Ophthalmology 436

Refractive Errors

Objectives : Not given):

Resources: slides, 435 team, 434 team
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[Color index: Important | Notes | Extra] Editing File

❖ Facts:

- 75% of avoidable blindness is due to:
- **Uncorrected refractive error .**
- Cataract .
- Trachoma .
- Blindness due to refractive errors is a substantial public health problem in many parts of the world.

❖ Physiology:

- To have a clear picture in the retina & to be seen in the brain, there should be a clear cornea, clear anterior chamber, and clear lens, clear vitreous cavity then the picture should be focused on the retina with normal refractive index.
- The retina is responsible for the perception of light. It converts light rays into impulses; sent through the optic nerve to your brain, where they are recognized as images.
- Normal refractive power of the eye is 60 diopters. (The cornea accounts for approximately two-thirds of this refractive power (about 40 diopters ثابت) and the crystalline lens contributes the remaining). 60 is the power when we're looking at something far (the lens is relaxed). but when we look at near objects the lens's power increases according to the distance of the object we're looking at.
- The normal axial length is 22.5 mml (it's measured from the tip of the cornea to the surface of the retina).
- If the axial length is longer = the picture will be in front of the retina "**Myopia**".
- If the axial length is shorter = the picture will be behind the retina "**Hyperopia**".

❖ Refraction:

- In optics, refraction occurs when light waves travel from a medium with a given refractive index to a medium with another. At the boundary between the media, the wave's phase velocity is altered, it changes direction.
- The power of the lens is measured by the Diopter (D) The unit of refraction.
- Dioptre = 1 / focal length of a lens.يعني المقلوب حق الطول
- The amount of bend depends on the refractive index of the media and the angle of incidence.
- The refractive index of a medium is defined as the ratio of the phase velocity of a wave light in a reference medium to its velocity in the medium itself.
- For the eye to generate accurate visual information light must be correctly focused on the retina.

❖ The Eyes optical System: very important

- **Cornea**:

1. Main refracting surface (2/3rd the power of the eye, 40 diopter).
2. The power of the cornea is fixed, it reaches its maximum power at the age of 18. That's why it's NOT recommended to do any refractive surgery before age of 18. In children the power is (32 diopter) and it reaches (40 diopter) at age of 18

- At the age of 40 = they will have presbyopia **Power of lens at the age of 60 = 0

- **Lens**:

1. The lens provides 20 diopters (القوة البؤرية)of refractive power.
2. The relaxed lens = 20 diopter. In accommodative stage it can increase the refractive power up to 15d more like in children (with time it becomes less).

❖Accommodation:

- **Helmholtz theory: Viewing a NEAR object (< 6 meters)**

When the eye look at close object → Contraction of ciliary muscle → decrease tension in zonule fibers → elasticity of lens capsule mold lens into spherical shape → greater dioptric power → divergent rays are focused on retina.

contraction of ciliary muscle is supplied by parasympathetic third nerve.

- **Viewing a DISTANT object (≥ 6 meters)**

Relaxed situation: Light rays are coming parallel Accommodation is very relaxed Eye power = 60D (40D + 20D)

- Note:

Power of accommodation is {(15 - age)/4} of the lens.

Accommodation is strong in children.

After prolonged reading there might be ciliary spasm associated headache

More globular shape of lens attained with accommodation

❖ Visual acuity (VA): if you want to check the vital signs of the eye first thing to do is check visual acuity

- VA is the vital sign of the eye and the first thing to do at the clinic with IOP (intraocular pressure).
- To assess the effect of pathology on VA. You must eliminate the effect of refractive error. This is achieved by measuring: the patient's best spectacle correction or viewing the test chart through a pinhole.

The pinhole (picture) is typically a glasses with a hole diameter of about 1 mm to 1.2mm, we tell the patient to focus his sight through the hole, The pinhole will cause muscle spasm, eliminate the mild refractive error of the patient(eliminate other rays, only passes the rays going to fovea. Therefore corrects for about three diopters.! تقريبا مشابه للناس اللي يصغرون عيونهم لما يبون يقروؤن شي When examining the patient you should examine each eye alone (and cover the other eye)

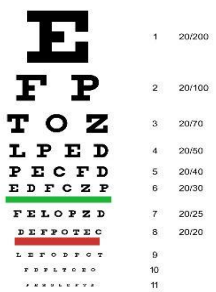
How to test the vision (Test with closed eye):

- Central visual acuity: Display of different –sized targets shown at a standard distance from the eye. (allen's & snellen's chart) always start showing large letters (assuming everyone is blind) and go smaller till normal. 20/20 ft = 6/6 m. (the distance where patient can read/distance where normal population read) After measuring visual acuity do pinhole:
  - If improved 20/20 => means refractive error
  - No improvement => other causes (could be cataract)
  - If improved but 20/80 => both refractive error + other causes.

- In the first 2 months of life: do light objection test (if the baby objecting or closing the eye in response to light it means he/she is seeing)
- From 2 months – 3 years: do follow and fixate test. At this age, babies will start to follow the objects, so bring a toy in front of them and do the test. (If following the toy ------> good vision). OR you can do (central= seeing centrally. Steady= no nystagmus. Maintained= baby is following object & after blinking he/she continues following the same object)
- Age 3 – 6 years: Allen's chart
- More than 6 years: Snellen's chart
- The vision maturation is acquired skill for the brain, so babies when they're first born they will be legally blind.
- The axial length of the eye will grow quickly in the first 6 months. So if anything stops the growing they will have amblyopia (lazy eye) E.g: vitreous hemorrhage, congenital cataract.

Allen's chart

Snellen's chart



Testing poor vision:

- ● If the patient is unable to read the largest letter <20/200 >> Move the patient closer e.g. 5/200
- ● If patient cannot read:

1. 1. Count fingers (CF)
2. 2. Hand motion (HM)
3. 3. Light perception (LP)
4. 4. No light perception (NLP)

● **Legal blindness:** if the vision in the best eye is w/ best correction and providing less than 20/200, this is

The criteria used to determine eligibility for government disability benefits and which do not necessarily indicate a person's ability to function. In the US, the criteria for legal blindness are: * Visual acuity of 20/200 or worse in the better eye with corrective lenses. * Visual field restriction to 20 degrees diameter or less (tunnel vision) in the better eye. Note that the definition of legal blindness differs from country to country and that the criteria listed above are for the US.

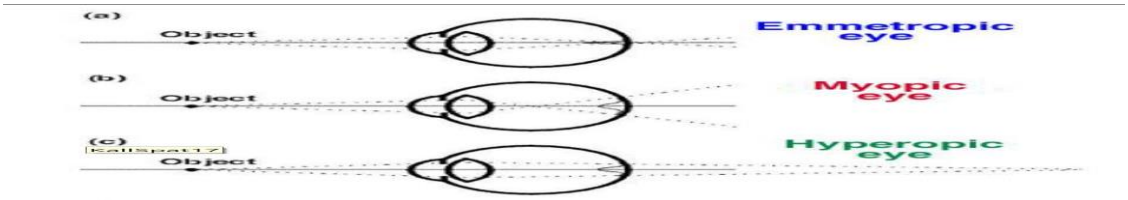
● **Testing near visual acuity**
It is done at a standard working distance ~ 30---40 cm A variety of charts are available

❖ Refractive errors :

- A mismatch between the refractive power and the focusing distance of the eye.
- Inability to see clearly is often caused by refractive errors.
- Three types of refractive errors (Ametropia):
  - **Myopia** (nearsightedness), extra power and long Axial length يشوف القريب أوضح Image infront of the retina
  - **Hyperopia**(farsightedness),less power and short Axial length. Image behind the retina
  - **Astigmatism**.
- **Emmetropia** (normal)
- **Ametropia** = Refractive error

❖Emmetropia:

- Adequate correlation Or matching between axial length and refractive power of the eye.
- Rays of light from a distant object are brought to a pinpoint sharp focus on the retina (no accommodation). All refractive errors are some deviation from emmetropia.



❖ Ametropia:

When parallel rays of light from a distant object are brought to a focus on the retina with the eye at rest (i.e. not accommodating) the refractive state of the eye is known as **emmetropia**. Such an individual can see sharply in the distance without accommodation.

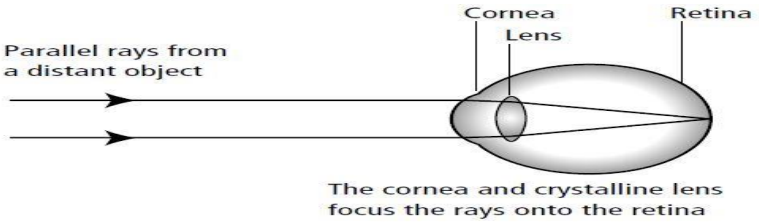
In **Ametropia** , parallel rays of light are not brought to a focus on the retina with the eye at rest. A change in refraction is required to achieve sharp vision.

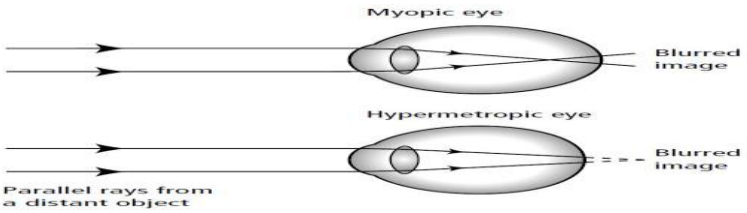
Ametropia may be divided into:

- **Myopia** (short-sightedness): the optical power of the eye is too high (usually due to an elongated globe) and parallel rays of light are brought to a focus in front of the retina.

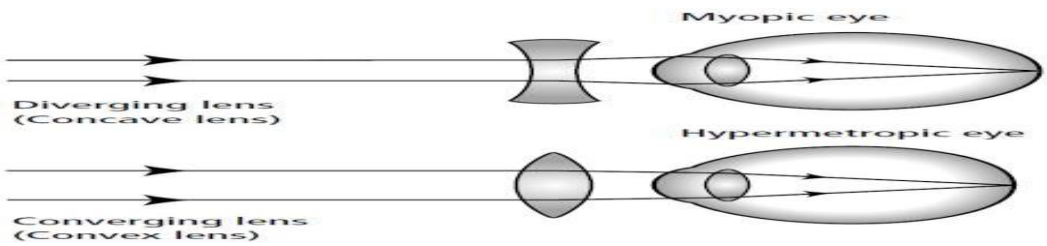
- **Hypermetropia** (long-sightedness):the optical power is too low (usually because the eye is too short) and parallel rays of light converge towards a point behind the retina.

- **Astigmatism**:the optical power of the cornea in different planes is not equal. Parallel rays of light passing through these different planes are brought to different points of focus .





- All three types of Ametropia can be corrected by spectacle lenses.These diverge the rays in myopia, converge the rays in hypermetropia, and correct for the non - spherical shape of the cornea in astigmatism.
- It should be noted that in hypermetropia, accommodative effort will bring distant objects in to focus by increasing the power of the lens. This will use up the accommodative reserve for near objects.



❖Myopia:

- Rays of light from a distant object converge in front of the retina, causing a blurred image on the retina.
- Myopes can see close objects clearly, myopia is commonly known as “nearsightedness”.
- Most prevalent among Asians (80---90%), followed by 25% of African Americans and 13% of Caucasians.
- Average age of onset:8 years and normally stops at 20.
- Etiology: not clear, genetic factors, Acquired (excessive accommodation, near objects, aging) “japanese tend to have myopia more due to their crowded narrow surroundings which requires excessive accommodation”
- Diabetics patients have both myopia and hyperopia depending on the level of the blood sugar high blood sugar > high sugar in aqueous humour > shrink of lens (osmosis) > HYPEROPIA low blood sugar > fluid shift into lens > globular shape > MYOPIA .

❖ Causes of myopia : could be essential or due to secondary causes

➔ Increased refractive power:

- Change in lens nucleus or shape:
  - cataract (thick, hard, high density=high refractive power) spherophakia, diabetes .
- Lens repositioning:
  - ciliary muscle shift e.g. miotics. causes the ciliary muscle to be contracted persistently
  - Lens movement e.g. anterior lens dislocation trauma
- Ciliary muscle tone*: excessive accommodation
  - Medical student: reading a lot at a near distance

➔ Increase corneal power:

- keratoconus (cone shaped) , congenital glaucoma

➔ Increase axial length more common

- congenital glaucoma, posterior staphyloma (bulging of posterior part of thr eye|)

❖ Symptoms:

- Blurred distance vision.
- Squint in an attempt to improve uncorrected visual acuity when gazing into the distance.
- Headache due to eyestrain.

❖ Myopia forms:

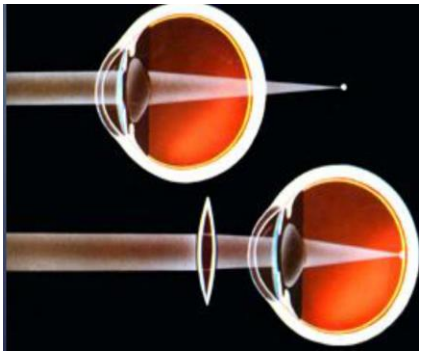
- Benign myopia (school age myopia)
  - Onset 8---12 years,
  - myopia increases until the child stops growing in height
  - Generally tapers off at about 20 years of age
- Progressive or malignant myopia: (also called Degenerative or pathological myopia).
  Myopia increases rapidly each year and is associated with, fluidity of vitreous and chorioretinal change.

❖ **Morphologic eye changes in pathological myopia:** only happens with axial myopia, no changes happen if benign myopia

1. Deep anterior chamber
2. Atrophy of ciliary muscle due to excessive stretching
3. Vitreous may collapse prematurely leading to opacification. Vitreous (gel-like) can no longer fill the whole space, so aqueous fluid (watery) mixes with it cause liquified vitrous (less density)
4. Fundus changes: Loss of pigment in RPE (Retinal pigment epithelium), large disc and white crescent-shaped area on temporal side, RPE atrophy in macular area, posterior staphyloma, and retinal degeneration ------> hole ------> increase risk of RRD (rhegmatogenous retinal detachment). Vision loss كيف يصير ديتاتشمنت؟؟ الريتنا لها حجم مناسب للعين، فلما العين تكبر تبدا الريتنا تتوسع وتصير طبقة خفيفة جدا مثل بالصورة! بالفراغات ويدف liquefied vitreous وتوصل مرحلة انها ما تستحمل التوسع فبتتكون عندنا فراغات مافيها ريتنا! فهنا يدخل ال الريتنا لقدام لما تنفصل!
   Retina is transparent. Red color is from the choroid underlying it.

- Correction of Myopia: (negative) concave lenses. posterior staphyloma

❖Hyperopia:



- Rays of light from a distant object now focus behind the retina.
- Hyperopic people must accommodate when gazing into distance to bring focal point on to the retina
- However, this reduces their accommodative reserve when they want to view close objects. This means their distance vision is generally better than their near vision, hence the term “long- sightedness”

- Etiology: not clear, inherited , trauma may cause dislocation of the lens.

❖ Causes of hyperopia:

- Decreased refractive power of the eye:
  - ■ Absent (aphakia) or posteriorly repositioned lens
  - ■ Weak accommodation: trauma, marijuana (marijuana causes a weak accommodation after using it).
- Decreased effective axial length (retina pushed forward) : tumor orbital mass.

❖ Symptoms:

- Visual acuity at near tends to blur relatively early ‘’inability to read fine print’’
- Asthenopic symptoms: eye pain, headache in frontal region.
- Accommodative esotropia: because accommodation is linked to convergence leading to easotropia.

❖ Correction of hyperopia: (positive) convex lenses.

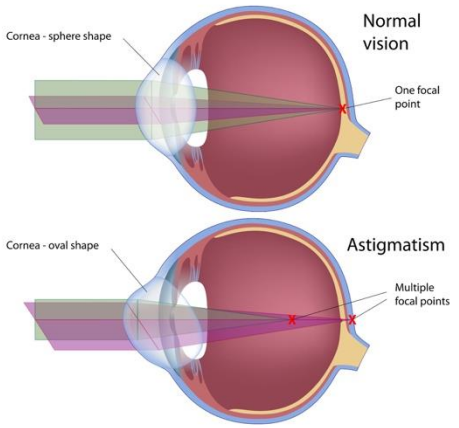
❖ Astigmatism (اللابؤرية):

- Astigmatism is a common and generally treatable imperfection in the curvature of the eye that causes blurred distance and near vision. you may describe it to the patient as " your eye is shaped as a rugby ball instead of a football"
- Astigmatism occurs when either the cornea or the lens, has mismatched curves. Instead of having one curve like a round ball, the surface is egg shaped. This causes blurred vision at all distances.
- In astigmatism, surface of cornea is not homogenous. Usually it is congenital.
- Parallel rays come to focus in 2 focal lines rather than a single focal point.
- 5 types:
    - 1-Simple Myopic Astigmatism: one before the retina, and one on the retina
    - 2- Simple Hyperopic Astigmatism: one on the retina and another behind the retina.
    - 3-Compound Myopic Astigmatism: both of which are before the retina but at two different locations before the retina
    - 4-Compound Hyperopic Astigmatism : both behind the retina but at different virtual locations.
    - 5-Mixed Astigmatism: one is before the retina and the other is behind the retina

● It's the worst in the quality of vision.

❖ Causes of astigmatism:

- Corneal causes (majority):
    - Simple corneal astigmatism,
    - Keratoconus القرنية المخروطية (causes Myopic astigmatism),
    - Masses e.g. lid tumor,
    - Ptosis وزن الجفن يضغط على القرنية



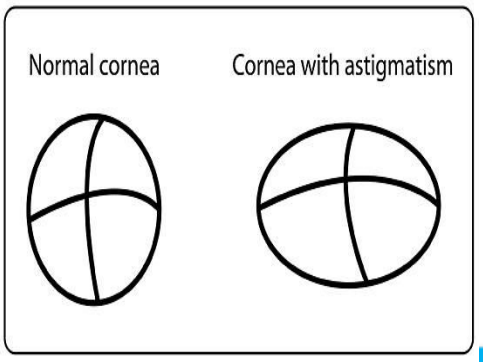
- Lenticular causes:
    - Lens dislocation. part of the zonules are cut مرتخي العدسة من جزء غير متساوية فتصير
    - Lenticonus.

❖ Symptoms:

- Asthenopic symptoms (headache, eye pain)
- Blurred vision
- Distortion of vision
- Head tilting and turning
- Uncorrected astigmatism > 1.5Diopters might lead to amblyopia in children.

❖ Classification:

1. Regular astigmatism: (2 meridians) power and orientation of principal meridians are constant. The principal meridians are 90 degrees apart (perpendicular to each other).
    - With the rule astigmatism, Against the rule astigmatism, Oblique astigmatism
2. Irregular astigmatism: (different meridians > 2) power and orientation of principal meridians change, across the pupil. The principal meridians are not perpendicular.



❖ Correction of astigmatism: cylindrical lenses

❖Presbyopia:

- Age related Physiological loss of accommodation
- Deposition of insoluble proteins in the lens with advancing age leads to progressive decrease in the elasticity of the lens and decrease accommodation.
- Around 40 years of age, accommodation become less than 3D . reading is possible at 40-50 cm -> difficulty reading fine print, headache, visual fatigue.
- Patient with Myopia and later have presbyopia, they would remove the glasses to see near objects. Vice versa with hyperopic patient.
- With aging zonules relaxes, Lense gets dry

Correction of Presbyopia: convex lenses

❖Anisometropia:

- Anisometropia is the condition in which the two eyes have unequal refractive power. Generally a difference in power of two diopters or more is the accepted threshold to label the condition anisometropia.
- More than 3 diopters difference if not detected in pediatrics and corrected it can cause unilateral amblyopia “in the weaker eye”.
- Individuals can tolerate up to 2-3 Diopters of anisometropia before becoming symptomatic

If the difference between 2 eyes: (D=Diopter)

Less than 3D -> it’s ok to wear glasses

More than 3 but less than 7D -> patient can’t tolerate glasses but can use contact lenses
More than 7D -> refractive surgery

An ocular condition in which the image of an object in one eye differs in size or shape from the image of the same object in the other eye.

❖ Causes:

- Correction of a refractive error
- Anisometropia
- Antimetropia (being myopic (nearsighted) in one eye and hyperopic (farsighted) in the other.)
- Meridional aniseikonia occurs when these refractive differences only occur in one meridian (see astigmatism).
- Refractive surgery

❖Types of optical correction:

1. **Spectacle lenses**
   - Monofocal lenses: spherical lenses, cylindrical lenses
   - Multifocal lenses. for patients with: presbyopia + myopia/hyperopia
2. **Contact lenses:**
   - Higher quality of optical image and less influence on the size of retinal image than spectacle lenses
   - Indication:
     - cosmetic, athletic activities, occupational, irregular corneal astigmatism, high anisometropia, and corneal disease
   - Disadvantages:
     - careful daily cleaning and disinfection.
   - Complications:
     - infectious keratitis, giant papillary conjunctivitis, corneal vascularization, and severe chronic conjunctivitis

❖Refractive Surgery:

Keratorefractive surgery: (work on the cornea. Doesn't correct high power)

- Refractive surgery – flattens corneal surface (more successful because it's easier to flatten than to make it more convex) for myopia or increases its curvature in Hyperopia.
- Improves unaided visual acuity but may have complications

  Examples: PRK, LASIK, LASEK, EPILASIK

  Intraocular surgery: for high power (يا نشيل العدسة بكبرها ونحط جديدة او نرزع عدسة قدام العدسة الطبيعيةللي نقصهم مره عالي)

- Give best optical correction for aphakia; avoid significant magnification and distortion caused by spectacle lenses.
- Clear lens extraction.
- Phakic IOL (intraocular lenses): lenses made of plastic or silicone that are implanted into the eye permanently to reduce a person's need for glasses or contact lenses.
- One of the side effects of the intraocular lens procedure => loss of accommodation.

Notes:

Photo refractive keratectomy (PRK):

(no flap.We just remove the epithelium apply laser then the epithelium will grow)

Advantages: safer on the long run

Disadvantages: severe pain for 1 week, blurred vision for 2 3 weeks

laser-assisted-in-situ keratomileusis (LASIK)

(thin flap)

Advantages: immediate 20/20 vision, no pain, good visual rehabilitation, can correct high numbers (up to – 8)

Disadvantages: severe trauma the flap can fall down