

Refractive errors

Objective

- not provided



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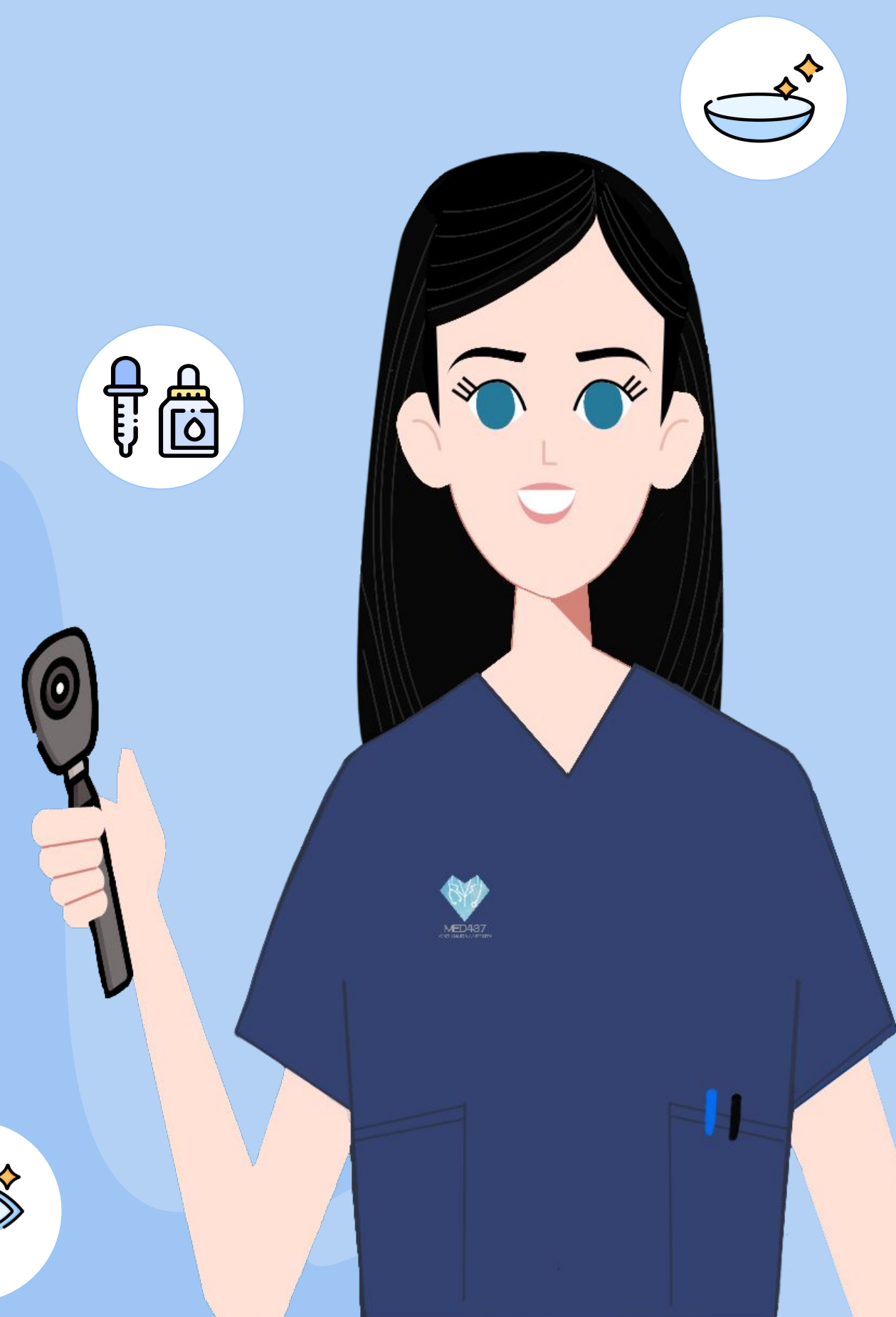
Resources :

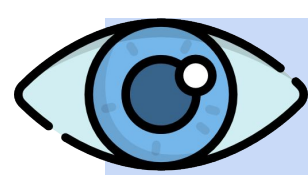
Dr. AlMezaine slides and notes(F2), Dr. Saad AlDahmash(F1), 436 teamwork Book (Lecture notes in Ophthalmology)

- Editing file

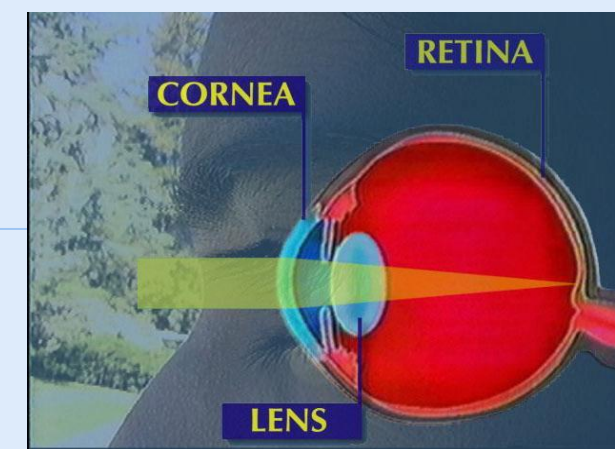
Color index

- **Important**
- **Notes**
- **Book**
- **Extra**
- **Golden note**





How the eye works



Facts:

- ❖ 75% of avoidable blindness is due to:
 - ◇ **Uncorrected refractive error.** Refractive error is a common issue in the community (myopia & hyperopia and Astigmatism) . Emmetropia eye is normal with No refractive errors (very rare)
 - ◇ Cataract. We don't consider as a pathology because it is a physiological change with age
 - ◇ Trachoma. Cause by Chlamydia trachomatis (which is a bacteria behave like a Parasite) it is come via direct contact in a poor hygiene environment
- ❖ Blindness due to refractive errors is a substantial public health problem in many parts of the world

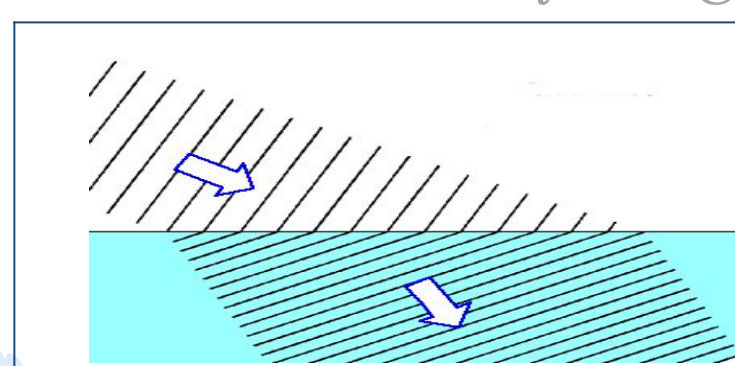
Physiology:

- ❖ Simply light enters the eye by going through the cornea where it will refract (bend) and then refract again at the lens. These two organs modify light rays by a phenomenon called refraction in order to have a single point in the fovea as it should be to see clearly.
- ❖ To have a clear picture in the retina & to be seen in the brain, there should be a clear cornea, clear anterior chamber, clear lens & clear vitreous cavity then the picture should be focused on the retina with normal refractive index.
- ❖ Light rays enter the eye through a clear cornea, pupil and lens.
- ❖ These light rays are focused directly onto the retina in the same way as a camera focuses light onto a film (the light sensitive tissue lining the back of the eye).
- ❖ 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.
- ❖ The eye requires about **60 diopters of power** to focus the light from a distant object precisely onto the retina (In other words, the 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 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".



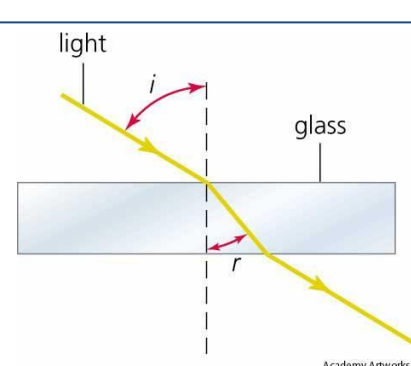
Refraction:

- ❖ 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. (Pic 1)
- ❖ The power of the lens is measured by the diopter (D) (**the unit of refraction**).
- ❖ Diopter = $1 / \text{focal length of a lens(m)}$. where the light rays be on one point (نقطة تقاطع الأشعة)
- ❖ The eye requires about 60 diopters of power to focus the light from a distant object (6 meters or more) precisely onto the retina.
- ❖ The amount of bending depends on the refractive index of the media and the angle of incidence. (Pic 2)
 - ◇ Parallel rays = far object (at least 6 meters far).
 - ◇ Lens with 1 dioptre is a lens that can bend parallel rays to a single point 1 meter away from the lens "
- ❖ 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.
- ❖ In order for the eye to generate accurate visual information light must be correctly focused on the retina.

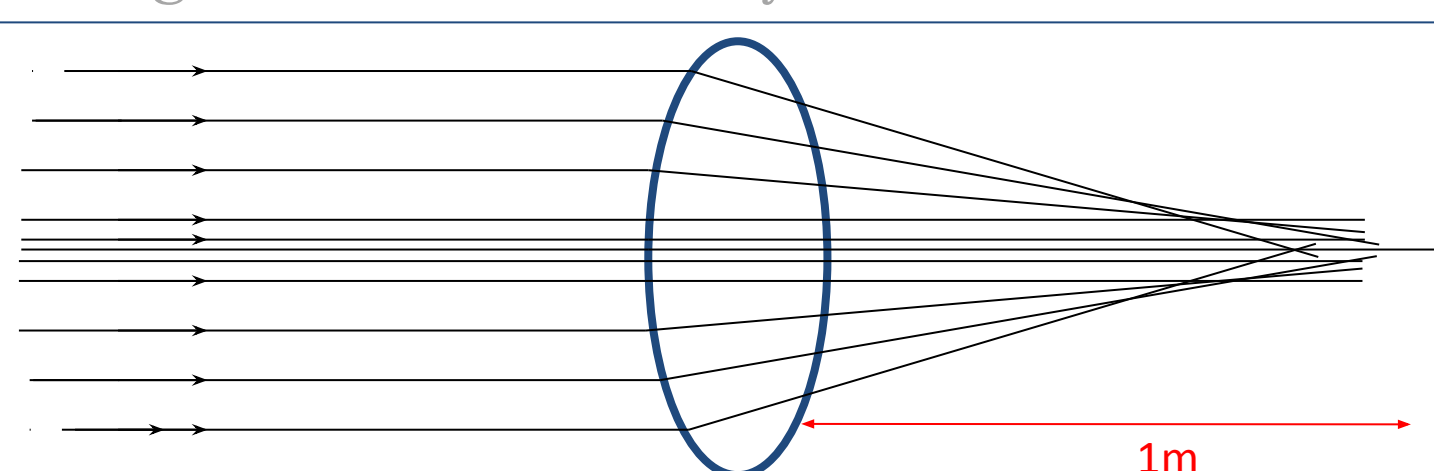


Pic 1

when light moves from air (lower density) to water (higher density), light waves will slow down then it will refract towards the medial vertical line (central line).



Pic 2



Pic 3

When looking at a far object, light rays are coming parallel (≥ 6 meters). It will enter through the lens and then it will refract in a single focal point at 1 meter. This is due to the power of lens, which is 1 diopter. Example: If we used another lens, rather than having a focal point at 1 meter it will be at 25 cm distance. What is the power of the lens? 4 diopter. How? diopter = $1/\text{focal length (m)}$ | $25 \text{ cm} \rightarrow 0.25 \text{ m}$ | diopter = $1/0.25 = 4$



The Eyes optical System (very important).

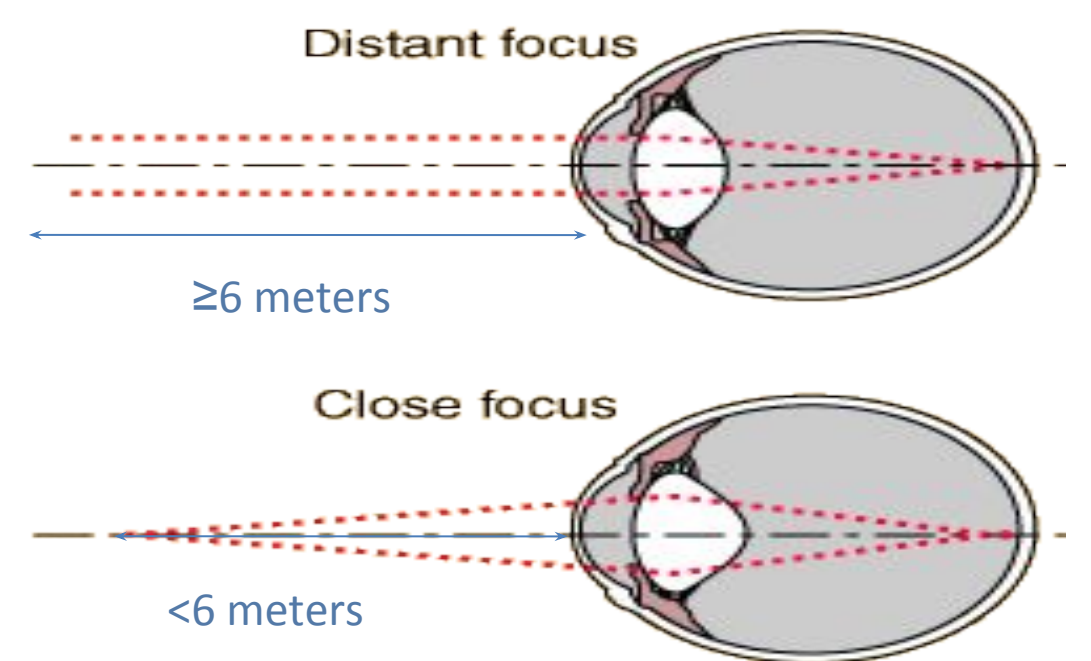
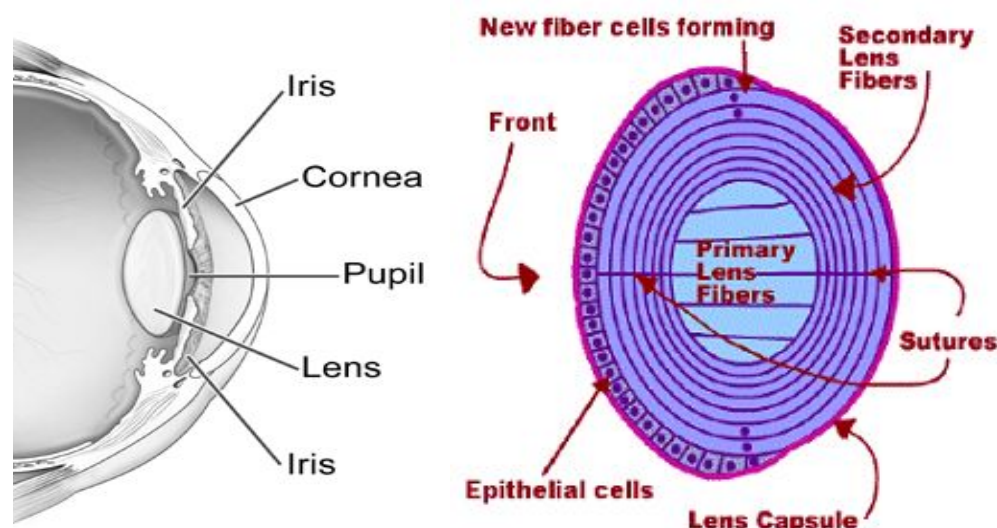


Cornea:

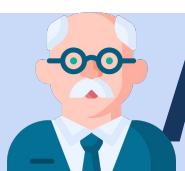
- ❖ The main refracting surface.
- ❖ It provides **40 diopter** (75% the total refracting power of the eye).
- ❖ **The power of the cornea is fixed (doesn't change)**, it reaches its maximum power at the age of 18. That's why it's NOT recommended to do any refractive surgery before the age of 18.
 - ◇ 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.

Crystalline Lens:

- ❖ Double purpose: balancing eye's refractive power and providing a focusing mechanism.
- ❖ The lens provides **20 diopters** (القوة البؤرية) of refractive power. **Which changes bc it depends on the accommodation (how far the object is from the eye)**
- ❖ 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).



When the object gets closer. The lens thickened to reflect more otherwise it wall fall behind the fovea



Accommodation:



Emmetropic (normal) eye

- ❖ Objects closer than 6 meters send divergent light that focus behind retina, adaptative mechanism of eye is to increase refractive power by accommodation.

Helm-holtz theory:

- ❖ Viewing a NEAR object (< 6 meters):
 - ◇ When the eye looks at a close object → contraction of ciliary muscle → decrease tension in zonule fibers → elasticity of lens capsule mold lens into a spherical shape **anterior-posterior curvature (diameter) increase (become thicker)** → greater dioptric power → divergent rays are focused on retina.
- ❖ **Contraction of ciliary muscle is supplied by parasympathetic third nerve.**
- ❖ **Accommodation has three components:**
 - ◇ **Change of lens shape.** Notice how the shape of the lens changes in relation to different distances (in near object we need a more powerful lens to maintain the point in the fovea so the lens becomes more thick)
 - ◇ **Miosis:** to allow as much light rays as possible to enter.
 - ◇ **Convergence:** contraction of medial recti muscle
- ❖ 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 $\{(15 - \text{age})/4\}$ of the lens.
 - ◇ # Accommodation is strong in children.
 - ◇ # After prolonged reading there might be ciliary spasm associated headache.



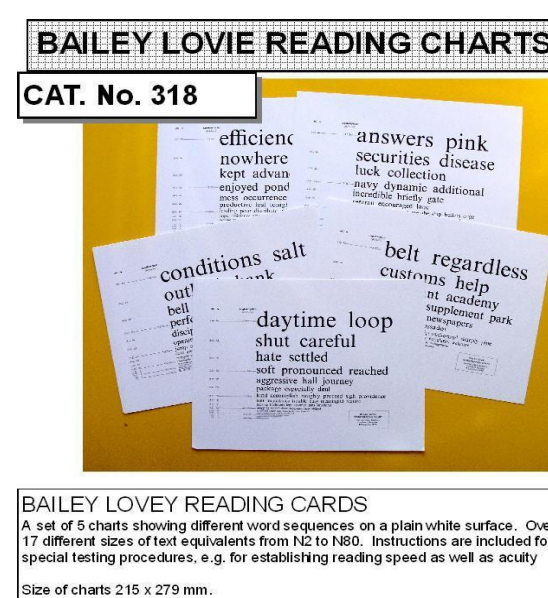
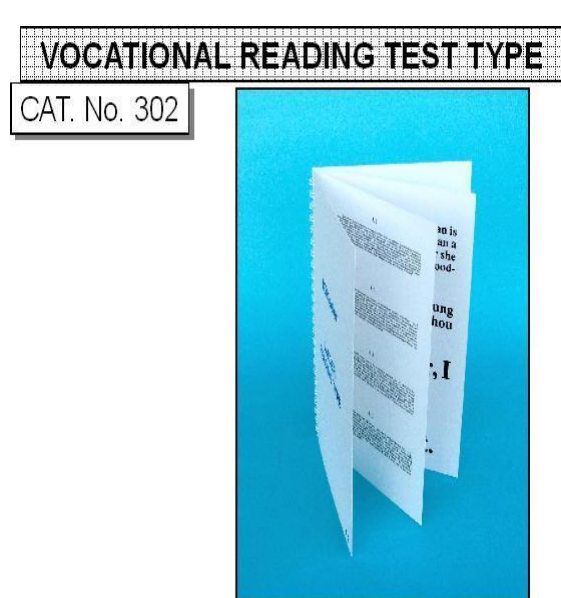
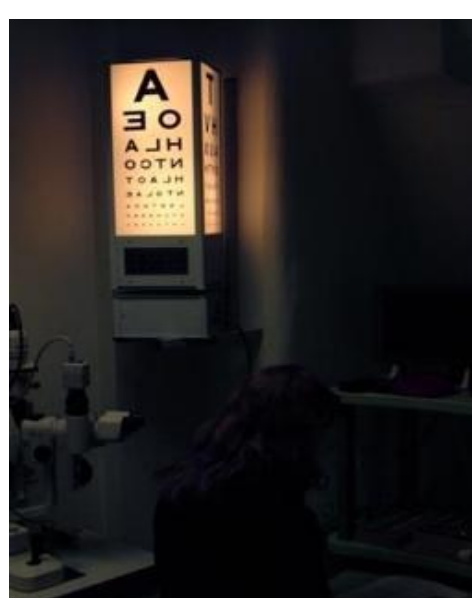
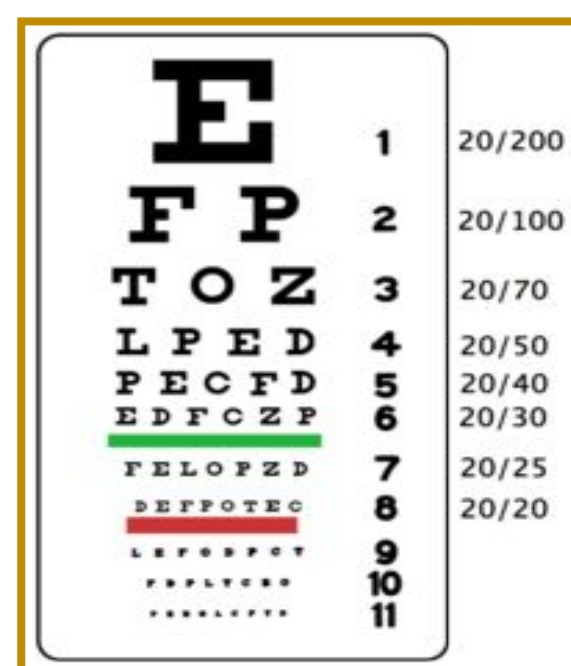
Visual acuity (VA)

- ❖ 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.
- ❖ The effect of refractive error must be eliminated.
- ❖ display of different -sized targets shown at a standard distance from the eye.
- ❖ Snellen chart.
- ❖ 20/20, 6/6
 - This is achieved by measuring: the patient's best spectacle correction or viewing the test chart through a pinhole.
 - Pinhole: optimal size 1.2mm, correct 3D of RE.
 - The pinhole (picture) is typically a glasses with a hole diameter of about 1 mm to 1.2mm (allows only 1 ray to pass), 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 confusing rays, only passes the rays going to fovea. Therefore, corrects for about three diopters!
 - تقریباً مشابه للناس اللی یصغرون عیونهم لما یرون یقروؤن شی .
 - When examining the patient you should examine each eye alone (and cover the other eye).



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

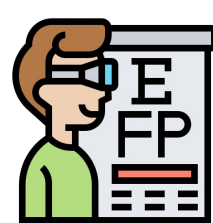
- ❖ Central visual acuity:
 - ◇ Display of different-sized targets shown at a standard distance from the eye (allen's & snellen's chart).
 - ◇ Always start showing large letters (assuming everyone is blind) and go smaller till normal (the 20/20 line).
 - ◇ 20/20 ft = 6/6 m (the distance where patient can read/distance where normal population read).
 - Example: 20/200 = the patient can see at 20 ft only where the normal population see at 200 ft
 - ◇ After measuring visual acuity do **pinhole**:
 - **If improved 20/20 → means refractive error.**
 - No improvement → other causes (could be cataract, glaucoma).
 - **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).



BAILEY LOVIE READING CARDS
A set of 5 charts showing different word sequences on a plain white surface. Over 17 different sizes of text - equivalents from N2 to N80. Instructions are included for special testing procedures, e.g. for establishing reading speed as well as acuity
Size of charts 215 x 279 mm.

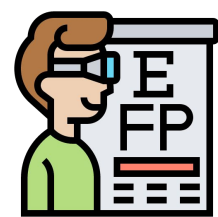
- From 2 months – 3 years: do follow and fixate test. At this age, babies will start to follow the objects, so bring a toy in front of them and do the test. (If following the toy → good vision). OR you can do (central= seeing centrally. Steady= no nystagmus. Maintained= baby is following object & after 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 an acquired skill for the brain, so when babies are 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.

Testing poor vision:



- ❖ If the patient is unable to read the largest letter $<(20/200)$ (visual acuity) → move the patient closer e.g. 5/200.
- ❖ Then If the patient cannot read: (بالترتيب):
 1. Count fingers (CF) (how many fingers do you see? do it at 1 ft , 2 ft, etc).
 2. Hand motion (HM) (do u see my hand moving?).
 3. Light perception (LP) (shine the torch up, down, temporal, nasal “right and left”).
 4. No light perception (NLP) (can't see any of the above = complete blindness).
- ❖ Legal blindness: if the vision in the best eye w/ best correction and providing is 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: One of the causes of decreased visual acuity

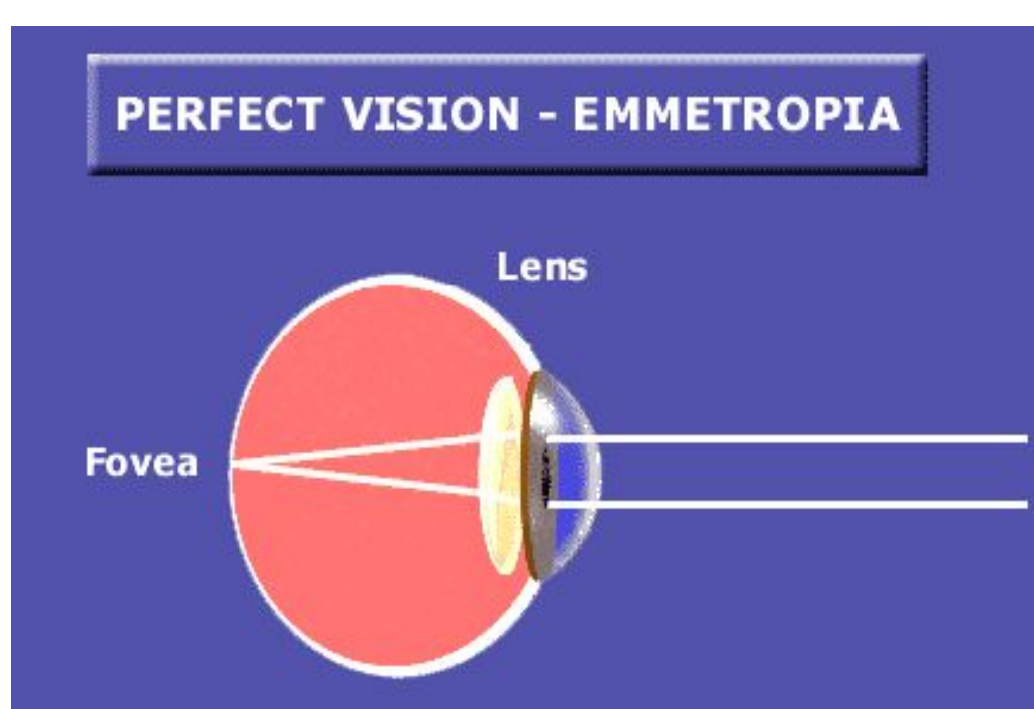
- ❖ A mismatch between the refractive power (**cornea and lens**) and the focusing distance of the eye (axial length)
عشان نسقط البوينت على الفوقيا بالضبط لازم يكون فيه ماتشقق بين ال refractive power and axial length ◇
- ❖ Inability to see clearly is often caused by refractive errors.
- ❖ Three types of refractive errors (ametropia):
 - Myopia (nearsightedness), extra power and long Axial length (image in front of the retina).
 - Hyperopia (farsightedness), less power and short Axial length (image behind the retina).
 - Astigmatism (irregular surface of cornea and lens). انحراف
- ❖ Emmetropia (normal).
- ❖ Ametropia = Refractive error. **The 3 types**
- ❖ **The gold standard of measuring refractive errors is retinoscope.**

Emmetropia:

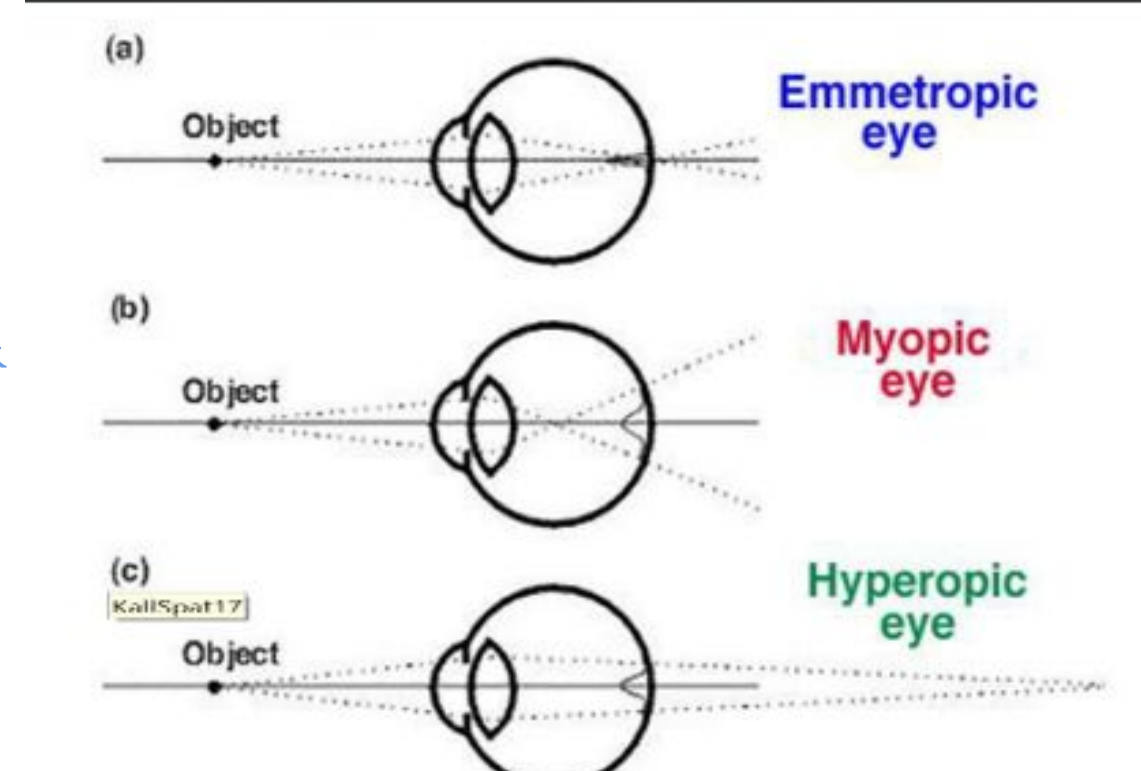
- ❖ Adequate correlation **or** matching between **axial length** “eye size” and **refractive power of the eye**.
- ❖ Rays of light from a distant object are brought to a pinpoint sharp focus on the retina (without accommodation).
- ❖ All refractive errors are some deviation from emmetropia.

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.



- Point at the retina Matching between axial length (AL) & refractive power (RP)
- Point in front of the retina * high RP & normal AL OR * normal RP & long AL
- Point behind the retina * low RP & normal AL OR * normal RP & short AL



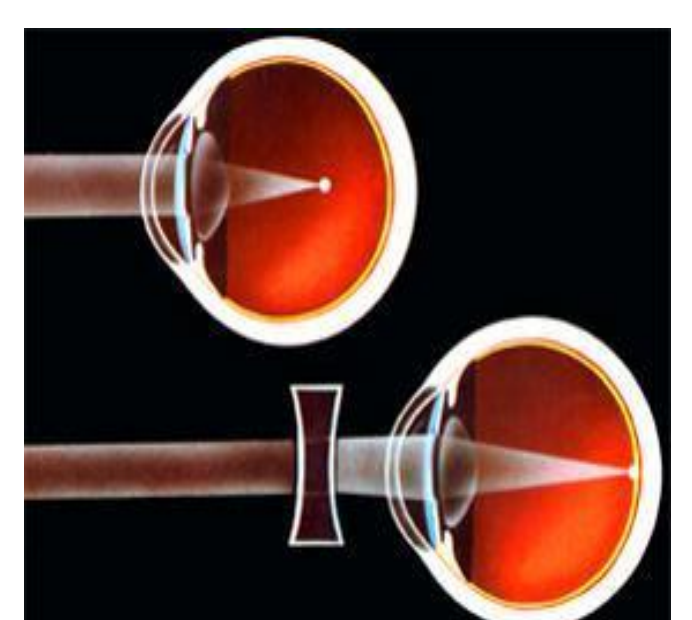
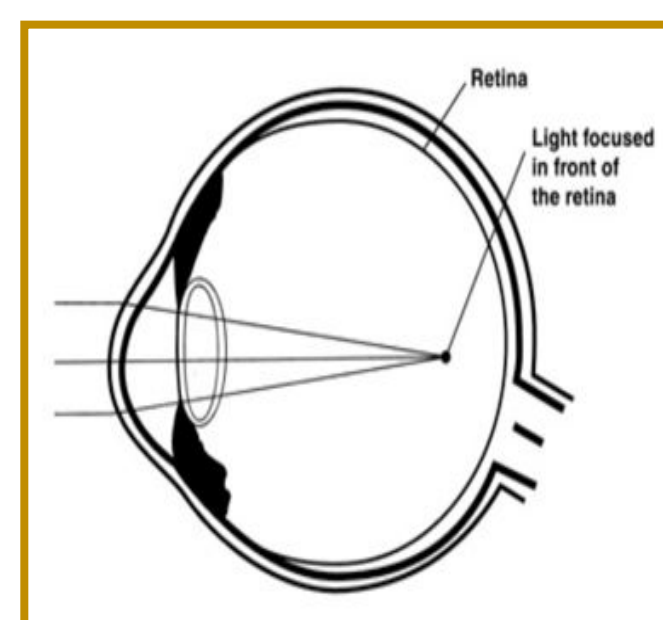
Myopia:

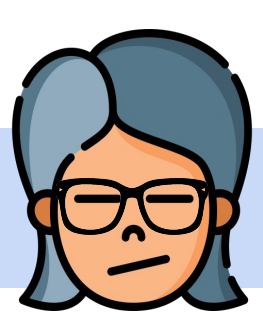
- ❖ Rays of light from a distant object converge in front of the retina, causing a blurred image on the retina.
- ❖ **Myopes can see close objects clearly**, myopia is commonly known as “nearsightedness”.
- ❖ Most prevalent among Asians (80-90%), followed by 25% of African Americans and 13% of Caucasians.
- ❖ Average age of onset: 8 up to 10 years and normally stops at 18-20 years (teenage years; can't see the board)
- ❖ **Acquired myopia** : come because excessive + prolonged accommodation مثلاً زي طالب طب يقول ماكان فيني شي فجاه جاني لانه صار دايم يركز باشياء قريبيه ويزيد الضغط والقوة
- ❖ **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.
- ❖ Myopia can be essential (primary) or secondary (increase in the refractive power of cornea or lens → become more curved)
- ❖ **Causes**:
 - Excessive refractive power (refractive myopia). Eye is normal ; lens and cornea high refractive power
 - Excessive long globe (axial myopia): **more common**. Huge eye



1. Increased refractive power: القوه كبيرة ولكن حجم العين طبيعي

- A. Change in **lens nucleus** or shape: (cornea or lens is too curved)
- Cataract due to growth (thick, hard, high density = high refractive power → induced myopia .
 - o The lens start growing more and more + refractive index increase = myopia
- "طول عمره ما يعرف النظارة لكن لما يوصل عمره 70/60 يبدأ تصير عنده أرقام myopia جديدة بسبب الـ cataract senile"
- Spherophakia: congenital anomaly where the lens is spherical in shape = more curvature = more myopia
 - Diabetes.
 - ◇ Diabetic patients have both myopia and hyperopia depending on the level of the blood sugar.
 - High blood sugar → high sugar in aqueous humour → pull the fluid from the lens → shrink of lens (flat) > hyperopia.
 - Low blood sugar → fluid shift into lens → globular shape lens (swollen) → myopia.
 - Uncontrolled (fluctuations in blood sugar) lead to blurry vision. زغللة
- "لما تتابعي patient ويقولك أنا عندي زغللة نظر مستمرة تعرفي أنه مو الـ controlled sugar blood لأن فيه fluctuation عالي"
- B. Lens repositioning:
- Ciliary muscle shift e.g. miotics (medications)
 - ◇ Contraction of ciliary muscles → zonules relax → the lens become more curved induced myopia
 - Lens movement e.g. anterior lens dislocation Trauma → lens moves forward → image will be in front → myopia
- C. Ciliary muscle tone:
- Excessive accommodation e.g. medical students, people who read a lot or use their phones for long period of times without stop
- D. Increase corneal power:
- keratoconus (a collagen disease causing a cone shaped cornea → more curvature → induced myopia),
 - Congenital glaucoma (big globe + protrusion of cornea) congenital disease characterized by increase in IOP in babies





Myopia:

2. Increase axial length: more common

❖ Congenital glaucoma, posterior staphyloma (bulging of posterior part of the eye).

❖ Symptoms:

- Blurred distance vision.
- Squint in an attempt to improve uncorrected visual acuity when gazing into the distance.
- Headache due to eyestrain.
- Amblyopia (كسل العين) – uncorrected myopia > -5 D. children علشان كذا اذا جاني طفل لازم اعالجه علشان مايوصل لكسل العين
- Strabismus children

◇ All types of refractive errors in the first 7 yrs of life will cause strabismus and amblyopia.

▪ Children will have amblyopia and strabismus

❖ 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 18- 20 years of age.

▪ Progressive or malignant myopia (uncommon)

- Also called Degenerative or pathological myopia.
- Myopia increases rapidly each year and is associated with, fluidity of vitreous and chorioretinal change. "الأرقام مستمرة في النزول"
- Pt is 25 year old with a refractive error $-5 \rightarrow 30$ years old $-7 \rightarrow 35$ years old -8
- Pathophysiology: due to abnormality in the wall of the sclera causing it to get more and more thinner \rightarrow the eye gets bigger and bigger

❖ Morphologic eye changes in pathological myopia: (Axial Myopia)

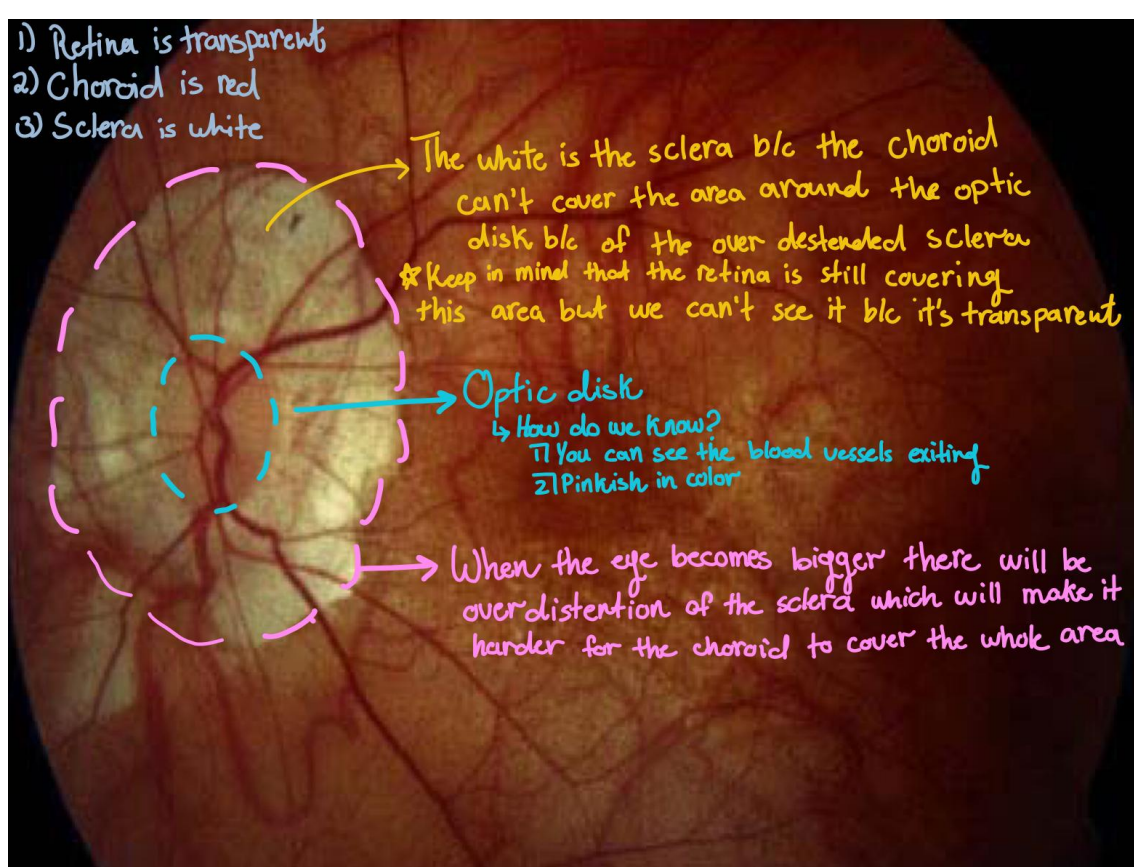
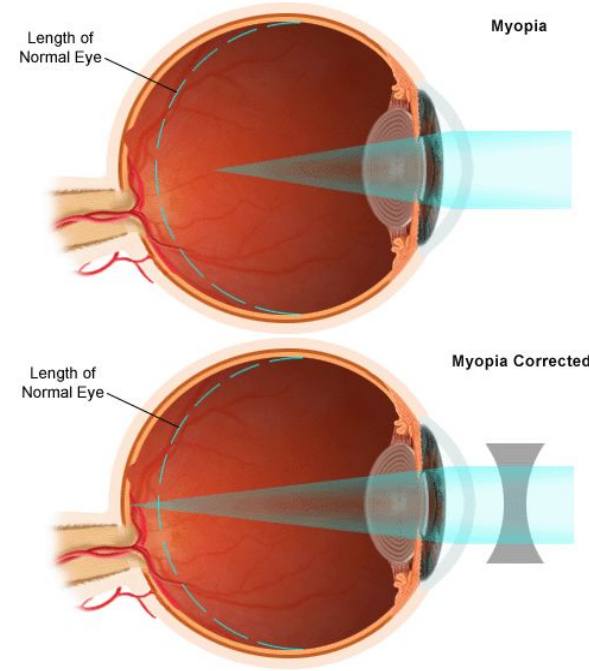
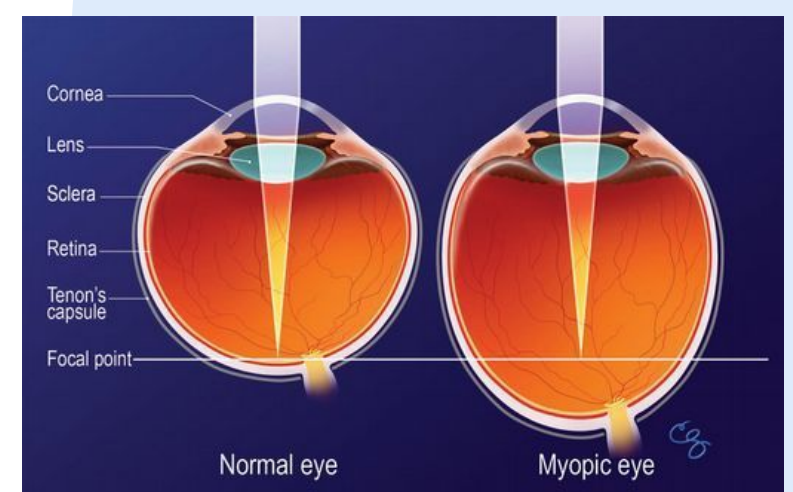
▪ Only happens with axial myopia, no changes happen if benign myopia.

1. Deep anterior chamber.
2. Atrophy of ciliary muscle + iris atrophy due to excessive stretching.
3. Vitreous may collapse prematurely leading to opacification
 - The eye is bigger (more space) and the vitreous (gel-like substance) will stay the same. Compensatory, The space will be partially filled with vitreous and the area where vitreous is unable to cover will be covered with aqueous humour causing them to mix in a process called "liquefaction" (causing the density of the vitreous to decrease)
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 \rightarrow hole \rightarrow increase risk of RRD (rhegmatogenous retinal detachment) \rightarrow vision loss.

"لو قلنا أن أرضية الغرفة هي الـ retina وجينا بعدنا الجدار، وش حيصير في الأرضية؟ فيه أماكن ما راح يكون فيها coverage في الـ retina، في البداية لو كان موكيت ممكن يجي معاك بس بعدين حينقطع بيصير حاجة اسمها break retinal الـ retina ما عاد تقدر أنها تغطي حجم العين الكبيرة فيصير فيه breaks والجل liquified فيدخل مع الـ breaks هذي، لما يدخل وش يسوي في الـ retina؟ يدها/يفصلها، فيصير عندنا حاجة اسمها detachment retinal أو انفصال الشبكية

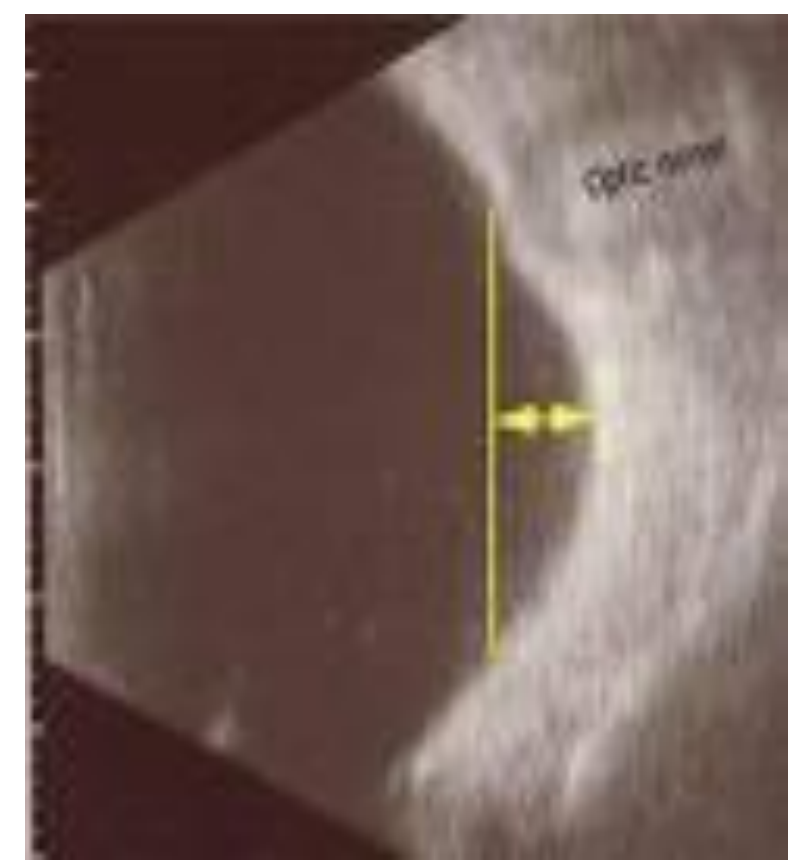
- One of the complications of axial myopia is retinal detachment

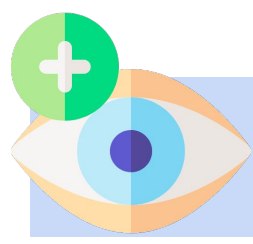
❖ Correction of Myopia: (negative) concave lenses. posterior staphyloma



US showing posterior staphyloma (bulging of the posterior part of the eye)

- As the eye gets bigger, the sclera gets thin & weak which in return make the optic nerve able to push this area to the back





Hyperopia:

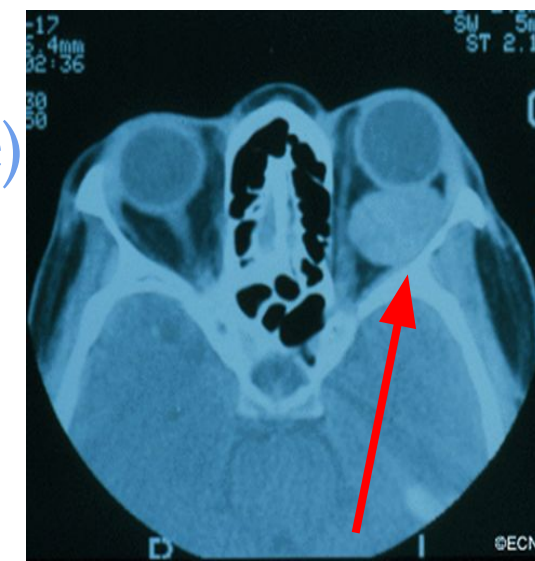
- ❖ Parallel rays converge at a focal point **posterior to the retina**.
نعكس كل الأشياء التي كانت بال myopia
- ❖ Etiology: not clear, inherited, trauma may cause dislocation of the lens.
- ❖ Rays of light from a distant object now focus behind the retina.
- ❖ Hyperopic people must accommodate when gazing into distance to bring focal point on to the retina. الأشياء البعيده اوضح من القريبه لكن ستل البعيده مو واضحه مية بالمية
- ❖ 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”.



Causes:

1. Excessive short globe (decreased effective axial length): (small eye)

- ◇ Axial hyperopia.
- ◇ **More common.**
- ◇ Retina pushed forward: tumor, orbital mass.



Mass pushing the retina forward which will make the axial length shorter > induce hyperopia

2. Insufficient (decreased) refractive power (refractive hyperopia).

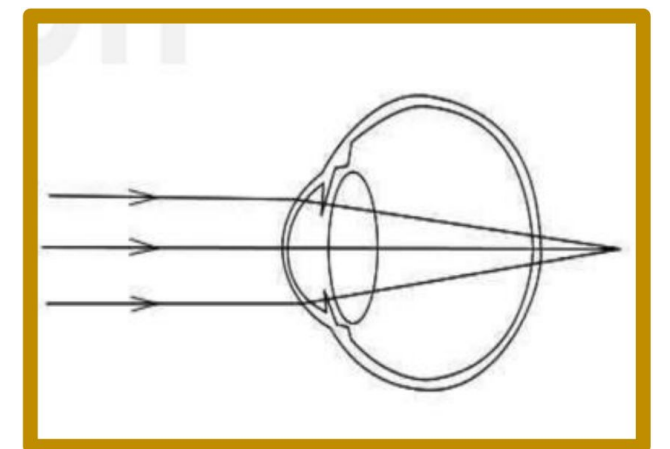
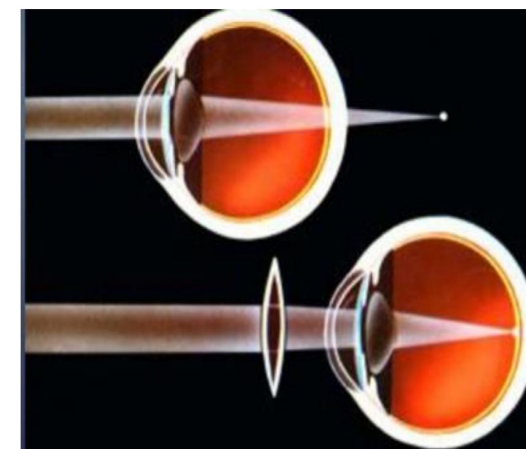
- ◇ Absent (aphakia) “lens came out from trauma or surgical removal = loss of 20 diopter” or posteriorly repositioned lens.
- ◇ Weak accommodation: trauma (ciliary muscle), marijuana “marijuana weakens ciliary muscles after using it (induced hyperopia)” relaxation of accommodation.

Symptoms:

- ❖ Visual acuity at near tends to blur relatively early “inability to read fine print”.
- ❖ Asthenopic symptoms: eye pain/ strain, headache in frontal region
 - ◇ Especially after reading/using the phone they require more accommodation.
- ❖ **Accommodative esotropia***: because accommodation is linked to convergence leading to esotropia (ET).
- ❖ Amblyopia* – uncorrected hyperopia > +5D.
- ❖ Strabismus.
- ❖ Children will have amblyopia and strabismus

Correction of hyperopia: (positive) convex lenses

إذا جاني طفل فيه طول نظر غالباً اذا كبر بيصير طبيعي بس في هالحالتين ماننتظر ونتدخل*



Rays of light from a distant object focus **behind** the retina

Astigmatism (اللابؤية):

- ❖ Astigmatism is a common and generally treatable imperfection in the curvature of the eye that causes blurred distance and near vision.
 - The essential cause is the eye shape > you may describe it to the patient as “your eye is shaped as a rugby ball (اقطارها مو متساوية) instead of a football”.
- ❖ Cornea is usually shaped like half a football. In these eyes there will be no astigmatism.
- ❖ 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 > will lead to either myopia or hyperopia.
- ❖ In astigmatism, surface of cornea is not homogenous. Usually it is congenital.
- ❖ Parallel rays come to focus in 2 focal lines (the vertical line المضغوط will give a point, and the horizontal line الفلات will give another point) rather than a single focal point.
- ❖ Etiology: hereditary.
- ❖ Cause: refractive media is not spherical → refract differently along one meridian than along meridian perpendicular to it → 2 focal.

This ball will give you only one point > either ON the retina, or in front of it, or behind it.



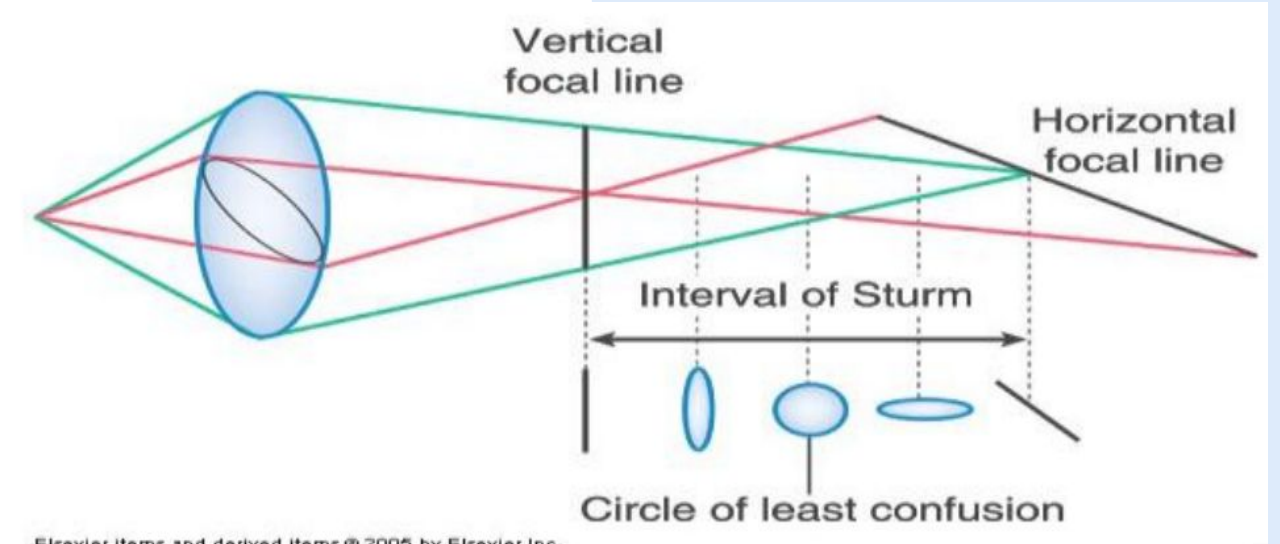
This ball will give you 2 points one by the horizontal surface and the other by the vertical surface.



◀ ≡ Astigmatism (اللابؤية):

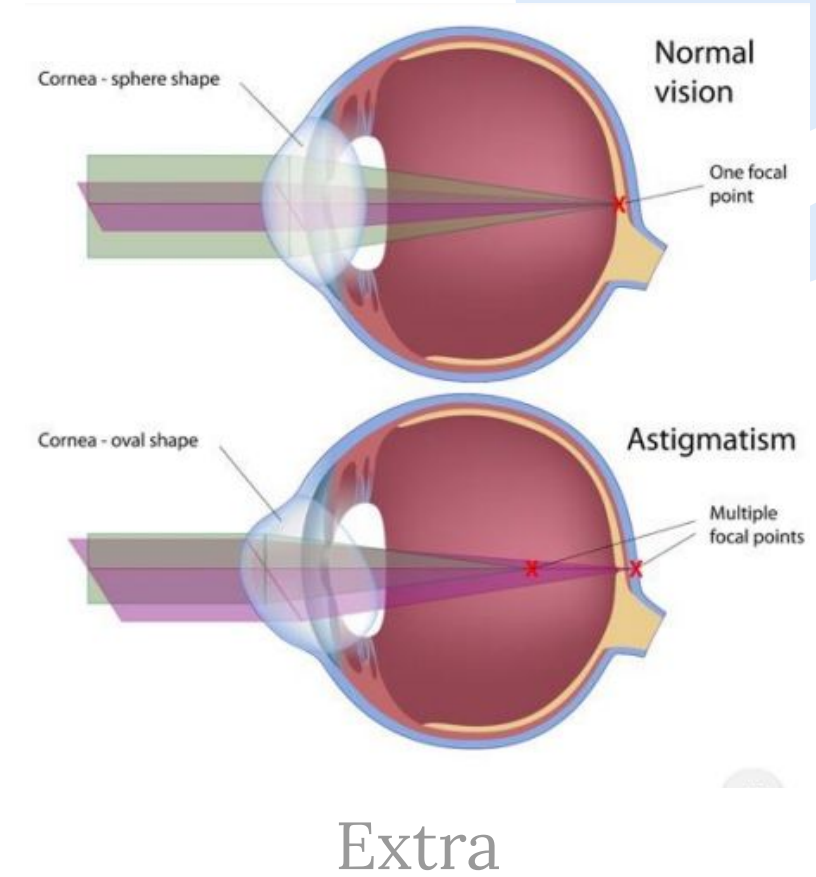
❖ 5 types: the doctor didn't mention the names but he said the rays could be anywhere.

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 this is the eye shape مضغوطة > it is essential not a secondary cause.
 - ◇ Keratoconus (المخروطية القرنية) causes Myopic astigmatism.
 - ◇ Masses e.g. lid tumor (induced astigmatism > weight of tumor press on the cornea > remove the tumor.
 - ◇ Ptosis could be congenital وزن الجفن يضغط على القرنية



- ❖ Lenticular causes :
 - ◇ Lens dislocation ضربة على العدسة ميلتها
 - ◇ Lenticonus.

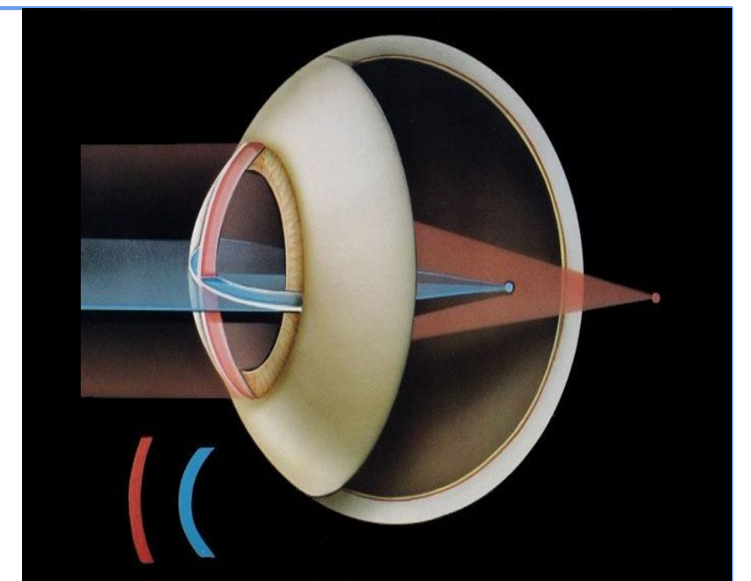
Notice the horizontal surface gives the blue rays.

The vertical surface gives the red rays.

This is called regular astigmatism

This is a distorted image.

The man doesn't look like this in reality but this is how the patient sees him.

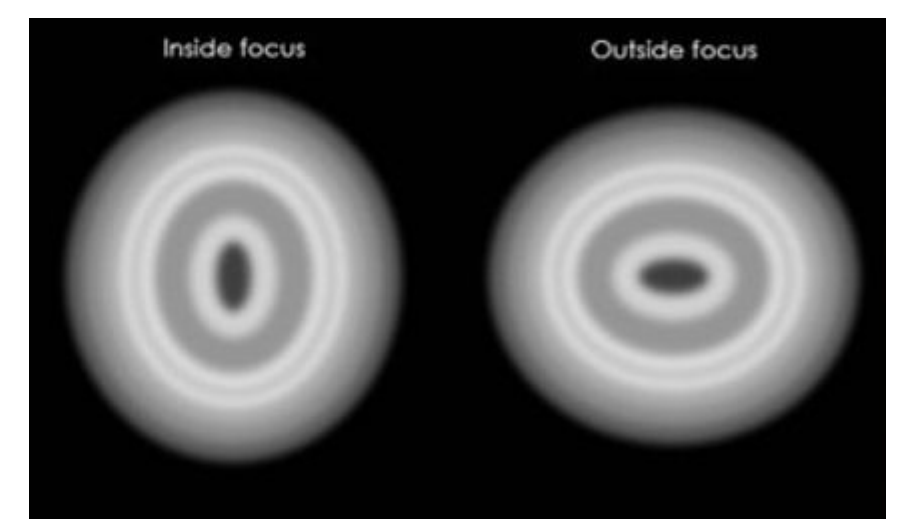


Symptoms:

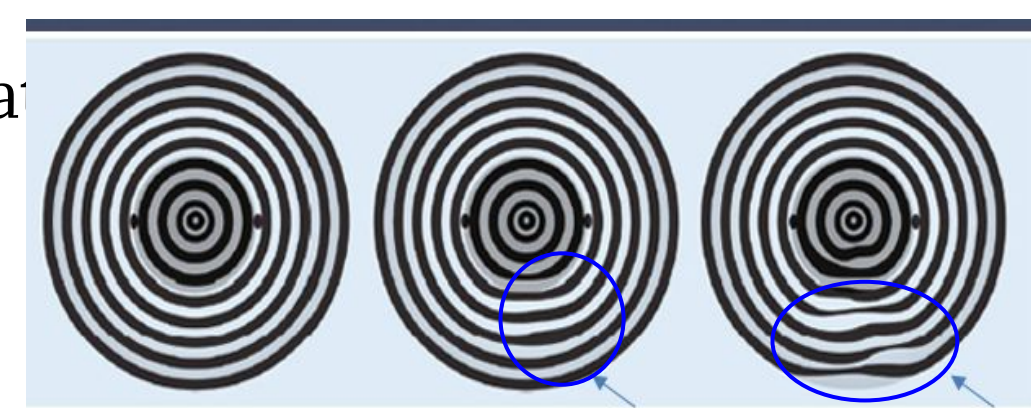
- ❖ Asthenopic symptoms (headache & eye pain).
- ❖ Blurred vision.
- ❖ **Distortion of vision.**
- ❖ Head tilting and turning.
- ❖ Uncorrected astigmatism > 1.5Diopters might lead to **amblyopia** in children كسل في العين وحول

Classification: the management is different for each type.

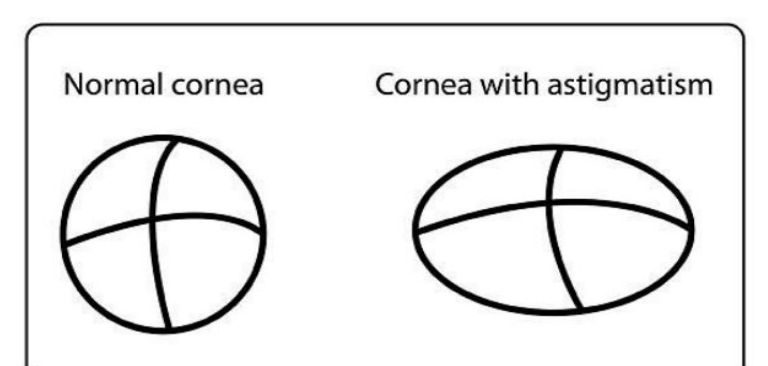
- ❖ **Regular astigmatism** (2 meridians):
 - ◇ Power and orientation of principal meridians are constant. The principal meridians are 90 degrees apart (perpendicular to each other).
 - ◇ With the rule astigmatism, Against the rule astigmatism, oblique astigmatism
- ❖ **Irregular astigmatism** (different meridians > 2):
 - ◇ Power and orientation of principal meridians change across the pupil. The principal meridians are not perpendicular.
 - ◇ Trauma, sutures > scar in cornea > irregular astigmatism
 - ◇ (fixed by hard contact lens pressing on the cornea عليها غصب عليها regular)



This is regular astigmatism



This is irregular astigmatism



Extra

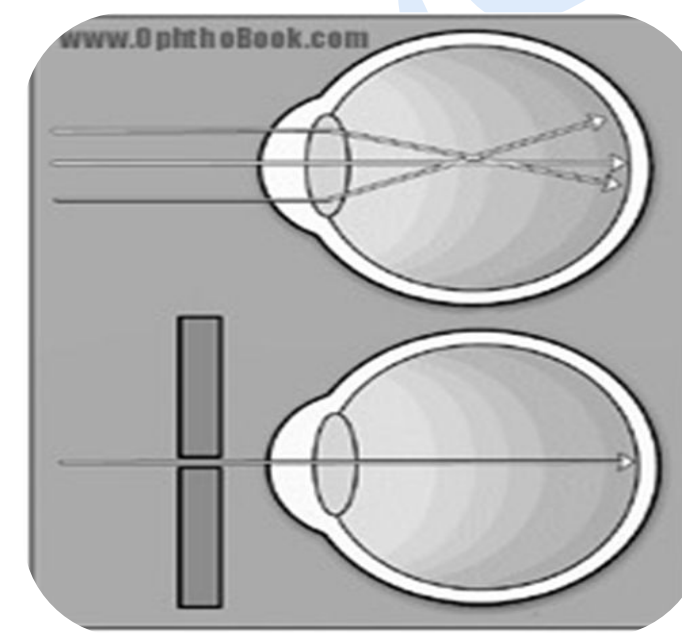
Correction of astigmatism: cylindrical lenses.

How To diagnose a refractive error?

1. Measure the visual acuity by the chart.
2. Pin hole> either the patient will improve (it means it is a refractive error), or he will not improve (it is something else like cataract).
3. Measure the refractive error (3 types) by Retinoscope, but now there are computerised machines> but when there is a complicated case we use the old gold standard (the retinoscope)



This is how we measure the refractive error, by the retinoscope and using these lenses.



Why pt with a refractive error will improve by using the pin hole? The holes will let only the rays that stop exactly on the fovea to pass through , and prevent the others.

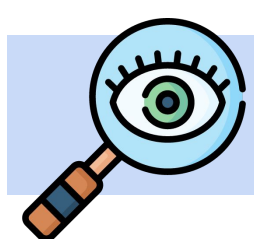


Presbyopia:

- ❖ Physiological loss of accommodation in advancing age.
- ❖ 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 becomes less than 3D. Reading is possible at 40-50 cm → difficulty reading fine print, headache, visual fatigue *نعطيهم نظارات قراءة*.
- ❖ Patients with myopia and later have presbyopia, they would remove the glasses to see near objects. While Hyperopic patients need to use another glasses for reading or can have one glasses with the lens split into upper half for far objects and lower half with different power for reading.
- ❖ With aging zonules relaxes, Lens gets dry.
- ❖ The difference between presbyopia and hyperopia is that in presbyopia the zoom function is lost while in hyperopia its still intact”.
- ❖ Because he lost the flexibility of his lenses and it become more rigid with advanced age *لما نقيس النظر عنده نلقاه 20/20 لكن يحتاج نظارة قراءة ليه؟*



Correction of presbyopia: convex lenses.



Anisometropia:

- ❖ A difference in refractive error between the two eyes.
- ❖ Individuals can tolerate up to 2-3 Diopters of anisometropia before becoming symptomatic.
- ❖ Refractive correction often leads to different image sizes on the 2 retinas (aniseikonia).
- ❖ Aniseikonia depends on degree of refractive anomaly and type of correction.
- ❖ 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”.

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

- ❖ Less than 3D > it is ok to wear glasses.
- ❖ If 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.



Far point (Correction of refractive errors)

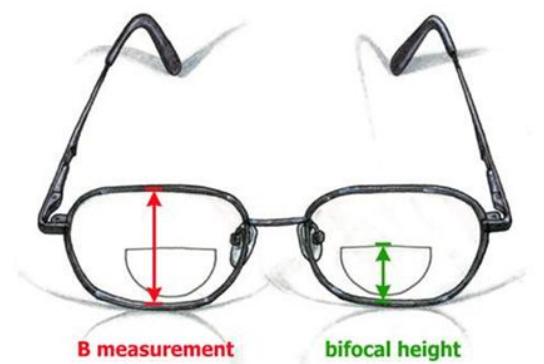
- ❖ A point on the visual axis conjugate to the retina when accommodation is completely relaxed.
- ❖ Placing the imaging of the object at far point will cause a clear image of that object to be relayed to the retina.
- ❖ Use correcting lenses to form an image of infinity at the far point, correcting the eye for distance



Types of optical correction.

(1) Spectacle lenses :

- ❖ **Monofocal lenses (one power): spherical lenses (for myopia and hyperopia) & cylindrical lenses (for regular astigmatism combines the minus with plus).**
- ❖ **Multifocal lenses: the upper and lower parts have different powers for patients with: presbyopia + myopia/hyperopia. (hyperopia since 18 YO. Now 45 YO can not read)**
- ❖ **In hyperopia the power of the eye is decreased → correct with convex, plus lens.**
- ❖ **In myopia the power of the eye is increased → correct with biconcave, minus lens.**
- ❖ **In astigmatism two unequally focused parts → plus & minus lenses on top of each other (cylindrical).**



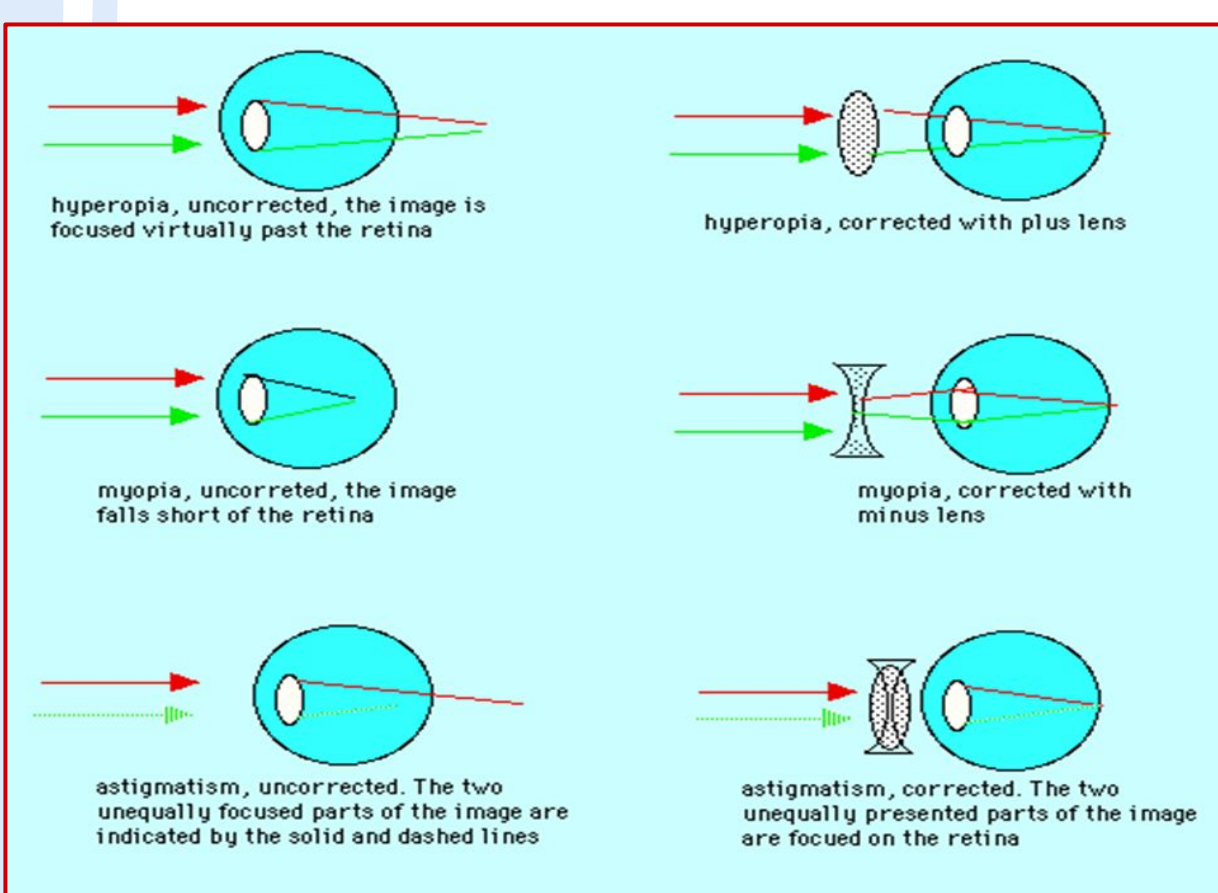
-This is multifocal lens
اللي بالاخضر الجزء الصغير
يخدم بالقراءة والكبير بالاحمر
يخدم النظر للبعيد

(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 & expense.
- ❖ **Complications:**
 - Infectious keratitis, giant papillary conjunctivitis, corneal vascularization, and severe chronic conjunctivitis.



Contact lenses



In hyperopia the lens is weak (pic is behind) so we give it more power by using the convex lens.

In myopia the lens is strong I need the weaken it by using biconcave lens..

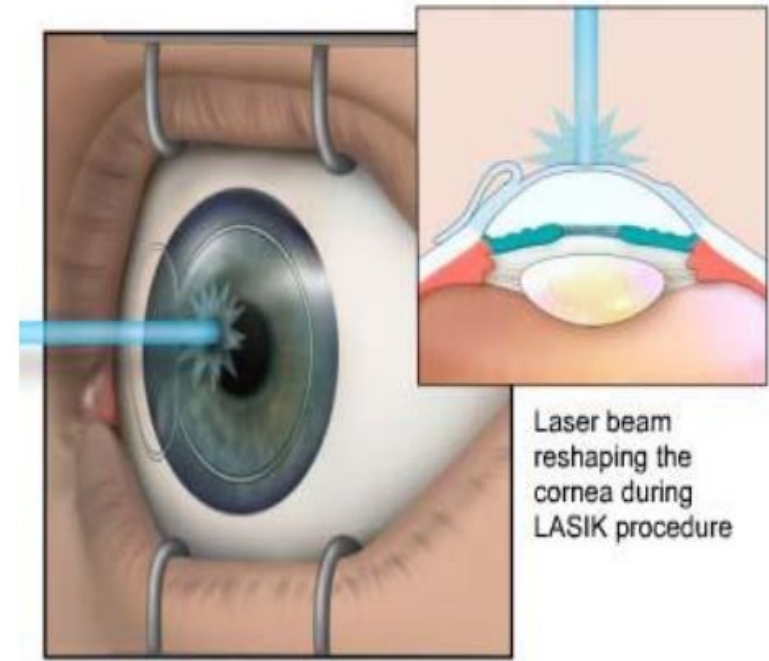
In astigmatism I have 2 points so I need to use 2 lenses(one plus , one minus)to correct it, so how?

we combine them(the minus with the plus) by using cylindrical lens.

Surgical correction:

(1) **Kerato-refractive 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 نشيل من الأطراف كأنك تزيد السمك للسنتر
- ❖ Focus the laser on the stroma to reduce the power of the cornea in the center (myopia).
- ❖ Improves unaided visual acuity but may have complications:
 - Examples: **PRK, LASIK, LASEK, EPILASIK**. عمليات تصحيح النظر
 - LASEKS: laser assisted stromal in-situ.
 - In PRK we focus the laser on the corneal surface to remove the epithelium only without the stroma (we don't make a cut).
 - Patient is more than 40 we can do it , but still might need glasses to read.



(2) **Intraocular surgery:** for high power للي نقصهم مرة عالي

يا نشيل العدسة بكيها و نحط جديدة أو نزرع عدسة قدام العدسة الطبيعية

- ❖ Give best optical correction for aphakia.
- ❖ Avoid significant magnification and distortion caused by spectacle lenses.
- ❖ Clear lens extraction (with or without IOL).
- ❖ Phakic IOL (ICL) (In front of lens or attached to iris)
 - 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)

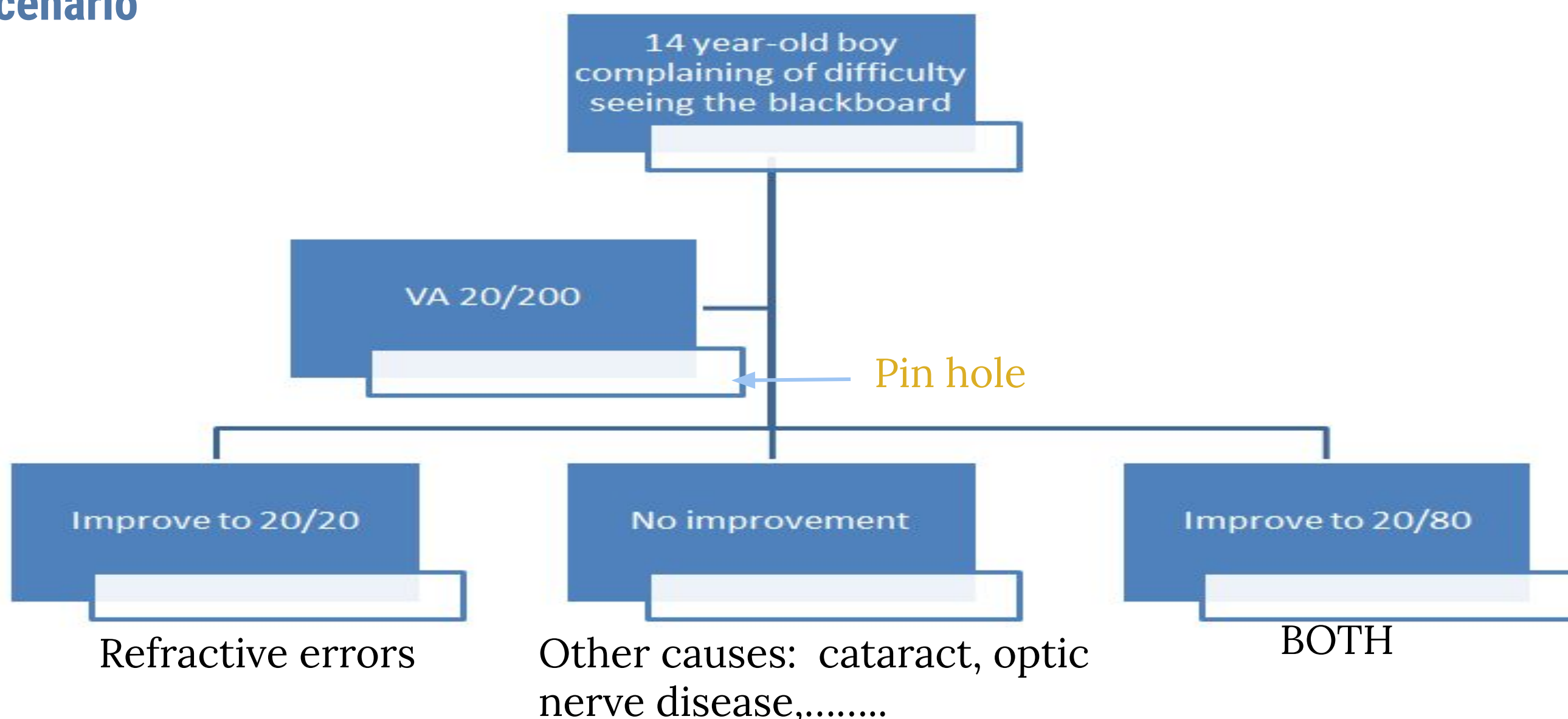
(thin flap)

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

Extra

Clinical scenario



Practice Questions

Q1. In presbyopia, all true Except:

- A. Correct by concave lens.
- B. Correct by Convex lens.
- C. In 40 years of age.

Q2. A young patient has a trauma to his right eye and the lens was displaced to the anterior chamber, what kind of refraction problem patient will shift to?

- A. Myopia.
- B. Hyperopia.
- C. No shift.
- D. Astigmatism.

Q3. A kid with decreased visual acuity was prescribed 2+ spherical and 2+ cylindrical glass for both eyes. What is the diagnosis?

- A. Myopia with astigmatism.
- B. Hyperopia with astigmatism.
- C. Hyperopia.
- D. Anisometropia.

Q4. A 12-year-old boy had a visual problem, his visual acuity was 20/50 and was corrected with + pin hole to 20/20. What condition does he have?

- A. Amblyopia.
- B. Congenital glaucoma.
- C. Glaucoma.
- D. Myopia.

Q5. An 8 years old girl brought by her mother because she noticed that she prefers to watch the TV at a very close distance. Slit lamp examination was unremarkable. Using pinhole, her visual acuity dramatically improved. Which one of the following is the best management option?

- A. Reassurance.
- B. LASIK.
- C. Glasses.
- D. Contact lenses.

Q6. A 10 year old girl came to the clinic with her mom complaining of gradual visual loss in both of her eyes, visual acuity examination revealed 20/200 after pinhole 20/30, what is the most likely cause?

- A. Congenital cataract.
- B. Optic nerve atrophy.
- C. Refractive error.
- D. Amblyopia.

Answers

1) A, 2)A, 3)B, 4)D, 5)C, 6)C