Optics & Eye

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AP Ophthalmology

KGMC, HMC

objectives

- Discuss visual functions(visual acuity, color vision, contrast sensitivity, light brightness).

- Discuss refraction, aphakia, pseudophakia and anisometropia.

Optics of the eye

- Light rays enter the eye through the clear cornea, pupil and lens.

- These light rays are focused directly onto the retina, the light-sensitive tissue lining the back of the eye.

- The retina converts light rays into impulses, sent through the optic nerve to the brain, where they are recognized as images.

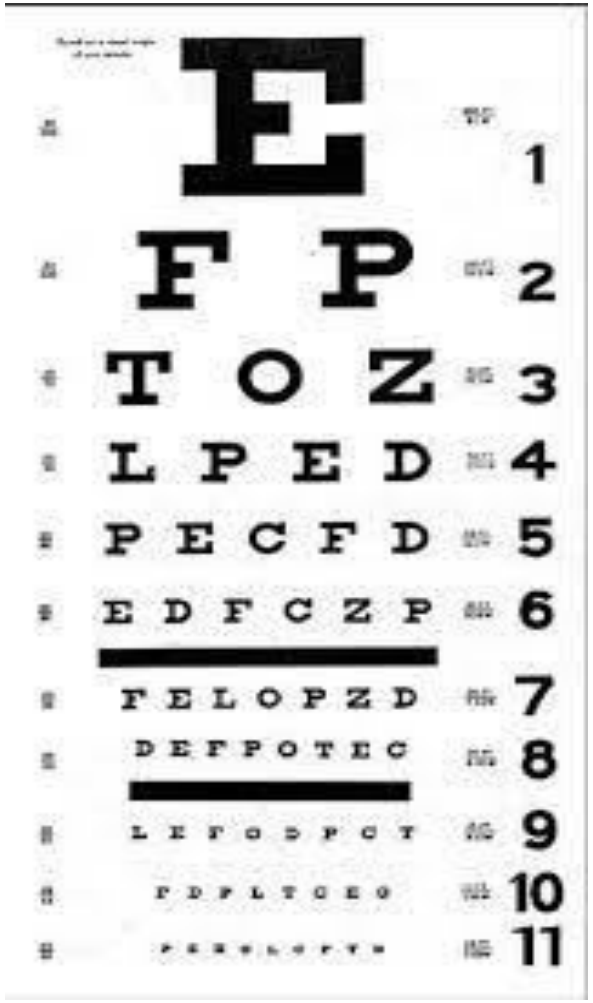
- 70% of the eye's focusing power comes from the cornea and 30% from the lens.

Visual acuity

- Visual acuity (VA) is **a measure of the ability of the eye to distinguish shapes and the details of objects at a given distance**.
- It is important to assess VA in a consistent way in order to detect any changes in vision.
- One eye is tested at a time.

Test for Visual acuity

- **Snellen visual acuity**
  - Distance visual acuity (VA) is directly related to the minimum angle of separation (subtended at the nodal point of the eye) between two objects that allow them to be perceived as distinct.
  - In practice, it is most commonly carried out using a Snellen chart, which utilizes black letters or symbols (optotypes) of a range of sizes set on a white chart with the subject reading the chart from a standard distance.
  - Distance VA is usually first measured using a patient's refractive correction, generally their own glasses or contact lenses.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11

- For completeness, an unaided acuity may also be recorded.
- The eye reported as having worse vision should be tested first, with the other eye occluded.
- It is important to push the patient to read every letter possible on the optotypes being tested.

- Normal monocular VA
  - equal to 6/6 (metric notation; 20/20 in non-metric ‘English’ notation) on Snellen testing.
  - Normal corrected VA in young adults is often superior to 6/6.
- Best-corrected VA (BCVA)
  - denotes the level achieved with optimal refractive correction.

- Pinhole VA:
  - a pinhole (PH) aperture compensates for the effect of refractive errors, and consists of an opaque Occluder perforated by one or more holes of about 1 mm diameter.
  - However, PH acuity in patients with macular disease and posterior lens opacities may be worse than with spectacle correction.
  - If the VA is less than 6/6 Snellen equivalent, testing is repeated using a pinhole aperture.
- Binocular VA
  - usually superior to the better monocular VA of each eye, at least where both eyes have roughly equal vision.

Very poor visual acuity

- Counts (or counting) fingers (CF)
- Hand movements (HM
- Perception of light (PL)

Log MAR acuity

- Log MAR charts address many of the deficiencies of the Snellen chart and are the standard means of VA measurement in research and increasingly in clinical practice.

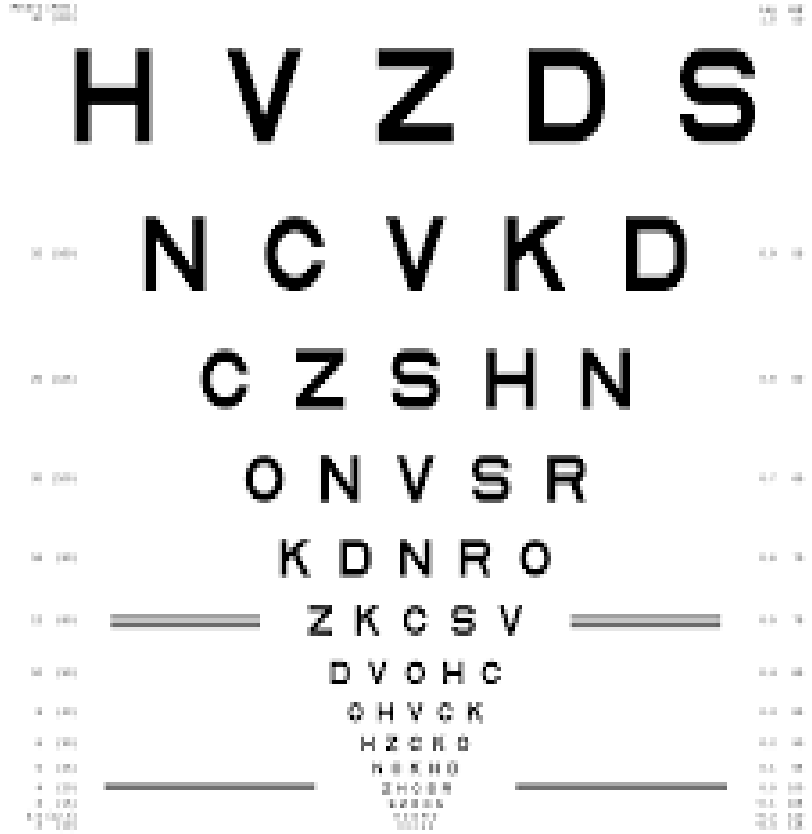
- Log MAR is an acronym for the base-10 logarithm of the minimum angle of resolution, and refers to the ability to resolve the elements of an opto type.

LogMAR charts

- The Bailey–Lovie chart.
  - ✓ Used at 6 m testing distance.
  - ✓ Each line of the chart comprises five letters and the spacing between each letter and each row is related to the width and the height of the letters. A 6/6 letter is 5′ in height by 4′ in width. The distance between two adjacent letters on the same row is equal to the width of a letter from the same row, and the distance between two adjacent rows is the same as the height of a letter from the lower of the two rows.
  - ✓ Snellen VA values and logMAR VA are listed to the right and left of the rows respectively.

- Other charts are available that are calibrated for 4 m. The Early Treatment Diabetic Retinopathy Study (ETDRS) charts utilize balanced rows comprising Sloan optotypes,.

- Computer charts are available that present the various forms of test chart on display screens, including other means of assessment such as contrast sensitivity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N C V K D
C Z S H N
O N V S R
K D N R O
Z K C S V
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Comparison of Snellen and logMAR visual acuity testing

Snellen

- Shorter test time
- More letters on the lower lines introduces an unbalanced 'crowding' effect
- Fewer larger letters reduces accuracy at lower levels of VA
- Variable readability between individual letters
- Lines not balanced with each other for consistency of readability

Log MAR

- Longer test time
- Equal numbers of letters on different lines controls for 'crowding' effect
- Equal numbers of letters on low and higher acuity lines increases accuracy at lower VA
- Similar readability between letters
- Lines balanced for consistency of readability

- 6 m testing distance: longer testing lane (or a mirror) required
- Letter and row spacing not systematic
- Lower accuracy and consistency so relatively unsuitable for research
- Straightforward scoring system
- Easy to use

- 4 m testing distance on many charts: smaller testing lane (or no mirror) required
- Letter and row spacing set to optimize contour interaction
- Higher accuracy and consistency so appropriate for research
- More complex scoring
- Less user-friendly

color vision

- Colour vision is the ability of the eye to discriminate between colours excited by lights of different wavelengths.

- Colour vision is a function of cone .

- Better appreciated in photopic condition

THEORIES OF COLOUR VISION

- TRICHROMATIC THEORY:

- Also called as young - helmholtz theory Thomas Young Helmholtz

- It postulates the existence of three kinds of cones

- Each cone containing a different photopigment and maximally sensitive to one of three primary colours i.e. Red, Green and Blue.

- Human eye can see any colour due to a combination of red, green and blue monochromatic light in different proportions.

- Humans are considered trichromats –

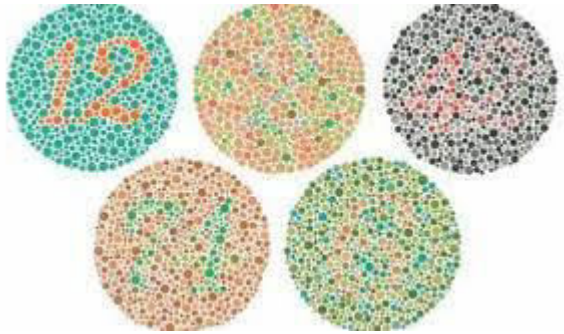
  - Blue, Red, and Green Cone Photoreceptors
  - Rod photoreceptors – are important for vision in dim light

- Colour vision depends on three populations of retinal cones, each with a specific peak sensitivity;
  - blue (tritan) at 414–424 nm,
  - green (deuteran) at 522–539 nm
  - red (protan) at 549–5

- Trichromats possess all three types of cones (although not necessarily functioning perfectly), while absence of one or two types of cones renders an individual a dichromat or monochromat, respectively.

Colour vision tests

- The Ishihara test
- The Hardy–Rand–Rittler test
- The City University test
- The Farnsworth–Munsell 100-hue test



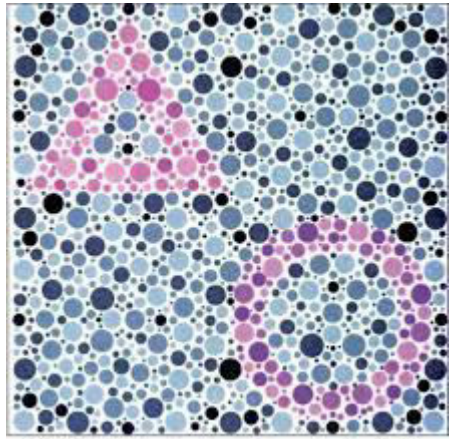


FIGURE 1: A plate from handy-rapidotter pseudoisochromatic test

contrast sensitivity

- Contrast sensitivity is a measure of the ability of the visual system to distinguish an object against its background.

- A target must be sufficiently large to be seen, but must also be of high enough contrast with its background; a light grey letter will be less well seen against a white background than a black letter.

- Contrast sensitivity represents a different aspect of visual function to that tested by the spatial resolution tests such as visual acuity, which use high-contrast optotypes.

- Many conditions reduce both contrast sensitivity and visual acuity, (e.g. amblyopia, optic neuropathy, some cataracts, and higher-order aberrations),
- but under some circumstances visual function measured by contrast sensitivity can be reduced whilst VA is preserved.

- Hence, if patients with good VA complain of visual symptoms (typically evident in low illumination), contrast sensitivity testing may be a useful way of objectively demonstrating a functional deficit.

- Despite its advantages, it has not been widely adopted in clinical practice

Test for contrast sensitivity

- The Pelli–Robson contrast sensitivity letter chart
  - It is viewed at 1 metre and consists of rows of letters of equal size (spatial frequency of 1 cycle per degree) but with decreasing contrast of 0.15 log units for groups of three letters.
  - The patient reads down the rows of letters until the lowest resolvable group of three is reached.
- Sinusoidal (sine wave) gratings
  - require the test subject to view a sequence of increasingly lower contrast gratings

Pelli–Robson contrast sensitivity letter chart

light brightness

- Brightness is **an attribute of visual perception in which a source appears to be radiating or reflecting light.**

Refraction

- A refraction is **an eye exam that measures a person's prescription for eyeglasses or contact lenses**.

- Normal vision occurs when light is focused directly on the retina rather than in front or behind it.

Aphakia

- Absence of crystalline lens.

- Lens is absent from the pupillary line and does not take part in refraction.

CAUSES

- Congenital absence of lens.
- Surgical aphakia.
- Aphakia due to absorption of lens matter.
- Traumatic extrusion of lens.
- Posterior dislocation of lens.

Sign and symptoms of aphakia

- Blurred vision.
- Problems seeing things that are close and far away.
- Problems seeing the brightness of colours. Colours may seem to be faded. ...
- An iris that jiggles. This is called iridodonesis.
- Problems adjusting to differences in how far away or close something.

Treatment of aphakia

- infants with unilateral aphakia are treated with contact lenses for the first few years of life, after which an IOL can be implanted as a secondary procedure.

- Aphakic glasses are also an option for replacing focusing power, but are very thick, causing distortion.

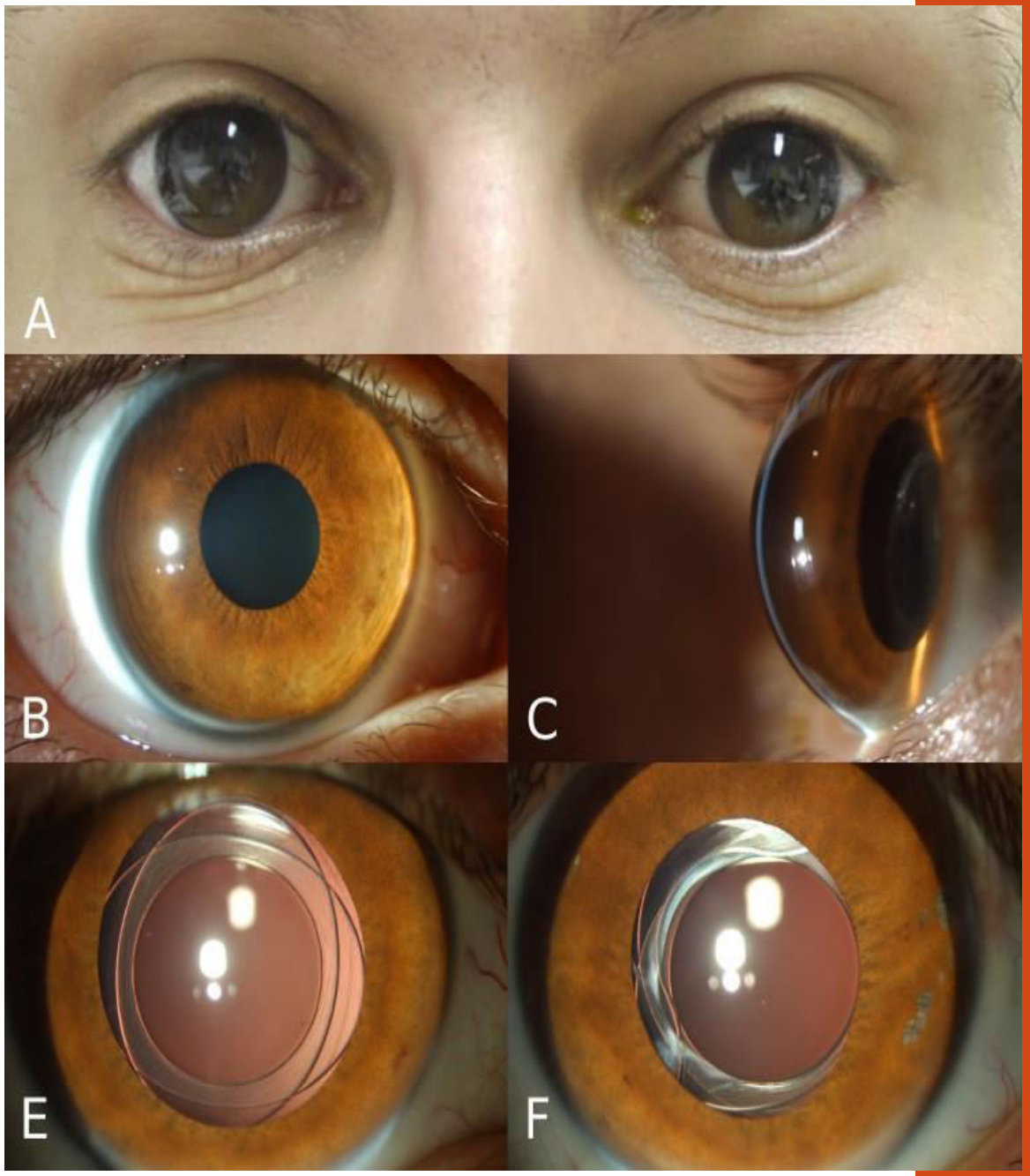
Pseudophakia

- Pseudophakia is a Latin word for **false lens**.

- This term use after placing an artificial lens into the eye. Also known as intraocular IOL, lens implants, or “fake eye lenses,”

- This procedure can significantly improve vision after removing cataracts and replacing them with a new lens

- Pseudophakic lenses can be made of
  - plastic composites,
  - silicone,
  - acrylic material.
- **Types of lenses**
  - Monofocal IOLs:
  - Multifocal IOLs:
  - Accommodative IOLs
  - Toric IOLs:



Anisometropia

- Anisometropia means that **vision in one eye is worse than the vision in the other due to a difference in refractive error.**

types of anisometropia

- There are six clinical types of anisometropia:
  - **Simple;**

    One eye sees normally, while the other is myopic or hypermetropic
  - **Compound;**

    Compound anisometropia: Both eyes are myopic or hypermetropic (also called ametropic
  - **Mixed;**

    One eye is myopic; the other is hypermetropic.
  - **simple astigmatic**
  - **compound astigmatic**
  - **mixed astigmatic.**

Symptoms of anisometropia

- Double vision (dipoplia).
- Blurred vision.
- Headaches.
- Poor depth perception.
- Dizziness.
- Eye pain or discomfort.

- Anisometropia is treated by correcting eyesight through glasses, contact lenses or surgery.

- If a child developed amblyopia (one eye is weaker than the other), the treatments may include forcing the brain to use the weaker eye by:
  - Patching the stronger eye.
  - Using eye drops that blur vision in the stronger eye.
  - Using filtered glasses that block vision in the stronger eye.

Thank you