ACCOMMODATION

Definition

As we know that in an emmetropic eye, parallel rays of light coming from infi nity are brought to focus on the retina, with accommodation being at rest.

However, our eyes have been provided with a unique mechanism by which we can even focus the diverging rays coming from a near object on the retina in a bid to see clearly. This mechanism is called **accommodation**. ln this increase in the power of crystalline lens occurs due to increase in curvature of its surfaces.

Mechanism of accommodation

accommodation is achieved by a change in the shape of lens as below:

When the eye is at rest (unaccommodated), the ciliary ring is large and keeps the zonules tense. Because of zonular tension the lens is kept compressed (flat) by the capsule.

Contraction of the ciliary muscle causes the ciliary ring to shorten and thus releases zonular tension on the lens capsule. This allows the elastic capsule to act unrestrained to deform the lens substance. Title lens then alters its shape to become more convex or conoidal (to be more precise). The lens assumes conoidal shape due to configuration of the anterior lens capsule which is thinner at the centre and thicker at the periphery.

Far point and near point

The nearest point at which small objects can be seen clearly is called near point or punctum proximum and the distant (farthest) point is called far point or punctum remotum. Far point and near point of the eye. These vary with the static refraction of the eye:

• In an emmetropic eye far point is infinity and near point varies with age.

• In hypermetropic eye far point is virtual and lies behjnd the eye.

• In myopic eye, it is real and lies in front of the eye.

Range and amplitude of accommodation

Range of accommodation. The distance berween the near point and the far point is called the range of accommodation.

Amplitude of a ccommodation. Th e difference between the dioptric power needed to focus at near point (P) and far point (R) is called amplitude of accommodation (A). Thus A= P- R.

Amplitude of accommodation and thus the near point of vision (punctum proximum) vary with age.

ANOMALIES OF ACCOMMODATION

Anomalies of accommodation are not uncommon. These include:

- Presbyopia,
- Insufficiency of accommodation,
- Paralysis of accommodation, and
- Spasm of accommodation.

PRESBYOPIA

Pathophysiology and causes

Presbyopia (eye sight of old age) is not an error of refraction but a condition of physiological insufficiency of accommodation leading to a progressive fall in near vision.

Pathophysiology To understand the pathophysiology of presbyopia a working knowledge about accommodation (as described above) is mandatory. As we know, in an emmetropic eye far point is infinity (oo) and near point varies with age (being about 7 cm at the age of l0 years, 25 cm at the age of 40 years and 33 cm at the age of 45 years). Therefore, at the age of 10 years, amplitude of accommodation (A) =100/7 (dioptric power needed to see clearly at near point)-1/ oo (dioptric power needed to see clearly at far point) i.e. A (at age 10) = 14 dioptres;

Similarly A (at age 40) = 100/25 -1/00 = 4 dioptres.

Since, we usually keep the book at about 25 cm, so we can read comfortably up to the age of 40 years. After the age of 40 years, near point of accommodation recedes beyond the normal reading or workiing range. This condition of failing near vision due to age-related decrease in the amplitude of accommodation or increase in punctum proximum is called **presbyopia.**

Causes

Decrease in the accommodative power of crystalline lens with increasing age, leading to presbyopia, occurs due to:

l. Age-related changes in the lens which include:

• Decrease in the elasticity of lens capsule, and

• Progressive increase in size and hardness (sclerosis) of lens substance which is less easily moulded.

2. Age-related decline in the ciliary muscle power may also contribute in causation of presbyopia.

Causes of premature presbyopia are:

• Uncorrected hypermetropia.

• Premature sclerosis of the crystalline lens.

• General debility causing presenile weakness or ciliary muscle.

• Chronic simple glaucoma.

Symptoms

1. Difficulty in near vision. Patients usually complaint of difficulty in reading small prints (to start with in the evening and in dim light and later even in good light). Another important complaint of the patient is difficulty in threading a needle, etc.

2. Asthenopic symptoms due to fatigue of the ciliary muscle are also complained after reading or doing any near work.

3. Intermittent diplopia, occurring due to disturbed relationship between accommodation a nd convergence, may be experienced by few patients.

Treatment

I. Optical treatment. The treatment of presbyopia is the prescription of appropriate convex glasses for near work.

Rough guide for providing presbyopic glasses in an emmetrope can be made from the age of the patient.

• 45 years: + l to + l.25O

• 50 years: + 1.5 to 1. 750

• 55 years: +2 to+ 2.25D

• 60 years: +2.5 to + 30

Exact presbyopic addition required, should however, be estimated individually in each eye in order to determin how much is necessary to provide a comfortable range.

Basic principles for presbyopic correction are:

• Always find out refractive error for distance and first correct it.

• Find out the presbyopic correction needed in each eye separately and add it to the distant correction.

• near point should be fixed by taking due consideration for profession of the patient

• The weakest convex lens with which an individual can see clearly a t the near point should be prescribed, since overcorrection will also result in asthenopic symptoms.

Presbyopic spectacles may be unifocal, bifocal or varifocal(progressive)

2. Surgical treatment of presbyopia is also being considered .

INSUFFICIENCY OF ACCOMMODATION

The term insufficiency of accommodation is used when the accommodative power is significantly less than the normal physiological limits for the patient's age. Therefore, it should not be confused with presbyopia in which the physiological insufficiency of accommodation is normal for the patient's age.

Causes

l . Premature sclerosis of lens.

2. Weakness of ciliary muscle due to systemic causes of muscle fatigue such as debilitating illness, anaemia, toxaemia, malnutrition, diabetes mellitus, pregnancy, stress.

3. Weakness of ciliary muscle associated with primary open-angle glaucoma.

Clinical features

All the symptoms of presbyopia are present, but those of asthenopia are more prominent than the blurring of vision.

Treatment

1. Treatment of underlying cause is essential.

2. Near vision spectacles in the form of weakest convex lens.

3. Accommodation exercises help in recovery.

PARALYSIS OF ACCOMMODATION

also known as cycloplegia refers to complete absence of accommodation.

Causes

1. Drug induced cycloplegia results due to the effect of atropine, homatropine or other parasympatholytic drugs.

2. Paralytic internal ophthalmoplegia (paralysis of ciliary muscle and sphincter pupillae) may result from neuritis associated with diphtheria, syphilis, diabetes, a alcoholism, cerebral or meningeal diseases.

3. Paralysis of accommodation as a component' of complete third nerve parcilysis.

Clinical features

1. Blurring of near vision is the main complaint in previously emmetropic or hypermetropic patients.

2. Photophobia (glare) due to accompanying dilatation of pupil (mydriasis)

3. Abnormal receding of near point and markedly decreased range of accommodation may be required on assessment.

Treatment

1. Self-recovery occurs in drug-induced cycloplegia.

2. Dark glasses are effecrive in reducing the glare.

3. Convex lenses for near vision may be prescribed if the paralysis is permanent.

SPASM OF ACCOMMODATION

Spasm of accommodation refers to exertion of abnormally excessive accommodation.

Causes

l. Drug-induced spasm of accommodation like use of strong miotics such as echothiophate .

2. Spontaneous spasm of accommodation is occasionally found in children who attempt to compensate for a refractive anomaly that impairs their vision.

Clinical features

1. Defective vision due to induced myopia.

2. Asthenopic symploms are more marked than the visual symptoms.

Diagnosis it is made with refraction under atropine cycloplegia.

Treatment

l. Relaxation of ciliary muscle by atropine for few weeks and prohibition of near work .

2. Correction of associated causative factors prevent recurrence.

3. Assurance and if necessary psychotherapy should be given.

Astigmatism

Astigmatism by definition is a condition where the parallel beam of light rays incident on the cornea after refraction are not focused to form a point image near or on the retina. The image may be focused on the retina in the horizontal plane but not in the vertical plane. Most astigmatic cornea have two curves, one is steeper and the other one is flatter curve. The refractive power of the astigmatic eye varies in different meridians. The image is formed as a Sturm's conoid as described before, which is specific for toric surface(resembling rugby ball or an egg) because they are not equally round in all directions. It has two meridians, one is steeper (more curved), the other meridian is flatter(less curved

Causes:

•Corneal: Corneal astigmatism is the result of abnormalities of curvature of cornea. It constitutes the most common cause of astigmatism. Asymmetric cornea (either surface) leading to meridional differences in refractive index

•Lenticular: is rare.it may be

1-Curvatural due to abnormalities of curvature of lens as seen in lenticonus (asymmetric surface).

2-Positional due to tilting or oblique placement of lens as seen in subluxation.

3-Index astigmatism may occur rarely due to variable refractive index of lens in different meridia.

•Other:

1-Posterior retina may be asymmetric, tilted or decentered.

2- eyelid mass lesion

Symptoms

1- Blurring of vision with image distortion at distance and near (most common).

2- Headaches & fatigue especially after reading or other prolonged visual tasks.

3- Asthenopia (pain in or around eye, blurring vision & occasionally double vision)

4-Tilting of the head-

5- Squinting

6-Letter confusion

Classification: by relation between principle meridia

Regular: in which the principle meridians are perpendicular (at 90°to each other) it can be caused by weight of the upper eyelid resting on eye ball.

Irregular: in which the principal meridians are not perpendicular.it is characterized by irregular change of refractive power in different merdia & can only be corrected by

using hard contact lenses or refractive surgery.it can result from scarring of the cornea caused by eye injury or from keratoconus (progressive thinning and steepening of the cornea)

Types of regular astigmatism

1-**With the Rule Astigmatism:** the vertical meridian of cornea is more curved (steepest), because similar condition exist normally (the vertical meridian is normally 0.25 D more convex than the horizontal meridian by the pressure of the eyelid)

* Eg : -3.0D cyl x 180˚

2-**Against the Rule Astigmatism**: the horizontal meridian of cornea is steepest (a rugby ball or American football standing on its end).Eg: -3.0D cyl x 90˚

Classification by orientation of meridian

1-OBLIQUE:the principal meridians are at 90°to each other but do not lie at or near 90° and 180°(e.g. Axis is 45˚ and 135˚) Eg : -3.0D cyl x 45˚.tilting of the crystaline lens is an example.

2-BIOBLIQUE: The meridians are not perpendicular.Eg: -3.0D cyl x 90˚/ -2.0 D cyl x 110˚

Classification based on focus of the principle meridians on to retina

Simple astigmatism

1-simple hyperopic astigmatism: first focal line on to the retina while the other is located behind it.

2-simple myopic astigmatism: first focal line on to the retina while the other is located in front of it.

Compound astigmatism

1-compound myopic: Both the two focal points are in front of the retina.

2-compound hyperopic: Both the two focal points are behind the retina.

Mixed astigmatism

One focal point in front and other behind the retina (myopic& hyperopic)

Classification by clinical sign

1-mild astigmatism: less than 1D

2-moderated astigmatism: 1D-2D

3-sever astigmatism: 3D & more

Diagnosis

1- Snellen chart or other eye charts may initially reveal reduced visual acuit

2-the fan & block technique (astigmatic fan chart):is a test pattern consisting of a semicircle of radiating black lines on a white background for determining the presence and the amount of ocular astigmatism . People with astigmatism will see some of the lines more clearly than others

3-stenopic slit :(a thin slit aperture), where the refraction is determined in specific meridian. This technique is particularly useful when in case where the patient has a high degree or irregular astigmatism.

4-an auto-refractor or retinoscopy may provide an objective estimates of the eyes refractive errors

5-Jackson cross cylinder

6-corneal topography: this advanced technology provide most details information about the shape of the cornea. The patient look at a visual target while the device collect thousands of tiny measurements. The computer then construct a color map, allowing us to see a three dimensional picture of the cornea. Such measurements are important for planning refractive surgery, cataract surgery and for fitting contact lenses.

7-kertometer to measure the curvature of the steepest and the flattest meridians in the cornea front surface.

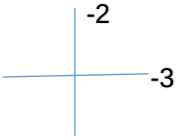
8-kerotoscope (placido disk): a series of concentric rings is projected onto the cornea and their reflection viewed by the examiner through a small hole in the center of the disk. A regular-shaped cornea should show equally spaced symmetric reflections. If the patient suffer from astigmatism or any corneal abnormality the rings will be distorted.

Treatment

1-specticles

*cylindrical lenses: for simple astigmatism (its power is opposite the power of the astigmatism & its axis is perpendicular to the astigmatic meridian)

*spherocylinderical (toric) lenses for compound & mixed astigmatism.



Corrected by toric lens -2 / -1 *90

2-contact lens (CL): hard CL, rigid gas permeable CL, toric CL.

3-refractive surgery: LASIK.

HYPERMETROPIA

A visual defect in which parallel rays of light coming from infinity are focused behind the sensitive layer of retina with accommodation being at rest. The posterior focal point is behind the retina which receives a blurred image

Classification by etiology

1) Axial: Most common, axial length is short (less than 22.22mm)
1mm shorting of axial length produce 3 D of HM
2) Curvature: Flattening of cornea, lens or both, 1mm increase in Radius of curvature= 6D of HM,Never exceed 6D HM physiologically,may be Congenital, trauma and disease
3) Index: Change in refractive index with age (lower than the standard eye)
4) Positional: Posteriorly placed crystalline lens,Occurs as congenital anomaly. Result of trauma or disease
5) Absence of the lens: Seen in aphakia

Physiological HM

Most newborn infants have mild hyperopia, with only a small number of cases falling within the moderate to high range.

Classification by clinical types

1-simple HM

Commonest form,Results from normal biological variations in the development of eyeball,Include axial and curvatural HM.May be hereditary

2-pathological HM

Pathologic HM may be due to mal-development of the eye during the prenatal or early postnatal period, a variety of corneal or lenticular changes, eye or orbital inflammation or neoplasms. It is rare in comparison with physiologic hyperopia.
*Microphthalmia. Nanophthalmia,Anterior segment malformations such as corneal plana, sclerocornea, are associated with high hyperopia.
*Acquired disorders that can cause a hyperopic shift result from corneal distortion or trauma, chalazion, chemical or thermal burn,

3-functional HM:Results from paralysis of accommodation.Seen in patients with 3rd nerve paralysis & Ophthalmoplegia

Classification by degree:

- ***Low hyperopia*** consists of an error of +2.00 D or less. The person may be able to accommodate enough to compensate for their hypermetropia & have clear vision in distant & near without spectacles. With or without symptoms.
- ***Moderate hyperopia*** includes a range of error from +2.25 to +5.00 D. the patient may complain of blurry near vision but with clear distant vision.
- ***High hyperopia*** consists of an error over +5.00 D. the patient here may complain blurred vision for both near & distant.

Total hypermetropia= LATENT +MANIFEST (facultative +absolute)

It is the total amount of refractive error, estimated after complete cycloplegia with atropine. Divided into latent & manifest

Latent hyperopia:
Amount of hyeropia corrected by physiological tone of ciliary muscle (Usually about 1D), High in children, decreases with age & Revealed after abolishing tone of ciliary muscle with atropine.
*signs:
1-eye strain on reading
2-neck pain & tension
3-difficulty doing close visual tasks & stress
Manifest hyperopia: Remaining part of total hypermetropia, Correct by accommodation and convex lens, measured by add strongest lens .Consists of facultative & absolute
*facultative HM:corrected by patients accommodative effort
*Absolute HM:residual part not corrected by either accommodation or ciliary tone.
Manifest (absolute + Facultative) + latent = total hypermetropia
***Example:* a man with accommodation of 6 D. the total HM is 9D with atropine total HM will be as: latent (1D) + manifest 8D (Facultative 6 D + absolute 2 D) = total HM (9D).
When all of the 6 D of accommodation is used, the 2 D of absolute HM corrected with a lens of 2 D. but that will make stress on the ciliary muscle, so you can use the strongest lens od +8 D for facultative & absolute HM (manifest HM).

Age in years	amplitude of accommodation
10	14
20	10
30	8
40	5-6
45	3-4
50	2
60	1
70	1 or less

SYMPTOMS
Principal symptom is blurring of vision for close work. Symptoms vary depending upon age of patient (amplitude of accommodation) & degree of refractive error
1. Asymptomatic
Small error produces no symptoms. Corrected by accommodation of patient
2. Asthenopia: Refractive error are fully corrected by accommodative effort

Thus vision is normal. Sustained accommodation produces symptoms.Asthenopia increases as day progresses. Increased after prolonged near work(Tiredness, Frontal or headache ,Watering Mild photophobia)

Stage of HM variation with age:

- at birth +2+3D HM
- slightly increase in one year of life,
- gradually diminished until by the age 5-10 years
- In old age after 50 year again tendency to HM (Tone of ciliary muscle decreases, Accommodative power decreases, Some amount of latent HM become manifest.More amount of facultative HM become absolute.Practically after 65 year all of it become absolute

Diagnosis:

1-visual acuity: Defective, according to the amount of HM.
2-in severe cases, from birth, the brain has difficulty in merging images from each individual eye.so if the brain never learns to see objects in details,then there is a high chance that one eye will become dominant ,this will cause amblyopia or strabismus.
3-the child with HM will stand close in front of a television, or may have difficulty seeing text books at school or might have problems with catching a ball because of blurred vision & decrease ability to see three dimensional objects.
4-a backward dislocation of the lens produce HM.

Treatment:

1-eyeglass prescription for corrective lenses.convex lens have a positive diopteric value, which causes the light to focus closer than its normal range.
2- a positive diopteric value contact lens.
3-refractive surgery.

Treatment of HM for children in & preschool: they prescribe only for HM more than +3 D or when symptomatic.it is important to detect a disorder or squint & early treating to prevent amblyopia.

Treatment of HM for young adult: If symptoms of eye-strain are marked, correct as much of the total hypermetropia as possible, trying as far as we can to relieve the accommodation. Some patients with hypermetropia do not initially tolerate the full correction indicated by manifest refraction so we under correct them.

Errors of refraction

Emmitropia: The condition of the normal eye when parallel rays are focused exactly on the retina and vision is perfect.

Myopia (shortsightedness):

is a refractive defect of the eye where the parallel rays of light that comes in does not directly focus on the retina but in front of it .Another term for myopia is short sighted that is everything close is clear, everything far away is out of focus and blurred.

Classification of myopia: Myopia has been classified according to:

By cause: Myopia can be classified to:

a- axial myopia. **b- Index myopia.** **c- Curvature myopia.**

To understand the classification of myopia remembers that:

The refractive power ……$P_e = 1/f_e = n_e - 1 / r_e$

Where fe: the focal length of the eye.

ne : the refractive index of the eye.

re : the radius of curvature of the eye.

A- Axial myopia (the commonest):

Is due to an increase in the eye's axial length (**the eye is longer than usual),**

According to equation: the refractive power of the eye increased by reducing the value of f_e.

The causes of (axial length) myopia:

1-Abnormal eye growth: At a very young age the eye may grow quickly, due to genetic problems or congenital glaucoma (continuous high pressure) and the eye ball is 'stretched'.

2-Reading and close work does lengthen the eye and causes myopia. Accommodative effort during near work is thought to be a causative factor in the development of myopia.

3-Cataract or anything preventing light reaching retina.

4- Increased of blood-glucose levels can also cause swelling of the crystalline lens (edema) may causes myopia.

B-Refractive (index) myopia: In this case, the eye is myopic because the refractive index of the eye is higher than the refractive index of the standard reduced eye. The higher refractive index results in the power of the eye are greater than + 60.00D causing the second principle focus to form in front the macula.

C- Curvature myopia is due to increased; curvature of one or more of the refractive surfaces of the eye, especially the cornea so the light is focused in front of the retina and caused myopia

Classification of myopia by Clinical Sign:

Different forms of myopia have been classified by their clinical appearance:

1-Simple myopia, more common than other types of myopia which progresses during childhood and adolescence and seldom exceeds -5 to -6D. It generally stops by the age of 21 years. There are no degenerative changes in the funds and corrected visual acuity is always normal (6/6).

2- Developmental myopia (congenital): It is rare and is characterized by abnormally long eyeball having refractive error of – 10 D. The condition is stationary.

3-Degenerative myopia (pathological, or progressive myopia): which manifests in early childhood. The refractive error rapidly increases during the period of active growth and may reach -20 to -30 D. are characterized by marked fundus changes with a high refractive error and subnormal visual acuity after correction. This form of myopia gets progressively worse over time. Degenerative myopia has been reported as one of the main causes of visual impairment.

Classification myopia by Degree

Myopia, which is measured in diopters by the strength or optical power of a corrective lens that focuses distant images on the retina.

1- Low myopia usually describes myopia of −3.00 diopters or less, where distance vision is blurred but good near vision.

2- Moderate usually describes myopia between −3.00 and −6.00 diopters, where distance vision is blurred but good vision.

3-High myopia usually describes myopia of −6.00 or more, where distance vision and near vision is blurred but distance vision is worse than near vision. People with high myopia are more likely to have retinal detachments, and primary open angle glaucoma. They are seeing floaters, shadow-like shapes which appear singly or in clusters in the field of vision. Roughly 30% of myopes have high myopia.

****Signs and symptoms:**

1-Myopia presents with blurry distance vision, but generally gives good near vision. In high myopia, even near vision is affected, and patients cannot read without their glasses for distance.

2-myopic people often have headaches or eye strain and might squint or feel fatigued when driving or playing sports.

3-The patient sees black spots (floaters) and sometime flashes of light are noticed.

4- In pathological myopia the eye is prominent with dilated pupil. May be an appearance of convergent squint.

5- The blind spot is enlarged and the peripheral vision field is constricted.

****** Diagnosis:**

Usually made during the first several years of elementary school when a teacher notices a child having difficulty seeing the chalkboard, reading, or concentrating.

1- Visual acuity test: by asking the patient to read letters from an eye chart which is kept at specific distance. Based on how much the patient can read from the chart.

2-Retinoscope: It is used to shine light into a patient's eye to examine the reflection of the retina. The light is moved from side to side across the pupil. Retinoscope is particularly useful in assessing corrective lenses, useful in assessing small kids.

Treatment

People with myopia have three main options: eyeglasses, contact lenses, refractive surgery. Note that wearing eyeglasses and contact lenses dose **NOT** treat the cause of the problem but are an adjustment. Eye surgery has reported risks and costy. Eyeglasses (the most common method used to correct myopia, by using appropriate *concave spectacles.*

Binocular vision

Binocular vision is vision in which both eyes are used together. The word binocular comes from two Latin roots, bini for double, and oculus for eye. Having two eyes confers at least four advantages over having one.

First, it gives a creature a spare eye in case one is damaged.

Second, it gives a wider field of view. For example, humans have a maximum horizontal field of view of approximately 180 degrees with two eyes, approximately 120 degrees of which makes up the binocular field of view (seen by both eyes) flanked by two uniocular fields (seen by only one eye) of approximately 30 degrees.

Third, it gives binocular summation in which the ability to detect faint objects is enhanced.

Fourth it can give stereopsis in which parallax provided by the two eyes' different positions on the head give precise **depth perception.**

Such binocular vision is usually accompanied by singleness of vision or binocular fusion, in which a single image is seen despite each eye's having its own image of any object

Singleness of vision

Once the fields of view overlap, there is a potential for confusion between the left and right eye's image of the same object. This can be dealt with in two ways: one image can be suppressed, so that only the other is seen, or the two images can be fused. If two images of a single object are seen, this is known as double vision or diplopia.

Stereopsis

Stereopsis is an ability to make fine depth discriminations from parallax provided by the two eye's different positions on the head.

What causes loss of binocular vision?

There are lots of reasons why binocular vision might become reduced or lost altogether. Reasons include:

• Reduced vision in one eye

• Loss of coordination of movement between the two eyes (squint)

• Problems with the brain comparing images from both eyes

1-Reduced vision in one eye

The brain needs clear images from each eye to compare any slight differences. The differences allow the brain to work out depth and speed of movement. If the sharpness of vision from one eye becomes poor the brain will be less able to do this. Binocular vision will become poorer. If the image becomes very blurred binocular vision may become lost altogether.

2-Loss of co-ordination of movement between the two eyes

The brain needs images of the same visual scene to compare any slight differences. The differences allow the brain to work out depth and speed of movement. If the eyes do not point in the same direction then the visual scenes will be too different. The brain will be unable to work out depth and speed of movement. Binocular vision will be lost.

When the eyes point in different directions it is called squint or strabismus.

There are many different causes of squint. One of them is itself loss of binocular vision.

3-Problems with the brain comparing images from both eyes

There is a special part of the brain that compares the slight differences in the images coming from both eyes. If this bit of the brain does not develop properly or becomes damaged binocular vision may become lost. There are many different causes of poor development or damage to this part of the brain. Most of the time no cause can be identified

Eye dominance

When each eye has its own image of objects, it becomes impossible to align images outside of Panum's fusional area with an image inside the area. This happens when one has to point to a distant object with one's finger. When one looks at one's fingertip, it is single but there are two images of the distant object.

When one looks at the distant object it is single but there are two images of one's fingertip. To point successfully, one of the double images has to take precedence and one be ignored or suppressed (eye dominance). The eye of the image that takes precedence is called the dominant eye.