce the power of his glasses. (2+3 marks)



Retinoscopy values performed at the vertical and horizontal meridian are shown in the images

Feature	Right Eye	Left Eye
Power cross	–1.0 / –1.5	–2.25 / –2.0
After deduction of –1 for distance	–2.0 / –2.5	–3.25 / –3.0

Prescription	–2.0D sphere –0.5D cylinder at 90°	–3.0D sphere –0.25D cylinder at 180°
Diagnosis	Compound myopic astigmatism (against the rule)	Compound myopic astigmatism (with the rule)

9. A 40-year old carpenter wants presbyopic correction. He is emmetropic for distance. His NPA (near point of accommodation) is found to be 50 cm and his working distance is 33 cm. Calculate the amount of 'plus' to be prescribed. Explain the impact of age on accommodation. (2+1 marks)

Amount of Plus

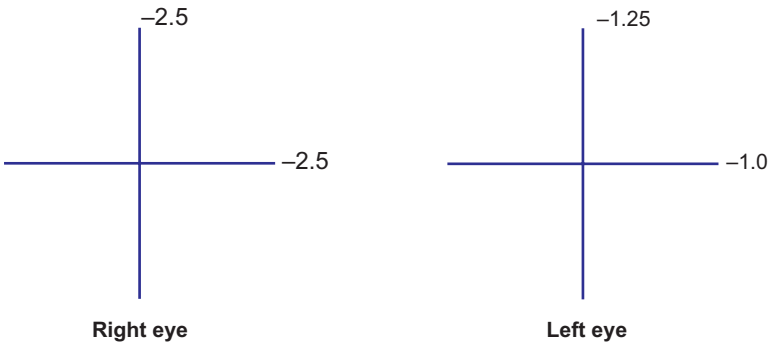
- For prescribing presbyopic correction, the patient's occupational requirement, ambient lighting, and NPA need to be considered
- NPA, in this case, is 50 cm hence the accommodating power necessary to focus adequately is 100/50 (reciprocal of focal length in meter) = 2D
- His working distance is 33 cm (0.3 m). Hence the accommodating power necessary to focus on the object is 100/33 = 3D
- So, the necessary add for presbyopic correction is 3 – 2 = 1D. However, while prescribing presbyopic correction, one-third of the necessary accommodating power (3D) is decreased to provide comfortable viewing. One-third of 3D is 1D
- Thus, this patient does not need presbyopic correction

Effect of Age on NPA

The NPA recedes with age due to a decrease in the elasticity of the lens capsule

Age (years)	Distance (cm)
10	7
20	10
30	14
40	20
50	40

10. A 23-year-old person came with a history of difficulty in seeing distant objects. On retinoscopy (at 1m), the following measurements were noted in both eyes. Determine the type of refractive error and its value. (1+2 marks)



Type of Refractive Error

Both eyes have a retinoscopy value of more than –1. So, there is myopia in both eyes.

Value of refractive Error

- *Value of refractive error in the right eye:* –2.5 – 1.0 in both horizontal and vertical meridian = –3.5D
- *Value of refractive error in the left eye:* –1.25 – 1.0 in both horizontal and vertical meridian = –2.25D

COMPETENCY

OP1.4 ENUMERATE THE INDICATIONS AND DESCRIBE THE PRINCIPLES OF REFRACTIVE SURGERY

LONG ESSAY

1. A 20-year-old patient with –9DS in the right eye and –8.5DS in the left eye wants to get rid of her spectacles.

A. Name two refractive surgeries that can be useful in this patient. (2 marks)
B. Classify various corneal and lenticular refractive procedures. (5 marks)
C. Explain the role of femtosecond LASER in refractive surgeries. (3 marks)

A. Refractive Surgeries that can be Useful

1. Photorefractive keratectomy
2. Laser-assisted *in situ* keratomileusis (LASIK)

B. Classification of Refractive Procedures

Corneal procedures/keratorefractive procedures	Lens-based procedures
Incisional • Radial keratotomy • Astigmatic keratotomy • Arcuate keratotomy • Limbal relaxing incisions • Hexagonal keratotomy	Phakic • Anterior chamber • Iris fixated or Worst Iris claw lens • Posterior chamber phakic IOLs
Excimer LASER • Surface ablation ▪ Photorefractive keratectomy ▪ Laser subepithelail keratomileusis ▪ Epipolis LASIK • Lamellar ▪ Laser *in situ* keratomileusis ▪ Femtosecond LASIK ▪ SMILE	Pseudophakic • Refractive lens exchange with multifocal/ toric IOL or accommodating IOL
Non-LASER lamellar • Intracorneal ring segments Collagen shrinkage • Conductive keratoplasty • LASER thermokeratoplasty	Combined (Corneal and lenticular) • Bioptics

C. Role of Femtosecond LASER in Refractive Surgeries

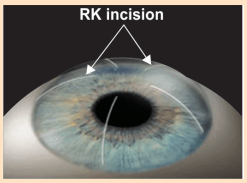
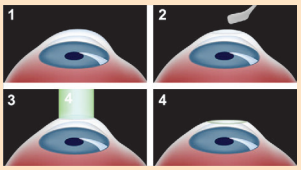
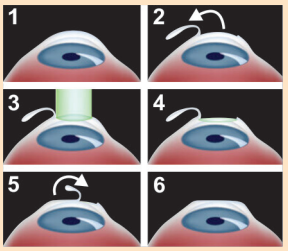
- Femtosecond LASER is an infrared laser and acts by photo disruption
- It is also called 'ultrafast LASER' as the wavelength is 10^{-15} m

- As a result, the energy delivered is much lesser with higher precision. There is lesser damage to the surrounding tissues
- Their uses in refractive surgeries are:
  1. In conventional LASIK, the corneal flap is created using a microkeratome. In femtosecond LASER-assisted LASIK, the flap is raised using LASER. Thus, it is a more delicate process
  2. Channel creation for intrastromal ring segments
  3. Astigmatic keratotomy
  4. Small incision lenticule extraction
  5. Intrastromal presbyopia correction

SHORT ESSAYS

1. Compare and contrast radial keratotomy, photorefractive keratectomy, and LASIK for correction of myopia. (5 marks)

Comparison of Radial Keratotomy, Photorefractive Keratectomy, and LASIK

Feature	Radial keratotomy (Fig. 1.4.1)	Photorefractive keratectomy (Fig. 1.4.2)	LASIK (Fig. 1.4.3)
Type of procedure	It is an incisional technique	Surface laser ablation	Lamellar laser ablation
Principle	Radial incisions are made up to 90% thickness of the cornea leaving a central 4 mm of the clear cornea. When these incisions heal by scarring, they flatten the cornea	The cornea is de-epithelialized and LASER ablation is done in the central part of the cornea that causes corneal flattening and thus correction of myopia	A superficial flap of the cornea (epithelium, basement membrane + superficial stroma) is raised with the help of a microkeratome or femtosecond LASER. The corneal bed is ablated and the flap is reposited
	 **Fig. 1.4.1:** Radial keratotomy	 **Fig. 1.4.2:** Photorefractive keratectomy	 **Fig. 1.4.3:** LASIK
Present-day use	It was a breakthrough in the early 80s, in which many myopic eyes were corrected with this procedure. It is obsolete now	Useful in thin corneas where LASIK is contraindicated Useful in the scarred cornea, epithelial basement membrane dystrophies, and people involved in contact sports	Most commonly used in the present day Novel improvements like epi-LASIK, wavefront-guided LASIK are gaining more importance
Range of myopia	Low range of myopia	Up to –14D	Up to –14D

Contd.

Feature	Radial keratotomy (Fig. 1.4.1)	Photorefractive keratectomy (Fig. 1.4.2)	LASIK (Fig. 1.4.3)
Disadvantages	• Diurnal variation of power due to increase in thickness in waking hours • Hypermetropic shift • Glare • Cornea is weakened • Can correct only low grades of myopia	• Central corneal haze and delayed healing	• Overcorrection can occur if the wound healing is delayed • Under-correction if wounds heal quickly • Decentered ablation • Flap dislocation • Dry eye due to injury to corneal nerves • Infectious keratitis • Keratectasia

2. Explain the indications, principles, and the procedure of LASIK.

(1 + 1 + 3 marks)

LASIK

Indications

1. Myopia up to –14D
2. Hypermetropia up to +6D
3. Astigmatism up to 5D
4. Presbyopia: Monovision LASIK, presbyopia bifocal LASIK

Principle

- A superficial flap of the cornea (epithelium, basement membrane + superficial stroma) is raised with the help of a microkeratome or Femtosecond LASER
- The corneal bed is ablated and the flap is reposited

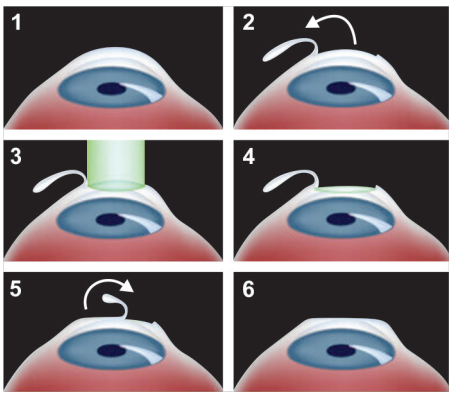


Fig. 1.4.4: LASIK procedure

Procedure (Fig 1.4.4)

- After a thorough examination to rule out contraindications for LASIK, and stable refraction for a year, the patient is taken up for LASIK procedure
- The amount of tissue to be ablated is calculated before the procedure based on the Munnerlyn formula

$$\text{Ablation depth} = \frac{\text{Diopter of myopia} \times (\text{Optical diameter})^2}{3}$$

- Topical anesthesia is applied, and the patient is instructed to view at a fixation light and to remain still
- A suction ring is applied, and the microkeratome creates a flap of the superficial cornea. The motor of the microkeratome oscillates the blade at the rate of 6000 cycles per minute
- Instead of microkeratome, femtosecond LASER can be used to create the flap

- The stromal bed is ablated with excimer LASER and then the flap is reposited and a bandage contact lens is placed
- The patient is started on topical antibiotics and steroids

3. Describe the refractive surgeries available for hypermetropia. (5 marks)

1. **Hyperopic LASIK**
   - The procedure of LASIK is similar to that performed for myopia: After calculation of the amount of tissue to be ablated, the flap is created using a microkeratome or femtosecond LASER
   - The mid-peripheral cornea is ablated using Excimer LASER to create steepening of the central cornea thus causing a myopic shift in refraction (Fig. 1.4.5)
2. **Hyperopic PRK**
   - The cornea is de-epithelialized and LASER ablation is done in the mid-peripheral part of the cornea that causes central corneal steepening and thus correction of hyperopia
3. **Refractive lens exchange**
   - This method is reserved for very high degrees of hypermetropia
   - It is a cataract surgery before the development of the cataract. The clear lens is extracted through small incisions created at the cornea or limbus and an appropriate IOL is placed in the posterior capsular bag

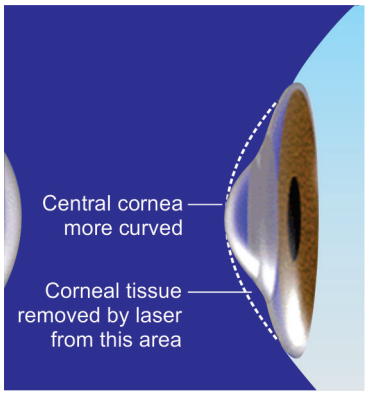


Fig. 1.4.5: Hyperopic LASIK

4. **Phakic intraocular lens**
   - In this procedure, an intraocular lens is placed in the posterior chamber (PC-PIOL), anterior chamber (AC-PIOL), or iris-claw lenses are used
   - This procedure demands a minimum depth of anterior chamber of 3 mm at the center and a healthy endothelium
5. **Holmium LASER thermoplasty**
   - The Ho:Yag LASER produces light in the infrared region and is used to cause heat production
   - When applied to the cornea, the heat generated by the tissues causes shrinkage and thus alters the shape of the cornea
   - These burns are applied in the mid-periphery and thus cause central steepening. This method has become obsolete now
6. **Conductive keratoplasty**
   - Galvanic current is used to flatten the mid-peripheral cornea
   - As a result, the central cornea is steepened

4. A 50-year-old actress has presbyopia and does not want to wear glasses. She requests refractive surgery for the same. Describe the refractive surgeries that you can offer her. (5 marks)

Treatment of presbyopia can be given as monovision or binocular procedures

A. Monovision

There is no binocularity following these techniques

1. **Monovision conductive keratoplasty**
   - In this technique, galvanic current is applied in the mid-periphery of the cornea to cause central corneal steepening
   - Thus one eye becomes slightly more myopic and presbyopia is corrected
2. **Monovision LASIK**
   - One eye is corrected for distance vision and the other is corrected for near vision
3. **Monovision with IOL**
   - Clear lens extraction with myopic correction in one eye and hyperopic correction in the other is the principle of this procedure

B. Binocular Surgeries

1. **Bifocal LASIK or LASIK PARM**
   - This is also called the Avalos technique
   - Here the cornea is ablated in such a way that there are two concentric zones: One for distance vision and the other for near vision
   - The central cornea is flatter, and the mid-peripheral cornea is steeper
   - Central presbyLASIK is a method in which the central cornea is steepened, and the mid-peripheral cornea is ablated for distance (Fig. 1.4.6)

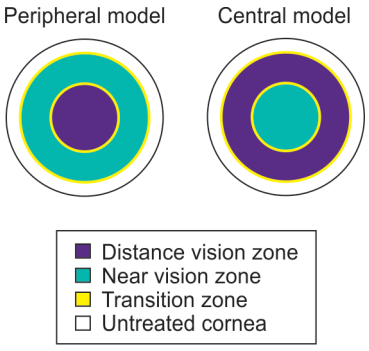


Fig. 1.4.6: Bifocal LASIK

2. **Multifocal LASIK**
   - Based on a similar principle as multifocal IOLs, the cornea is divided into several concentric zones of varying power. The central zone is meant for near vision
3. **Multifocal or accommodating IOL**
   - Clear lens extraction is followed by implantation of a multifocal or accommodating IOL
4. **Corneal inlays**
   - A pocket is created in the superficial cornea using Femtosecond LASER and intra-corneal rings are placed
   - These rings help to converge the divergent rays and thus help in presbyopia

SHORT ANSWERS

1. This Indian Scientist based in the USA discovered excimer LASER. Identify him.

Describe the principle of excimer laser in refractive surgeries. (1+2 marks)

Given Scientist

Rangaswamy Srinivasan discovered the use of Excimer laser in re-shaping the cornea.

Principle of Excimer Laser

- The word 'excimer' is derived from the combination of two words: excited dimer. The dimer is made of a noble gas such as argon or helium combined with a halogen (ArF, HeBr)
- It has a wavelength of 193 µm and lies in a high ultraviolet ray range

- It cannot pass through the cornea and thus is safe to the eye. Also, it is non-mutagenic
- This LASER acts by breaking the chemical bonds between the tissue, a process known as photoablation
- They break the carbon-carbon and carbon-nitrogen bonds that form the backbone of the collagen framework
- This property is used to re-mold the shape of the cornea to achieve the desired refractive outcome
- Properties of excimer that make it suitable for refractive surgeries:
  1. High precision, low collateral damage
  2. Low penetrability
  3. Non-mutagenicity

2. Explain the procedure of SMILE or small incision lenticule extraction. (3 marks)

- Small incision lenticule extraction or SMILE is also called as ReLex (refractive lenticule extraction) (Fig. 1.4.7)
- It is a relatively new, Femto-assisted, minimally invasive refractive surgery
- In this technique, after the calculation of lenticule to be removed, the lower interface of the lenticule is created first
- Followed by this, the upper interface or the 'cap' of the lenticule is created

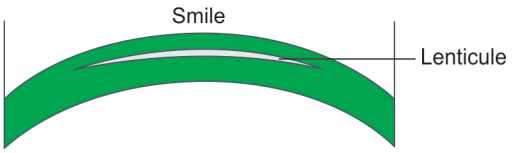


Fig. 1.4.7: Procedure of SMILE

- Then, a superotemporal 2–3 mm long tunnel incision is made to connect the lenticule to the surface of the cornea
- Then the patient is moved to the surgical microscope and the lenticule is extracted with the help of retinal micro-forceps

3. Define corneal topography. Enumerate two indications for the same. (3 marks)

Corneal Topography

Definition

- Study of the surface of the cornea
- It is a computer-assisted tool that gives a three-dimensional color-coded curvatural map of the cornea

Indications

1. Before performing a refractive surgery
2. Diagnosis and follow-up of keratoconus

4. Enumerate six complications related to LASIK. (3 marks)

Complications of LASIK

1. Microkeratome-related complications: The creation of free flap, too thin flap, buttonholing of flap
2. Flap folds or striae
3. Infectious keratitis
4. Traumatic flap dislocation
5. Diffuse lamellar keratitis
6. Post-LASIK ectasia

5. Describe the technique of arcuate keratotomy. (3 marks)

Arcuate Keratotomy

- It is an incisional technique that was used previously for the correction of astigmatism.
- Presently, it finds its use in the correction of post-keratoplasty astigmatism
- It is based on the principle of coupling: When one meridian of the cornea is flattened, the other meridian that is perpendicular to the former becomes steep (Fig. 1.4.8)
- In this technique, after applying topical anesthesia, a diamond blade is used to make 95% depth arcuate incisions in the steep meridian in the mid-peripheral cornea
- The length, depth, and site of the incision determine the amount of correction
- Longer, deeper, and more central the incision, the greater is the astigmatism correction

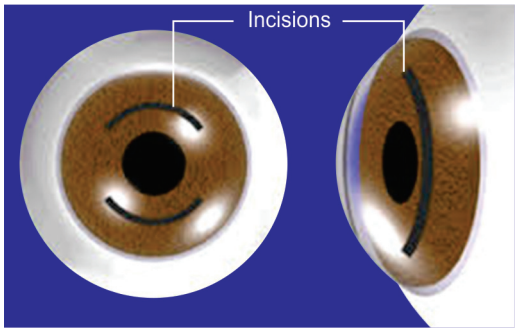


Fig 1.4.8: Arcuate keratotomy

6. What are intrastromal ring segments? List two advantages and disadvantages over LASIK. (2+1 marks)

Intracorneal Ring Segments

- These are PMMA rings that are placed in the mid-peripheral cornea
- They act by displacing the central lamellar bundles and cause central flattening

Advantages

1. No flap related complications
2. Reversible
3. Useful in thin corneas

Disadvantages

1. Can correct only low grades of myopia
2. Can induce astigmatism

7. Enumerate the mechanisms of LASER in refractive surgery with examples. (3 marks)

Type of tissue interaction	Mechanism	Clinical utility
Photoablation	Breaks chemical bonds using LASER	Excimer LASER used for photorefractive keratectomy LASIK (wavelength 193 µm)
Photodisruption	Tissue is transformed into plasma	Femtosecond LASER (wavelength 1053 µm)
Photothermal effect	LASER is absorbed by tissue releasing heat which causes collagen shrinkage	Holmium:YAG used in thermoplasty

8. Enumerate three refractive surgeries available for astigmatism. (3 marks)

1. **Incisional techniques**
   - Arcuate keratotomy
   - Limbal relaxing incision
2. **LASER assisted**
   - Astigmatic LASIK
3. **Intraocular surgery**
   - Lens extraction with toric IOL

COMPETENCY

OP1.5 DEFINE, ENUMERATE THE TYPES AND THE MECHANISM BY WHICH STRABISMUS LEADS TO AMBLYOPIA

SHORT ESSAYS

1. Define amblyopia. Explain its types. (1+4 marks)

Amblopia

Definition

- A reduction in the best-corrected visual acuity of one or both eyes that cannot be attributed to a particular structural abnormality of the eye
- Clinically it is defined as visual acuity of 6/12 in both eyes or a difference of 2 Snellen lines between the two eyes.

Types

1. **Stimulation deprivation amblyopia**
   - Was called "amblyopia ex anopsia"
   - Due to pathology of ocular media in formative years
   - Congenital cataract
   - Corneal opacity
   - Severe ptosis
2. **Anisometropic amblyopia**
   - Due to a difference in refractive error, which remains uncorrected
   - Myopia: >4D (less common)
   - Hypermetropia: 1–2D (more common)
3. **Ametropic amblyopia**
   - Bilateral uncorrected refractive error
   - Bilateral hypermetropia >5D and myopia >8D causes amblyopia
4. **Strabismic amblyopia**
   - Uniocular amblyopia in the squinting eye
5. **Meridional amblyopia**
   - High degrees of astigmatism in one or both eyes remain uncorrected.
   - Unilateral astigmatism >1.5D and bilateral astigmatism >2.5D causes meridional amblyopia.

2. Explain stimulation deprivation amblyopia. Give 4 causes for the same.
(1+4 marks)

Stimulation Deprivation Amblyopia

- Condition in which one or both eyes have a reduction in visual acuity due to a pathology that blocks the entry of light into the eye and thus prevents the 'stimulation' of the retina for normal development of the visual system in the amblyogenic period, i.e., 6 weeks after birth to 5 years (Fig. 1.5.1)
- It is more severe when unilateral and occurs at the age of 6 weeks to 18 months. This period is termed the critical period of visual development
- Thus, even if the cause for visual deprivation is corrected after the amblyogenic period, the vision is not regained
- Stimulation deprivation causes significant anatomical changes at the cortical level and is the most severe of all forms

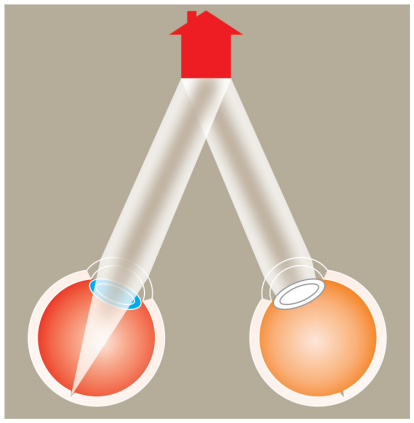


Fig. 1.5.1: Mechanism of stimulation deprivation amblyopia

Causes

1. Corneal opacities and cloudiness are congenital or acquired at a very young age
2. Congenital cataract
3. Ocular trauma leading to corneal or lenticular opacity
4. Congenital ptosis that covers the pupil
5. Nystagmus disorders that prevent foveation
6. Congenital retinal disorders

3. A 3-month-old child is diagnosed to have a unilateral central congenital cataract. Her parents want to wait until she turns one year of age as they feel the child is too young for surgery.

A. Explain the consequences of waiting for more time concerning visual acuity? (2 marks)

B. Enumerate the clinical features of this condition. (3 marks)

A. Consequences of Waiting for More Time Concerning Visual Acuity

- In this case, the child has a unilateral cataract, which is central
- As a result, the number of light rays entering the eye is decreased
- There is a high chance of developing stimulation deprivation amblyopia
- As the parents want to wait for a longer time, it is advisable to counsel parents in such cases regarding the development of amblyopia, especially as the cataract is unilateral
- Even if the child undergoes cataract extraction at a later date, a certain amount of amblyopia might have already set in and thus the postoperative best-corrected visual acuity is expected to be lower than usual
- This will affect the binocularity of the child

B. Clinical Features of Amblyopia

- Visual acuity is reduced
- It does not improve even after the offending factor is removed/corrected. In this case, congenital cataract
- Recognition acuity is more affected than resolution acuity

- Visual acuity when tested through a neutral density filter improves by one or two lines in amblyopia, in contrast to organic lesions
- Crowding phenomenon: Visual acuity is better when single letters are presented
- The fixation pattern may be central or eccentric
  - The degree of amblyopia in eccentric fixation is proportionate to the distance of the eccentric point from the fovea
  - In simple terms, amblyopia tends to more severe in a larger degree of squint

4. Explain the principles of treatment of amblyopia. (5 marks)

- Most of the treatment patterns have been adopted following the PEDIG (Pediatric Eye Diseases Investigator Group) study
- During the critical period, the steps in correction or treatment of amblyopia are:
  1. Removal of the offending agent like congenital cataract, corneal opacity, correction of squint, or correction of refractive error
  2. This is followed by increasing the use of the amblyopic eye by either occluding the healthy eye or causing cycloplegia for a limited number of hours per day. The "lazy eye" is put to use by restricting the use of the other eye by various mechanical and pharmacological methods
     - Patching or occlusion: This can be accomplished by using an adhesive patch or tape across the eye. Using ground glass spectacles is another method
     - Atropinization is the use of atropine in the sound eye so that there is cycloplegia and the child is forced to use the amblyopic eye. Studies have found occlusion to bring better results
  3. The occlusion can be done full-time or part-time (4–6 hours per day) and both are equally effective
     - However, the latter is preferred to prevent occlusion amblyopia in the sound eye
     - During the occlusion period, the child is made to have both outdoor and near vision work
     - The schedule is patching amblyopic eye: Sound eye in the number of days is given below:

<2 years	2:1
3 years	3:1
4 years	4:1
5 years	5:1

  4. Pharmacological manipulation using citicoline, levodopa-carbidopa have been found to generate new visual circuits and have found good results

SHORT ANSWERS

1. Define the following terms. (1 marks each)

A. Crowding phenomenon
B. Meridional amblyopia
C. Eccentric fixation

A. Crowding Phenomenon

- Visual acuity is better when tested with a chart that has single letters as opposed to the regular Snellen's chart
- This is characteristic of amblyopia

B. Meridional Amblyopia

- When there is a high degree of astigmatism that remains uncorrected, usually more than 1.5D in unilateral cases and more than 2.5D in bilateral cases

C. Eccentric Fixation

- When an extrafoveal point (a point on the retina outside the fovea) takes up fixation due to strabismus, it is called eccentric fixation.
- It is a mechanism to avoid confusion and diplopia

2. How does strabismus lead to amblyopia? (3 marks)

- In squint or strabismus, there is a loss of parallelism of eyes
- As a result, the images formed from both eyes are different
- This causes either confusion or diplopia
- More than diplopia, it is the confusion that causes a decreased response from one retina and this inhibition occurs at the level of the cortex when the strabismus is long-standing, and the eye is still in amblyogenic age
- In such a condition, the brain is capable of restructuring visual circuits that in turn lead to amblyopia
- The eye that is squinting will be suppressed as the image that is exactly in line with the visual axis (as in the straight eye) is chosen as the correct image based on feedback mechanisms by the brain
- Hence, this leads to amblyopia

3. Demonstrate the understanding of the term suppression with diagram. (3 marks)

- Suppression is a phenomenon characterized by temporary active cortical inhibition of images from the squinting eye
- It is seen when both eyes are open. When the nonsquinting eye is occluded, the squinting eye takes up fixation and suppression disappears
- It is due to two different objects projected onto the visual cortex from two eyes. Suppression is an effort to avoid confusion
- The mechanism is eccentric fixation (Fig. 1.5.2)
- Clinically suppression can be tested using the Worth 4 dot test, 4PD base out prism test, and a synoptophore

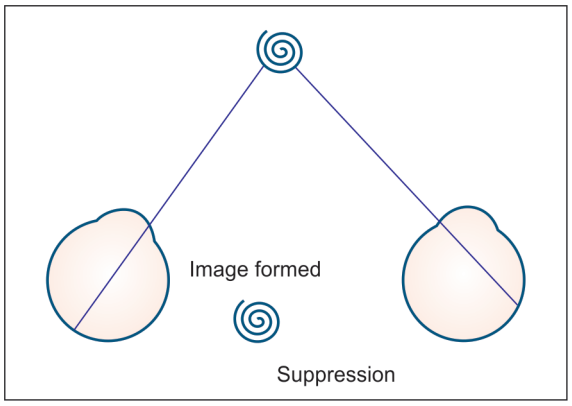


Fig. 1.5.2: Suppression with eccentric fixation

4. Describe occlusion therapy in amblyopia. (3 marks)

- The principle of occlusion therapy is increasing the use of the amblyopic eye by occluding the healthy eye for a limited number of hours per day
- The "lazy eye" is put to use by restricting the use of the other eye by various mechanical methods

- Patching or occlusion: This can be accomplished by using an adhesive patch or tape across the eye. Using ground glass spectacles is another method
- The occlusion can be done full-time or part-time (4–6 hours per day) and both are equally effective. However, the latter is preferred to prevent occlusion amblyopia in the sound eye
- During the occlusion period, the child is made to have both distance and near work
- The schedule is patching amblyopic eye: Sound eye in the number of days is given below:

< 2 years	2:1
3 years	3:1
4 years	4:1
5 years	5:1
6 years	6:1

Prognosis with Occlusion

- Occlusion is the best form of treatment at present when compared to penalization (use of atropine) or pleoptics
- Better results are found in children less than 7 years of age, although improvement has been found until 13 years of age
- Results are better if the visual acuity is good, to begin with, and thus the duration of treatment required is also less
- If there is no clinical improvement in 6 months, there is probably no further improvement expected

5. A 3-year-old child has visual acuity of 6/6 in her right eye, and 6/36 in the left eye. On performing retinoscopy, there is a refractive error of +4D in the left eye. Visual acuity is correctable to 6/18 with respective corrections.

A. State the type of amblyopia in this child. (1 mark)

B. Explain the regimen of occlusion therapy for this child. (2 marks)

A. Type of Amblyopia

This child has anisometropic amblyopia in the left eye.

B. Regimen of Occlusion Therapy

- Since the child is 3 years old, she needs occlusion of the right eye for 2 hours per day for 3 days followed by occlusion of the left eye for 2 hours for one day (3:1)
- During the period of occlusion, the child is made to do activities that engage her in distant and near vision. This is continued for around 6 months, by when improvement is expected

SHORT ESSAYS (MISCELLANEOUS)

1. Describe Listing's reduced eye and its features. Explain its use in ophthalmology. (3+2 marks)

Listing's Reduced Eye

Listing came up with reduced eye with only 4 cardinal points (Fig. 1.M.1).

Anterior focal point	15.7 mm in front of the anterior surface of the cornea
Posterior focal point	24.4 mm behind the anterior surface of the cornea
Principal point	1.5 mm behind the anterior surface of the cornea
Nodal point	7.2 mm behind the anterior surface of the cornea (posterior capsule of the lens)
Anterior focal length	15.7 mm + 1.5 mm = 17.2 mm
Posterior focal point	24.4 mm –1.5 mm = 22.9 mm

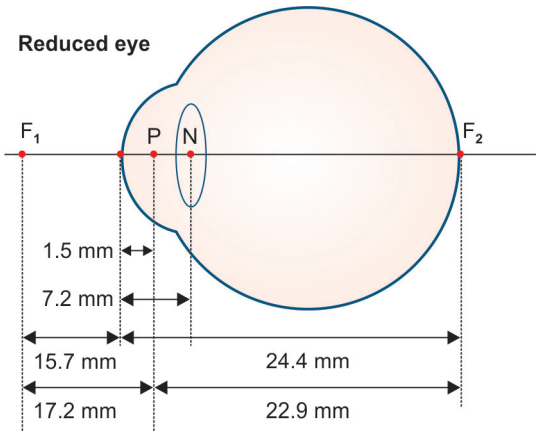


Fig. 1.M.1: Listing's reduced eye

Use in Ophthalmology

1. The concept of the reduced eye helps to understand the optics of various refractive errors like myopia, hypermetropia, and astigmatism
2. By using these points, the total power of the eye could be calculated
   Power of eye = refractive index of air/anterior focal length in meters
   = 1 × 1000/17.2 = 58.2D
3. Helps to understand the visual angle and the retinal image in various situations

2. Enumerate various angles and axes of the eye as an optical system.

(1.5+1.5 marks)

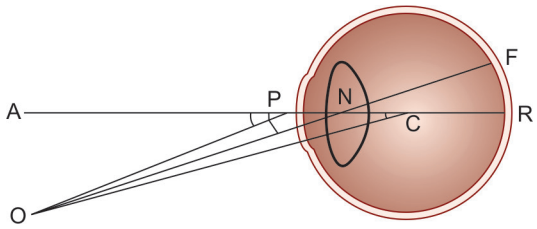


Fig 1.M.2: various angles of the eye

Angle and Axes of the eye (Fig 1.M.2)

Optical axis	AR	An imaginary line passing through the centre of the cornea, the centre of the lens and then meets the retina nasal to the macula
Visual axis	ONF	An imaginary line passing from the object of interest, nodal point, and the fovea
Fixation axis	OC	An imaginary line joining fixation point and the centre of rotation
Angle alpha	ONA	The angle between the optical axis and visual axis at the nodal point

Contd.

Angle kappa	OCA	The angle between the optical axis (AR) and fixation axis (OC) at the center of rotation of the eyeball
Angle gamma	OPA	The angle between the visual axis (OF) and pupillary line (AP). It is the only measurable parameter Positive angle kappa results in pseudo-exotropia (very high hypermetropia) Negative angle kappa results in pseudo-esotropia (very high myopia)

3. Explain the uses of prisms in ophthalmology. (3 marks)

- Prisms are of great use in ophthalmology
- It is a refracting medium with two surfaces that meet at an angle
- It has an apex and a base (square)
- The angle of the prism is the angle between the two refracting surfaces

Uses in Ophthalmology

1. Measurement of squint
   - Used to detect the amount of squint, to treat small degrees of squint by using a prism bar
   - The prism bar is made of increasing strengths of prisms attached in the form of a bar
   - Light reflex in the cornea is used to assess the amount of squint by placing the prism in front of the deviating eye
2. To detect malingerers by inducing diplopia:
   - A vertical prism of high strength is placed in front of one eye and light is shone
   - If the patient sees two lights, then he is malingering
   - It is a simple and objective test
3. To diagnose and measure fusional reserve in microtropia
   - A 4PD prism is used to detect a very small amount of squint
4. In ophthalmic microscopes, gonioscope, applanation tonometers, and keratometer, prisms are used
5. To eliminate diplopia in reversible and irreparable causes of diplopia, prisms are used. Also, they are used in develop fusional reserve
6. It can be prescribed as a low vision aid for patients with tubular vision or decreased visual field like advanced glaucoma, retinitis pigmentosa, hemianopia where the movements of the eye should be limited

4. Describe various optical aberrations of the eye. (3 marks)

Optical Aberrations of the Eye

1. **Diffraction**
   - When light passes through a small aperture, the light rays produce alternating bands of light and dark bands due to the bending of light rays
   - When the pupil is less than 2 mm, diffraction is highest
2. **Spherical aberrations**
   - It occurs because the spherical lens refracts peripheral rays more strongly than paraxial rays which in the case of a convex lens brings the more peripheral rays to focus closer to the lens (Fig 1.M.3)
   - They present as halos around objects
   - Physiologically, spherical aberrations are kept minimum due to the following factors
     - Pupil size between 3–5 mm. It increases with pupil size

- The Refractive index of the center of the lens is higher than at the periphery
  - Spherical aberrations increase after surface ablation and LASIK, for myopia and hyperopia. It is dependent on the size of the pupil

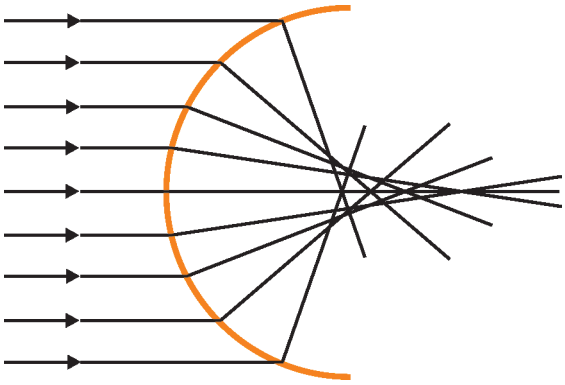


Fig. 1.M.3: mechanism of spherical aberration

3. **Chromatic Aberration**
   - The blue light is focused anteriorly compared to the red light
   - As a result, an emmetropic eye is slightly myopic to blue light and hypermetropic to red light
   - It forms the basis of the duochrome test which is performed at the end of subjective refraction
   - If the patient sees the green light more clearly, either my myopia is over-corrected or my hyperopia is under-corrected
   - If he sees red light more clearly, the inverse is true
   - A myopic should never be over-corrected and a hypermetropic should be fully corrected

5. Describe the etiology, clinical features, and management of anisometropia. (1+2+2 marks)

Anisometropia

- It is a condition in which both eyes have different refractive powers
- It is clinically defined as a difference of more than 2.5D is taken as anisometropia, as up to 2.5D can be tolerated by the cortex
- Up to 4D can be tolerated based on individuals, more than 4D cannot be tolerated

Etiology

- It can be congenital, i.e., if the growth of either eye has different rates, there will be resultant anisometropia
- Acquired anisometropia is following cataract extraction if the eye is left aphakic or an IOL of a wrong power is placed

Clinical Features

- In anisometropia, binocularity is at stake. As a result, stereopsis is compromised
- If one eye has very low vision compared to the other, the fellow eye is used as the fixing eye and the eye with lower vision becomes amblyopic
- If one eye is myopic and the other is hypermetropic, there is alternate vision

Management

- Spectacles for lower degrees of anisometropia, as there will be associated minification/magnification which can lead to aniseikonia
- Contact lenses are advised for higher degrees of anisometropia
- Refractive surgeries for the affected eye/eyes