Refractive Errors

Objectives:

- Not given.

[Color index : Important | Notes | Extra]

Resources: Slides+Notes+Lecture notes of ophthalmology+434team.

Done by : Abdulrahman Al-Shammari.

Revised by : Adel Al Shihri.

FACTS:

- 75% of avoidable blindness is due to:
- Uncorrected refractive error
- Cataract
- Trachoma

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) and the crystalline lens contributes the remaining).
- 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.

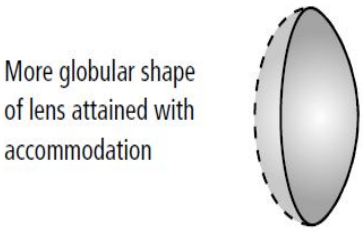
❖ The Eyes optical System:

- **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 of the 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**:

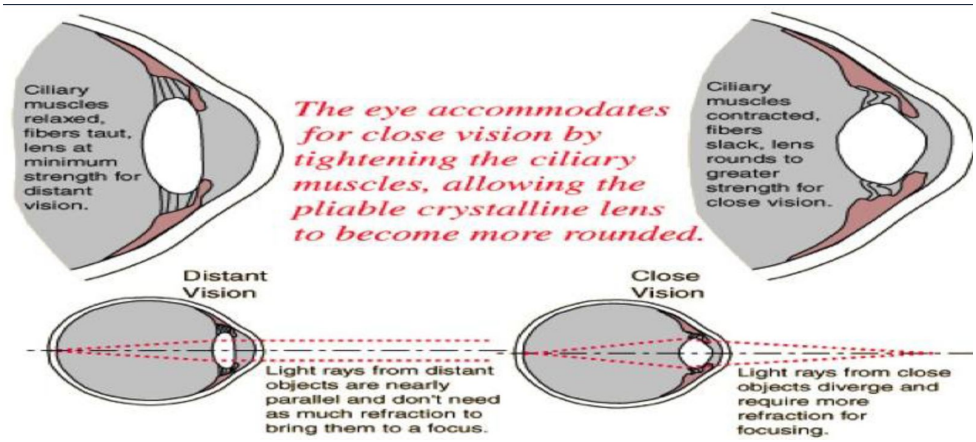
  - As an object of regard is brought nearer to the eye, focus is maintained by an increase in the power of the lens of the eye. This is brought about by ciliary muscle contraction, which relaxes zonular tension on the lens equator and allows the lens to take up a more spherical shape. This is accommodation.



  1. Emmetropic (normal) eye:
     - Objects closer than 6 meters send divergent light that focus behind retina; adaptive mechanism of eye is to increase refractive power by accommodation. Power of accommodation is {(15 - age)/4} of the lens. accommodation is strong in children.

  2. Helm- holtz theory:
     - 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 dioptic power ➡ divergent rays are focused on retina.
     - contraction of ciliary muscle is supplied by parasympathetic third nerve.

Note: Note: After prolonged reading there might be ciliary spasm associated headache



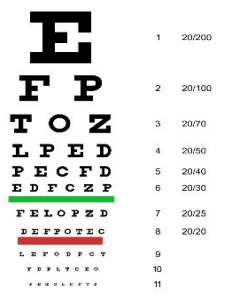
- **Visual acuity** (VA):

  - VA is the vital sign of the eye 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 is used to eliminate the mild refractive error of the patient. The pinhole will cause muscle spasm. Pinhole glasses typically have a hole diameter of about 1mm to 1.2mm. The pinhole corrects for about three diopters.
  - When examining the patient you should examine each eye alone (and cover the other eye)
  - After visual acuity do pin hole:
    - If improved 20/20 => means refractive error
    - No improvement => other causes
    - If improved but 20/80 => refractive error+ other causes.

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.
  - Notes:
  - 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.
- always start showing large letters (assuming everyone is blind) and go smaller till normal.
- 20/20 ft = 6/6 m.

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

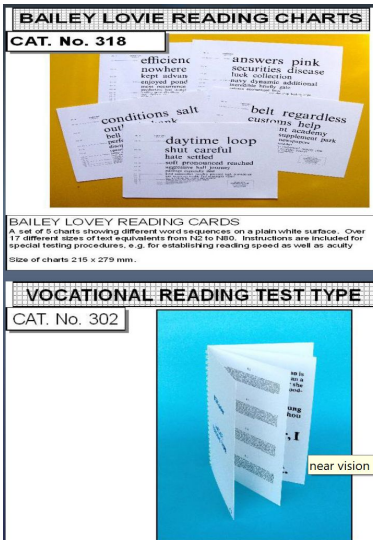
- Legal blindness: if the vision in the best eye is w/ best correction and providing less than 20/200, this is considered legal blindness. (patient needs assistance)

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

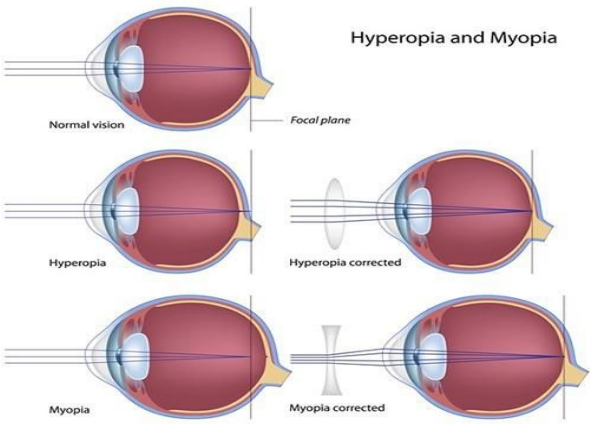
A variety of charts are available



Refractive errors :

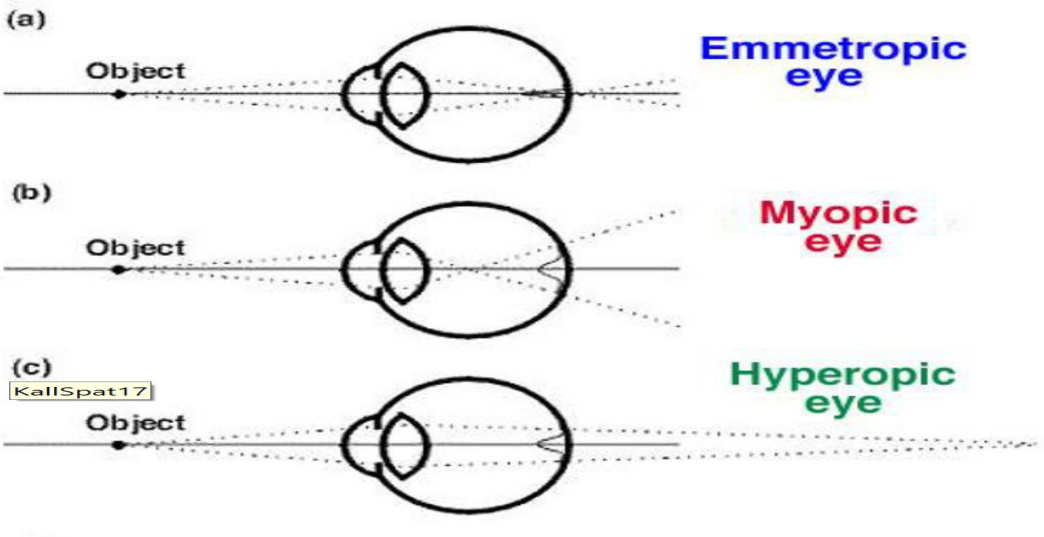
- **A mismatch between the refractive power and the focusing distance of the eye**
- **Inability to see clearly is often caused by refractive errors.**
- **Three types of refractive errors (Ametropia):**
  - **Myopia (nearsightedness),** extra power and long Axial length. يشوف القريب أوضح
  - **Hyperopia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

- Emmetropia (normal)
- Ametrpia = Refractive error.



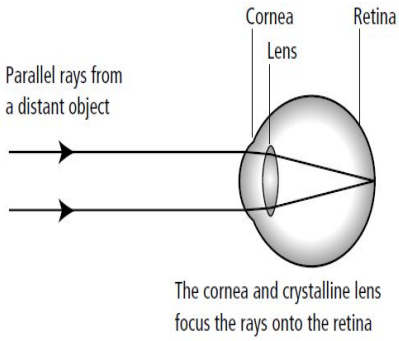
Emmetropia:

- 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.

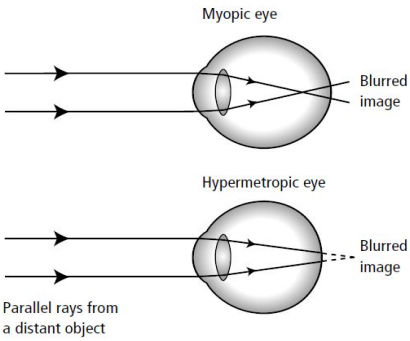


Ametropia:

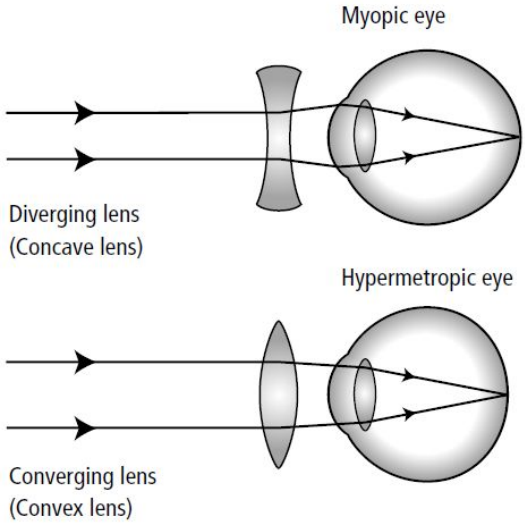
- When parallel rays of light from a distant object are brought to a focus on the retina with the eye at rest (i.e. not accommodating) the refractive state of the eye is known as **emmetropia**. Such an individual can see sharply in the distance without accommodation.



- 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 into 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 objects 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
- 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, this means their DM is not controlled!!

- **Causes** of myopia:

➔ Increased refractive power:
  - Change in lens nucleus or shape:
    - cataract, spherophakia, diabetes
  - Lens repositioning: ciliary muscle shift e.g. miotics. Or Lens movement e.g. anterior lens dislocation
  - Ciliary muscle tone*: excessive accommodation
    - e.g. medical students *Reading a lot at a near distance.

➔ Increase corneal power:
  - keratoconus, congenital glaucoma

➔ Increase axial length:
  - congenital glaucoma, posterior staphyloma (bulging of posterior part of eye).

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

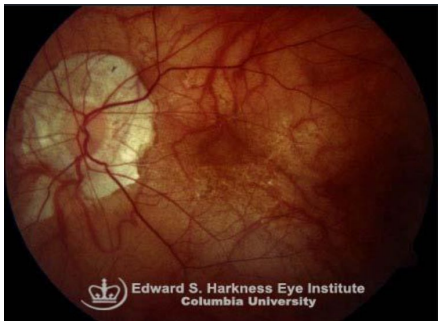
- Myopia **Forms**:

- 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:

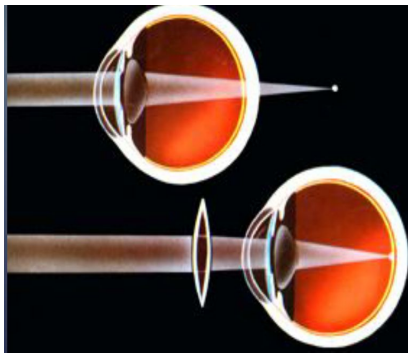
1. Deep anterior chamber
2. Atrophy of ciliary muscle
3. Vitreous may collapse prematurely leading to opacification
4. Fundus changes: Loss of pigment in RPE (Retinal pigment epithelium), large disc and white crescent- shaped area on temporal side, RPE atrophy in macular area, posterior staphyloma, and retinal degeneration ------> hole ------> increase risk of RRD(rhegmatogenous retinal detachment).



- Correction of Myopia: **(negative) concave lenses.**

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.

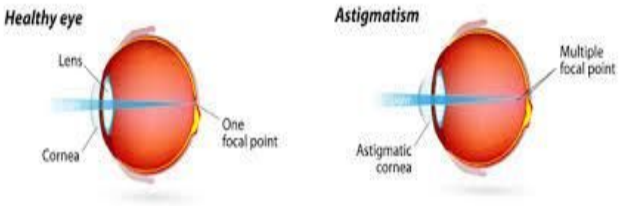
- **Correction** of hyperopia: **(positive) convex lenses.**

Astigmatism:

- Astigmatism is a common and generally treatable imperfection in the curvature of the eye that causes blurred distance and near vision.
- 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.
- 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
- Lenticular causes:
  - Lens dislocation,
  - 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.

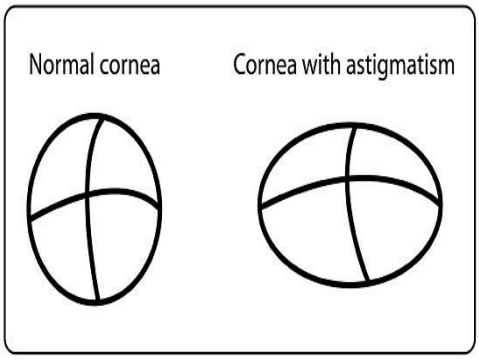
Classification:

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) power and orientation of principal meridians change across the pupil. The principal meridians are not perpendicular.

Another classification of astigmatism:

Three primary types of astigmatism:

- Myopic astigmatism: One or both principal meridians of the eye are nearsighted.
- Hyperopic astigmatism: One or both principal meridians are farsighted.
- Mixed astigmatism: One prinicipal meridian is nearsighted, and the other is farsighted.



Correction of astigmatism: **cylindrical lenses**

To summarize the Tx:

- Cylindrical lens => to correct astigmatism with either myopia or hyperopia.
- Biconcave lens => to correct myopia (- lens)
- Biconvex lens => to correct hyperopia (+ lens)

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
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 becuz it's easirr to flatten than to make it more convex) for myopia or increases it's curvature in Hyperopia.
- Improves unaided visual acuity but may have complications
- Examples: PRK, LASIK, LASEK, EPILASIK

Intraocular surgery: for high power

- 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 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