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Brief Overview about convergence excess esotropia

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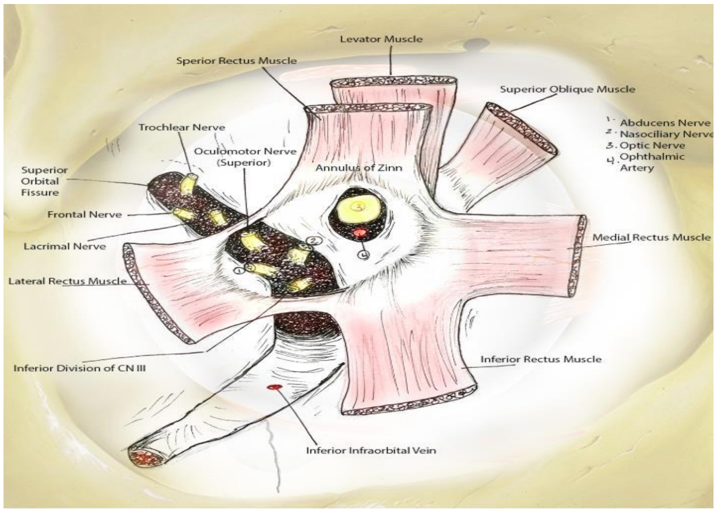
Abstract: Background: Accommodative esotropia is caused by an increased accommodative effort or an abnormally high AC/A ratio. However, several subdivisions of accommodative esotropia is present and must be obviously distinguished as each necessitates different clinical management. Convergence excess esotropia is a condition characterized by an esotropia which is greater for near fixation than for distance fixation after full hypermetropic correction with a single focus lens. Convergence excess esotropia may be classified according to the AC/A ratio into two subtypes: accommodative type and non-accommodative type. Bifocal glasses are a suitable option for the management of patients with a high AC/A ratio and for the hypoaccommodative type. However, the overall success rate with bifocals is still low even in selected patients. Surgery is often eventually needed for most patients with convergence excess esotropia. Surgical options that do not directly address the variability of the angle of deviation entail medial rectus recession with the target angle based on the distance deviation, the near deviation, an augmented formula based on an intermediate angle, or on a prism adaptation test. Surgical options that directly address the variability of the angle include partial myotomy, medial rectus muscle posterior scleral fixation with or without recession, pulley fixation, slanting recession, Y-splitting, or combined recession-resection of the medial rectus muscle.

Keywords: _convergence, esotropia_

Introduction

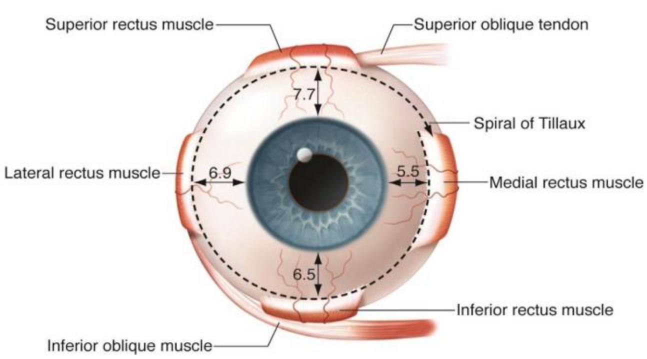
The four rectui muscles originate from a common tendinous ring known as annulus of Zinn, which is an oval band of connective tissue continuous with the periorbita, located at the apex of the orbit anterior to the optic foramen and the medial part of the superior orbital fissure _**(figure 1)**_. The medial and the superior rectus muscles are also attached to the dural sheath of the optic nerve. Rectus muscles then course anteriorly to insert on the anterior aspect of the globe.(1)(2)



(Fig. 1) Origin of extraocular muscles.(3)

Insertions of the recti muscles:

The insertion of the four recti muscles into the globe is anterior to the equator ***(figure 2).*** Spiral of Tillaux is described as a line joining the muscle insertions. This spiral starts at the medial rectus insertion that is the closest to the limbus and continues to the inferior, the lateral and finally the superior rectus insertion that is the farthest from the limbus. The insertion line has a horseshoe shape with the rounded apex facing the cornea, remembering this as the horseshoes are always running toward the cornea. During hooking a rectus muscle, passing the hook several milimemeters behind the central muscle insertion is required to dear the posterior aspect of the horseshoe insertion. Due to the proximity of the rectus muscle insertions, it is easy to hook the wrong muscle during strabismus surgery. (3)

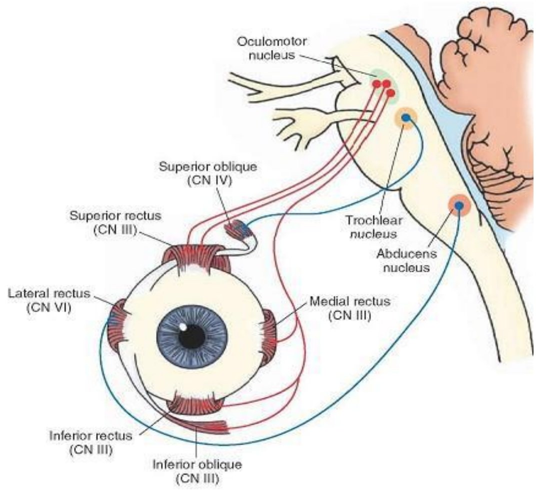


(Fig. 2) *Insertion of extraocular muscles*. (4)

Behind the recti insertions, the thickness of the sclera is the thinnest of the eye, being only 0.3 mm thick. The insertions' widths are all about 10 mm, and the intermuscular spacing (distance between insertions) is only 6 to 8 mm. we can remember that the rectus muscle length is 40 mm for all recti muscles that is also the length of the orbit. (5)

Nerve Supply:

Rectus muscles are innervated from the intraconal aspect of the muscle belly at the connection of the anterior two-thirds and posterior one-third of the muscle. The oculomotor nucleus is situated in the midbrain. (***Fig 3)***. Its nerve moves through the cavernous sinus and superior orbital fissure, where it divides into superior and inferior divisions. The superior division supplies the levator palpebrae superioris and superior rectus muscles. The inferior division supplies the medial rectus, the inferior rectus, the inferior oblique, and gives parasympathetic root to the ciliary ganglion.(6)



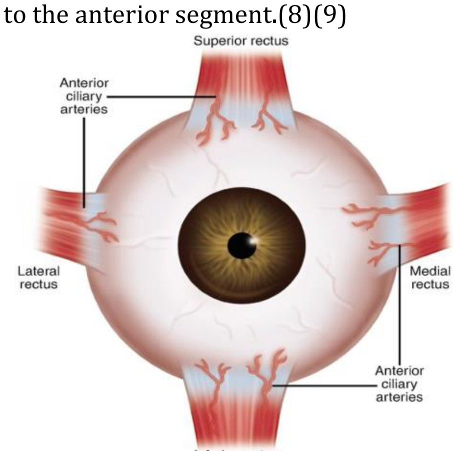
(Fig. 3) Nerve supply of extraocular muscles. (2)

Blood Supply:

The extraocular muscles are supplied by the ophthalmic artery that is a branch of the internal carotid artery. Also, the lateral rectus muscle is supplied by the lacrimal artery, a branch of the ophthalmic artery. The inferior rectus muscle and inferior oblique muscles are supplied by the infraorbital artery, a branch of the internal maxillary artery, arising from the external carotid artery.(7)

The anterior ciliary arteries that supply the anterior segment of the eye travel within the rectus muscles and enter the sclera just anterior to the rectus insertions (***figure 4***) anastomosing with conjunctival vessels and joining the major arterial circle of the iris, *circulus arteriosus major*. The superior and inferior orbital veins drain the extraocular muscles.(7)(8)

Surgical disinsertion of rectus muscles permanently interrupts the anterior ciliary arteries. If surgery is performed on multiple recti muscles simultaneously, anterior segment ischemia may result. The oblique muscles do not convey circulation to the anterior segment.(8)(9)



(Fig.4) Blood supply of extraocular muscles. Note that there are two muscular branches for each rectus muscle except for the lateral rectus muscle which has typically one. (7)

Embryology of the Recti Muscles:

The development of extraocular muscles begins at 3–4 weeks of conception; it is originated from mesoderm. Initial in pregnancy, mesodermal cells intended to become primary myoblasts of individual extraocular muscles are encircled by neural crest cells which guide them to their correct positions and form their connective tissue pulleys.(5)

After the myoblasts develop, cranial nerves migrate from the brain and form neuromuscular junctions. By 6 months of gestation, the extraocular muscles and their surrounding tissues are 3% in their last anatomic positions, but they mature later even after birth.(5)

Anatomy of the medial rectus muscle

The medial rectus is exceptionally a tiny muscle. It has the shortest arc of scleral contact (6 mm) and the shortest tendon length of the recti muscles (4 mm). The inferior oblique muscle, which isn't a rectus muscle, has really the shortest tendon (1 mm) of the extraocular muscles. The medial rectus muscle is a pure adductor in the primary position, it is innervated by the lower division of the third cranial nerve (oculomotor nerve).(10)

The medial rectus is the closest to the limbus of the extraocular muscles (5.5) mm and is thus liable to insult during anterior segment surgical procedures. Accidental removal of the medial rectus muscle is a recognized complication of pterygium removal. The medial rectus is the only rectus muscle without fascial connections to an adjacent oblique muscle and this makes it individual. This lack of oblique muscle connection makes the medial rectus the most difficult to surgically rescue if lost. When disinserted, the medial rectus would be free and retract completely off the globe into the orbital fat, making recovery extremely difficult and, in some cases, nearly incredible. (10)

Physiology of Extraocular Muscles

Extraocular muscles (EOM), unlike other skeletal muscles, contract more than 10 times faster but both are made up of striated fibers of variable size. Whereas other skeletal muscles have up to 100 muscle fibers for every nerve fiber; EOM fibers have ironic innervation at a high nerve fiber to muscle fiber ratio; nearly 1:1 which enhances the accuracy, control and exactness of eye movements. (11)

The muscle cells of the EOM muscles have distinctive structural and metabolic properties. There are two different muscle fiber types: fast muscle fibers and slow muscle fibers. The fast, twitch fibers, are single innervated fibers (SIF), innervated by a large motor neuron. The slow, tonic muscle fibers, are multiple innervated fibers (MIF) innervated by small-diameter motor nerves. (12)

There are two basic forms of eye movements; smooth pursuit and saccadic. Smooth pursuit eye movements are slow accurate eye movements, develop at 4-6 weeks of age and allow the eyes to carefully track a moving object. Saccadic movements are rapid eye movements develop before smooth pursuits, as early as 1 week of age and allow the eyes to maintain with targets moving too fast for smooth pursuit and for quick re fixation from one target to another. (13)

TERMS RELATED TO THE MECHANICS OF MUSCLES.

The ***tangential point is*** the point at which the center of the muscle or of its tendon first comes into contact to the globe. The direction of muscle pull is specified by the tangent to the globe at that tangential point. The location of this point varies when the muscle contracts or relaxes and the globe rotates.

The arc of contact is the curve formed between the tangential point and the center of the insertion of the muscle on the sclera. As the position of the tangential point is changeable, the length of arc of contact varies when the muscle contracts. It is the longest when the muscle is relaxed and its antagonist contracted and the shortest when the muscle is contracted and its antagonist relaxed.

The ***muscle plane*** is determined by the center of rotation and the tangent to the globe at the tangential point (the centers of origin and insertion of the muscle). It can describe the direction of pull of the muscle and determines the axis around which the eye would rotate during contraction (see ***figure 5***).(14)

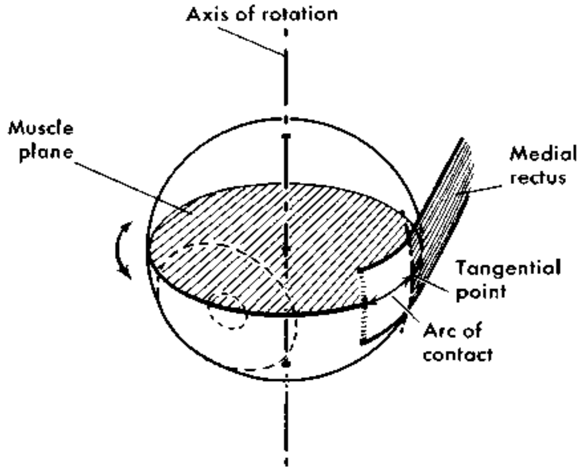
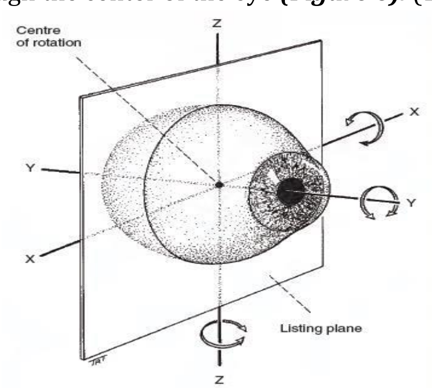


Fig 5. Schematic presentation of muscle plane, medial rectus, axis of rotation, tangential point, and arc of contact.(14)

Principles of ocular movements

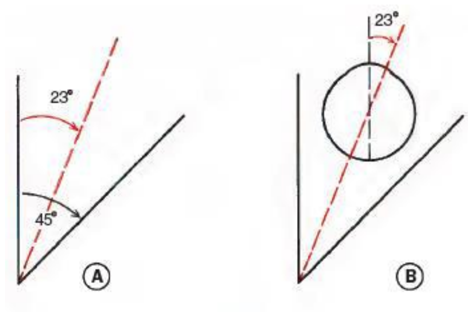
Ocular movements rotate the eye around a fixed center of rotation by contraction and relaxation of multiple muscle groups. ***The axes of Fick*** are the three axes that pass through the center of rotation. They include the Z axis vertically oriented for horizontal rotation, the X axis horizontally oriented for vertical rotation, and the Y axis oriented with the visual axis for torsional rotation. ***Listing's plane*** is an imaginary vertical plane that include the three axes passing through the center of the eye ***(Figure 6)****.* (11)



(Fig. 6) Listing's plane and axes of Fick. (11)

Ocular movements are either ductions, versions or vergence. Ductions are monocular movements around the axes of Fick while versions and vergence are binocular movments. Ductions consist of adduction, abduction, elevation, depression, intorsion and extorsion. Versions are binocular, simultaneous, conjugate movements in the same direction. Vergences, convergence or divergence, are binocular, simultaneous, disconjugate movements in opposite directions. (15)

The lateral and medial orbital walls are at an angle of 45° with each other. The orbital axis therefore forms an angle of about 23°with both lateral and medial walls (Fig. 7A). When the eye is in the primary position of gaze, the visual axis forms an angle of 23° with the orbital axis (Fig. 7B). The actions of the extraocular muscles depend on the position of the globe at the time of muscle contraction.(16)



(Fig. 7) A: relation between medial and lateral orbital walls and the orbital axis, **B**: angle between the visual and the orbital axes. (16)

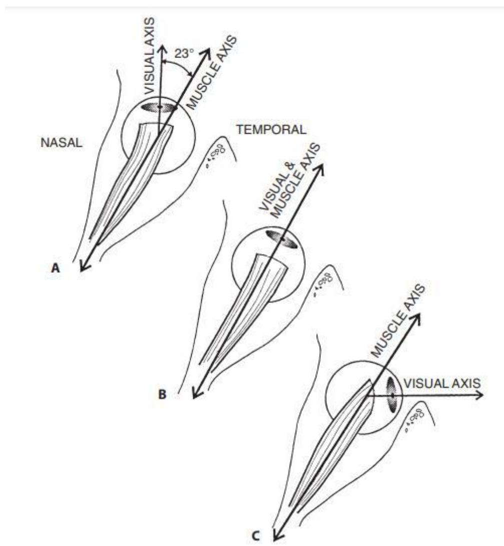
The primary action of a muscle is its major effect when the eye is in the primary position. Subsidiary actions are the additional effects, which depend on the position of the eye. (17)

Horizontal recti muscles

Horizontal rectus muscles action is relatively simple. These muscles have a common muscle plane that is horizontal in primary position and contains the line of vision. Their axis of rotation corresponds in primary position with the vertical Z axis, so when the eye is in the primary position; they have only primary actions horizontally on that vertical Z axis. Thus, the contraction of one of the horizontal rectus muscles yields a complete rotation around the vertical axis; the lateral rectus and the medial rectus abducts and adducts the line of gaze respectively. (14)

vertical recti muscles

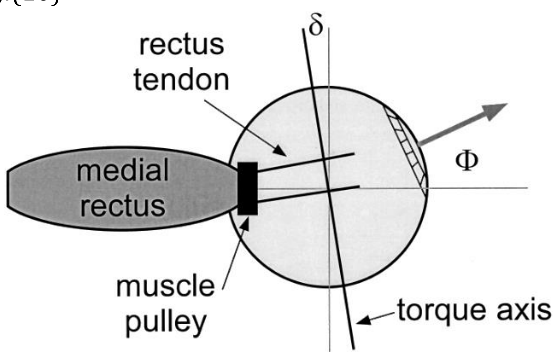
While, the vertical recti form an angle of 23° with the visual axis and have primary and secondary actions. So, when the globe is abducted 23°, the visual and orbital axes overlap, and so has no secondary actions and can act purely as vertical movers on the horizontal X axis. If the globe was adducted 67°, the angle between the visual and orbital axes would be 90°and so in this situation the vertical recti could only produce torsional movement ***(Figure. 8)*** (16)



(Fig. 8) Action of the vertical rectus muscles with the eye in various positions of gaze; **(A)** The eye is in primary position with the visual axis 23° nasal to the muscle axis. **(B)** The eye is abducted 23° from the primary position, and the visual axis is in line with the muscle axis. **(C)** The eye is abducted more than 23° from the primary position, and the visual axis is now temporal to the muscle axis(16)

Muscle Pulley:

Muscle pulleys are the functional origins of the EOMs that are able to regulate the actual pulling direction of each rectus muscle by reducing sideslip of the extraocular muscles during globe rotation**.** They are connective tissue that connect the rectus muscles to the orbital walls. The Tenon's capsule encircles each extraocular muscle like a sleeve ***(Figure 9)***.(18)



(Fig. 9): The fibromuscular pulleys keep the rectus muscle bellies fixed in the orbit, regardless of the orientation of the eye. However, the pulling directions of the extraocular muscles, and hence the torque axis, are altered in a manner depending on eye position. In this model, the magnitudes of rotation of the torque (**ẟ**) and the eye (Φ) axes are related by a pulley coefficient (**k**).(16)

Pulley displacement can clinically simulate muscle dysfunction, and orbital imaging using magnetic resonance imaging MRI may be needed to distinguish it accurately from palsy. (6)

Defects of eye movement as "V" and "A" patterns can be caused by displacement of the muscle pulleys. Muscle pulleys minimize upward and downward movement of the bellies of the medial and lateral rectus muscles during up gaze, downgaze and horizontal movement of superior and inferior rectus bellies in left and right gaze. (17)The horizontal strabismus can be treated by increasing (resection) or decreasing the strong point of some EOM (EOM) by surgical operation. (19)The muscle pulleys are near to the real physical state, so they can be used to decide the surgical amounts of the EOMs in strabismus and provide a theoretical suggestion to the clinician for the treatment of many other eye movement disorders. (20)

Esotropia

Esotropia is derived from the Greek word, ésō, meaning within, and trópos, meaning a turn. Esodeviations are caused by mechanical or innervation factors or a combination of both. (21)(14)

As with other types of strabismus, an esodeviation may be esophoria which is controlled by fusional divergence, intermittent esotropia which is controlled intermittently, or manifest esotropia.(15)

Other adjustable features of esodeviations include; their state of comitance, the age of the patient at the onset, the mode of onset, the angle size strabismus, and the state of fixation behavior (unilateral or alternating) and the presence of sensorial adaptations.(1)(14)

Esotropes are difficult to classify because the several characteristics may overlap in a single group of esotropes. For example, it is established that the features of infantile esotropia are justly identical in most patients and are dissimilar in those with accommodative esotropia. Yet, accommodative factors may become superimposed in patients with essential infantile esotropia.(10)(14)

Esotropia is closely associated to accommodation and accommodative convergence. This association is essential in all forms of ET, and is not restricted to pure accommodative ET. Appropriate controlling of hyperopia and accommodation are essential in treating all types of ET (21)(14)

Table 1 classifies briefly types of esotropia.

Classification of Esodeviations (1) (14)

I. Comitant esodeviations

A. Accommodative esotropia

1. Refractive accommodative esotropia (normal AC/A)
2. Non refractive accommodative esotropia (high AC/A)
3. Hypo accommodative esotropia (reduced NPA)
4. Partially accommodative esotropia

B. Non accommodative esotropia

1. Infantile esotropia 2. Non accommodative convergence excess (normal AC/A)
3. Acquired (basic) esotropia 4. Acute-onset esotropia
5. Divergence insufficiency or paralysis 6. Cyclic esotropia
7. Recurrent esotropia

II. Incomitant esotropia

A. Paralytic

B. Non paralytic

1. A- and V-pattern esotropia 2. Retraction syndrome
3. Mechanical-restrictive esodeviations
   a. Congenital fibrosis of extraocular muscles
   b. Acquired restriction (endocrine myopathy, trauma to orbital wall, excessive resection of medial rectus muscle(s), myositis, strabismus fixus)

III. Secondary esodeviations

A. Sensory B. Consecutive

Accommodative Esotropia

Accommodative esotropia is caused by an increased accommodative effort or an abnormally high AC/A ratio. However, several subdivisions of accommodative esotropia is present and must be obviously distinguished as each necessitates different clinical management.(1)

Refractive Accommodative Esotropia (Normal AC/A Ratio)

Definition and mechanism

Refractive accommodative esotropia is an esotropia that is returned to orthotropia at all fixation distances, (near, far), and in all gaze positions by optical correction of the causing hypermetropic refractive error.

The majority of patients with uncorrected hypermetropia will try to sharp the image haze by increasing accommodative effort and so increasing accommodative convergence. Esotropia will develop If the fusional divergence amplitudes are insufficient in the presence of a normal or a high AC/A ratio. But If the fusional divergence amplitudes are sufficient, an esophoria will be developed. The patient may remain orthotropic if the AC/A ratio is low or normal as the convergence made by elevated accommodation is subnormal or normal. Lastly, few patients with uncorrected high hypermetropia may remain orthotropic because they favor blurry vision over the continuous effort of excessive accommodation. Those patients may develop a mild form of deprivation amblyopia in both eyes due to ametropic amblyopia or due reduced near point of accommodation because of accommodative deficiency, or both.(14)

Clinical Characteristics

The accommodative esotropia onset, whether refractive or non-refractive, is between the ages of 2 and 3 years. The onset can be late until adolescence or even adulthood, but rarely seen in children of 1 year. The ocular deviation is variable and typically larger at near than at far fixation (near far disparity). Usually; there are asthenopic symptoms, closure of one eye when doing close work, or intermittent diplopia complaints.

Therapy of Refractive accommodative esotropia

Initially, it is mandatory for recovery to completely correct the hypermetropic refractive error.(4) ***(figure 10)***

FIG 10: A patient with refractive-accommodative esotropia may have *A,* manifest esotropia without glasses; *B, orthotropia* with Prescription of the full cycloplegic hyperopic correction(14)

The majority of patients who have refractive accommodative esotropia have an outstanding outcome in terms of binocular vision and visual acuity. Present controlling approaches result in an obvious reduction in the incidence of amblyopia. However, the grade of hyperopia remains stable with poor predictions for putting an end to spectacles wear. The probability that extended term full time spectacles wear slow down emmetropisation must be respected. On the other hand; It is also possible that these patients may behave in a different way with normal and be appointed to remain hyperopic.(22)

If the distance deviation is reduced or vanished by spectacles but esotropia remains at near fixation, the AC/A ratio is higher than normal (non-refractive accommodative esotropia), or the patient has a non-accommodative convergence excess. If the spectacles only partially reduce the angle of strabismus both at near and distance fixation, then the strabismus is not totally refractive accommodative in nature (partially accommodative esotropia).(21)

Non refractive Accommodative Esotropia (High AC/A Ratio)

Definition

Non refractive accommodative esotropia is well-defined as an esotropia that is unrelated to an uncorrected refractive error, greater at near than at distance fixation, and, in the presence of a normal near point of accommodation, there is an abnormally high accommodative convergence AC/A ratio. It is closely linked with an abnormal relation between accommodation and accommodative convergence; the effort to accommodate makes an abnormal response (high AClA ratio). (14)(21)

Clinical Characteristics

Most patients with non-refractive accommodative esotropia present between the ages of 6 months and 3 years.(21) Non refractive accommodative esotropia most commonly occurs in patients with moderate grades of hypermetropia but can be present in emmetropia ***(figure 11)*** ,high hypermetropia or even myopia.(14)

FIG 11: ametropic patient (A) orthophoric at distance fixation and (B) 25 PD ET at near fixation.

In non-refractive accommodative esotropia, with fully corrected refractive error, there is a significant esodeviation at near fixation on an accommodative fixation target and a high AC/A ratio recognized by the gradient method so can be differentiated from the non-accommodative convergence excess condition.(14)

With all types of strabismus; It is essential to measure the angle of deviation at near fixation with accommodation fully controlled, particularly in accommodative esotropia patients. Because they may try to keep their eyes aligned at near fixation by partial accommodation only or not accommodating at all making a frequent cause of diagnostic error. Using a fixation target that necessitates full accommodation to identify small details will eliminate this error.

If the angle of strabismus is measured at distance fixation in primary position and at near fixation in downward position; a confusion may arise in diagnosing a high AC/A ratio esotropia and a V-pattern esotropia. In the V pattern esotropia, the deviation increases typically only in downward gaze irrespective of whether the patient fixates at near or distance. With an accommodative esotropia, the deviation will increase at near fixation irrespective of the position of the eyes in which the angle of strabismus is measured.(21)(10)(14)

Non accommodative convergence excess

Non accommodative convergence excess esotropia (CEET) patients are those who look like high AC/A esotropes being esotropia at near fixation that is larger than at far fixation but do not have high AC/A ratio and the near deviation does not decrease with additional plus lenses. They are said to have a non -accommodative convergence excess, for which the pathophysiology is unclear. This difference is debate, because they can be treated the same as high AC/A esotropes, e.g., operating for the near angle measured through the distance correction.(21)(10)

Nonsurgical plans of convergence-excess esotropia CEET include observation only and single vision lenses with or without near plus addition like bifocals and progressive addition lenses (PALs). Several studies supported using bifocals and PALs as the primary management strategy due to the effectiveness of these two optical modalities in providing ocular alignment in patients with non-refractive accommodative (NRA) esotropia; however, others confirm that early surgical intervention can be a more conventional strategy than optical treatment. They noted that this method might be ineffective or even harmful so they need to accept the surgical intervention. In practice, the prescription of near plus addition lenses eithier bifocals or PALs could have positive and negative effects in the treatment course.(23)

Therapy of near far disparity esotropia

Refraction

All Children with ET Need to be refracted after Full Cycloplegia. It is better for a child with ET to do a cycloplegic refraction at least once a year. Identifying a change in anisometropia or hyperopia and making correct changes in the child's refractive management may avoid a decline in alignment or amblyopia recurrence before it occurs. It was standard to do atropine refractions in all esotropic children for Years ago. Consequent studies have shown that appropriate use of cyclopentolate can attain the same results in most children. This usually involves cyclopentolate 1% processed twice, or cyclopentolate 2% processed once for most children. Blue iris Children may attain adequate cycloplegia with cyclopentolate 1% given once, but darkly pigmented iris children may need tropicamide as an addition to cyclopentolate. However, the peak of cycloplegic effect of cyclopentolate reaches after the mydriatic effect and takes around a complete 40 min; it can take up to 75 min in children with darkly pigmented iris.(21)

A stable endpoint of the retinoscopic reflex noticed during retinoscopy is an important evidence that the cycloplegia is complete. If cycloplegia is not complete, enhancing the drops with supplementary cycloplegic agents or waiting longer for reaching peak the effect is indicated. If glasses were prescribed and there is a residual deviation, we can repeat refraction using atropine.

Be cautious that cyclopentolate 2% can have considerable central nervous system effects, principally in small children and children with seizures or other neurologic problems. Cyclopentolate 2% is more likely to cause problems than cyclopentolate 1% administered twice. We can think that one drop of the 2% concentration provides as much medication as the 1% administered twice, but that is not true. The 2% concentration delivers more medication systemically because the systemic diffusion gradient is determined by the concentration of the drop it self.(21)

Calculating accommodation convergence accommodation ratio (AC/A ratio)

Accommodation convergence accommodation ratio (AClA ratio) is the ratio of Accommodative convergence (AC) made per unit of Accommodation (A) that would be between 3 and 5:1 PD/D normally. It performs an important role in the development and prediction to treatment of accommodative esotropia. People with a high AC/A ratio have more convergence when they accommodate at near which can induce an esotropia. In general, a high AC/A ratio is associated with earlier presentation, higher incidence of surgery and lower incidence of restoration of binocularity.(24)

AC/A is usually calculated using one of two methods; the gradient method and the heterophoria method. They are theoretically dissimilar methods and give quantitatively different results but usually are qualitatively similar, e.g., high, low, or normal. (20)

Gradient Method

In the gradient method we can measure the angle of deviation before and after adding either plus lenses (+2 or +3 diopters) for a near measurement or minus lenses (1–2 diopters) for a distance measurement. Trusting on the hypothesis that added plus lens power at near represent the amount of relaxation of accommodation at near and the amount of minus lens power added at distance represent the patient's additional accommodation. The change in deviation is attributed to that change in accommodation, so one can calculate how much accommodative convergence arises per diopter of accommodation.(21)

In the following example we can measure the angle of deviation at a fixed distance at near (1/3 m) and then re measure after adding plus lenses (+3 lenses) to relax the accommodation. (24)

The ratio then is

AC/A = D - D'/P

where

• D = the primary deviation
• D′ = the deviation with plus lenses
• P = power of Plus lens in diopters

Usually this is measured with fixation at 1/3 m, using +3 lenses.

For example:

6-year-old girl presents to clinic with ahistory of esotropia for 6 months. On examination, she has a deviation of 50 PD for near and 20 for distance. The deviation for near decreases to 20 PD when it is measured with her wearing +3DS OU in a trial frame.

The AC/A ratio then is

Dn - Dn' /power of lens = 50-20/3 = 10:1 PD/D

where

• Dn = Deviation at near
• Dn′ = Deviation at near with plus lenses

• Power of lens = Power of plus lenses used

Thus, this girl has a higher AC/A (10:1) than normal (3-5:1) and so the bifocal glasses which would reduce the accommodative effort for near and therefore can treat the esotropia.(24)

Heterophoria Method

This method takes into account the inter pupillary distance and uses the measurements of the deviation at near and distance.(24)

AC/A = IPD (in cm) + Dn – Dd/ D

where

- IPD = Interpupillary distance in cm
- Dn = Deviation at near
- Dd = Deviation at distance
- D = Fixation distance at near

The heterophoria method involves comparing a distance deviation to a near deviation and is based on the assumption that the difference is completely due to accommodative convergence. If the distance and near deviation are the same, the AC/A ratio by this method equals the inter pupillary distance (ipd) in cm.(21)

If the near deviation differs from the distance deviation, the AC/A ratio equals the difference between the distance and near deviation divided by the dioptric equivalent of the near testing distance. This would be 3 if the near test distance was one-third meter, which is then added to the ipd in centimeters.

If the near deviation is more esotropic or less exotropic than the distance finding, the quotient of the fraction should be added to the ipd.

If the near deviation is less esotropic or more exotropic than the distance finding, the quotient should be subtracted from the ipd.

For example, 7-year-old boy presents to clinic with a history of esotropia for 6 months. On examination, he has a deviation of 50 PD for near and 35 for distance, if the ipd is 5 cm, the heterophoria AC/A is 10. This is attained by adding the difference between the distance and near ET, 15 Δ, by the dioptric equivalent of the near testing distance, 3, which equals 5. This is added to the ipd of 5, for a final result of an AC/A of 10:1. In practice, you can assume that the ipd is about 5 cm in children and 6 cm in adults.

The AC/A ratio then is

= IPD (in cm) + Dn – Dd/ D

= 5 +(50-35)/3 = 5+5=10:1 PD/D

An AC/A can be said to be "perfect" if the amount of accommodative convergence is exactly equal to the amount needed to maintain the same alignment at distance and near fixation. In that case it would be equal to the ipd in centimeters (about 5 for a child and 6 for an adult)(21)

why do the two methods give some- what differing results?

In clinical settings, both the gradient and heterophoria methods produce what is called a stimulus AC/A which means that the change in accommodation is exactly equal to the stimulus used. In gradient AC/A if the stimulus is −2 diopters lenses at distance, the patient accommodates 2 diopters more; if +3 diopters lenses were used at near, the patient relaxed accommodation by 3 diopters. But this may not be what happens. A young child may not exert the expected accommodative effort if tested through added minus lenses at distance, and also a presbyope may not be able to.

On the other hand, a heterophoria AC/A consideres that all differences in the distance and near measurement are due to accommodative convergence and do not take into account the role of other factors like the tenacious proximal fusion in exotropes.(21)

Which is the preferred way to measure the AC/A?

Both gradient and heterophoria methods for calculating AC/A have their uses. If we want to know how much reduction we will get in an XT using over-minus lens therapy, a gradient method AC/A using minus lenses at distance is used.

We are interested in a heterophoria AC/A ;If we want to know if a bifocal, will be useful managing an esotrope, and comparing the answer with the refractive error.(21)

PRESCRIBING BIFOCALS

In children with esotropia greater at near fixation than at distance, it is very suitable to bear in mind subgroups, which vary in terms of manages and responses to treatment. The first are the convergence excess children, who have normal AC/A ratios, there is no role for bifocal as their alignment does not improve with it. The second are the children who are esotropic at distance and near fixation and remain esotropic when adding + 3.00 or not. In this situation the bifocals will simply convert a near esotropia to a smaller near esotropia which could encourage gross binocularity but this benefit cannot be balanced by the numerous disadvantages of bifocals and so they can benefit from surgical treatment. The third are children with good motor fusion at distance but esotropic at near fixation and still have a significant deviation at near with or without adding + 3.00 so the bifocal has no role. Lastly the children with good motor fusion at distance fixation and esotropic at near fixation but show motor fusion with + 3.00 adds. These are the high AC/A patients for whom bifocals can be prescribed, we can give the least plus lens which can reduce the near deviation, and try to taper the bifocal gradually. Some of those children wish to stop wearing bifocals over time, and so strabismus surgery is an option for them(25)
The bifocals are the conventional treatment of high AC/A esotropia, they can reduce or eliminate the esotropia by reducing the accommodative effort thus reducing convergence at near fixation. (25)they are indicated for patients who are orthophoric in the distance but have 10 PD esotropia or more at near sufficient to disturb near fusion (10 PD). Meanwhile the esotropia at near is the main problematic to normal binocular single vision in patients with non-refractive accommodative esotropia (high AC/A ratio), the treatment with bifocal adds are ideal. (21) ***(figure 12)***

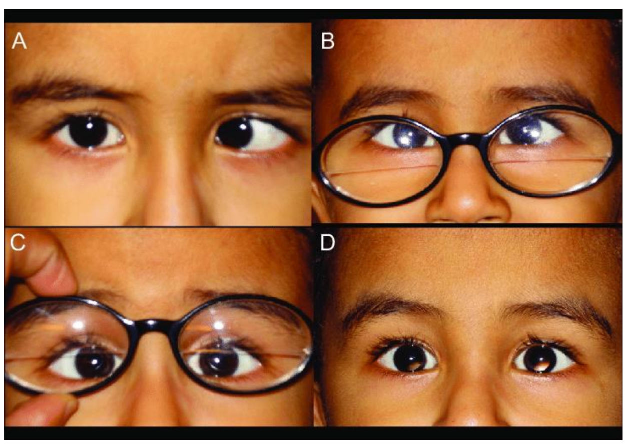


Fig 12:Serial face photographs of a child with Partially accommodative esotropia with convergence excess showing (A) left esodeviation without refractive correction, (B) residual esodeviation with spectacle correction, (C) residual esodeviation with spectacle correction and +3.0 D addition, and (D) residual esodeviation under cycloplegia(26)

The add will relax near accommodation, If the AC/A ratio is 7 (high), then a 3.00 add will reduce the near esotropia by 21 PD. Usually, start with a maximum near add of 3.00 or 2.5 D. Over time, the bifocal add can be diminished slowly to promote divergence. (21)

progressive lenses, although cosmetically preferable, should not be substituted for bifocal prescribed for the treatment of accommodative esotropia because children may not be motivated to look extremely downward during visual activities at near as the add is in the lower portion of the lens.(21)

Frame selection is very important for effective outcome:

you can give the optician a printed contribution of supplementary information of the fitting considerations to facilitate a successful outcome. For bifocals for the first time; you can usually order executive bifocal or a wide D segment to bisect the pupil. Then you can order it located at the bottom of the pupil, and yet at the lower eyelid margin when they get older and become familiar to using it. Idyllically, the frame should be of a style so the pupil is almost in the lens geometric center, both up and down ***(Figure. 13)***

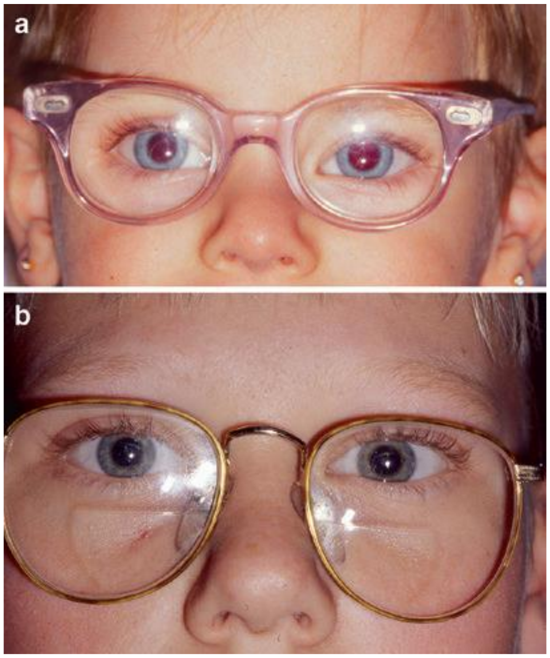


Fig. 13: (**a**) A good frame style for an infant. The pupil is near the geometric center of the lens. **(b)** A poor frame choice for a child in need of a bifocal. The frame has the pupil positioned disproportionately near the top of the lens.(21)

The frames should have curves wrapping around the ears (called a riding bow) to avoid slippage. A frame with a solid nose piece like a form-fit or saddle bridge is better. Frames with non-joined flexible nose pads are not suitable, as they rarely stay in place firmly enough, although they are being often recommend by opticians because that they can be adjusted to compensate for the fitting errors. Lastly, avoid frames that pushes the frame down on the child's face.

A Wide "D-Segment" Is Preferred

The flat-top division that divides the pupil is the most appropriate bifocal. Don't prescribe a low bifocal that a child can simply overlook which is a common error. D-style segment is better than executive bifocal; because a D-style segment is a flat-top segment that can come in measurements nearly equal to the parallel measurement of the lens also they are significantly thinner and lighter than an executive segment with the same prescription. ***(Figure. 14)*** shows two pairs of spectacles with the same prescription +5.00 OU with a +2.50 add. The edge thickness of the D-segment lens is thinner than the executive segment.

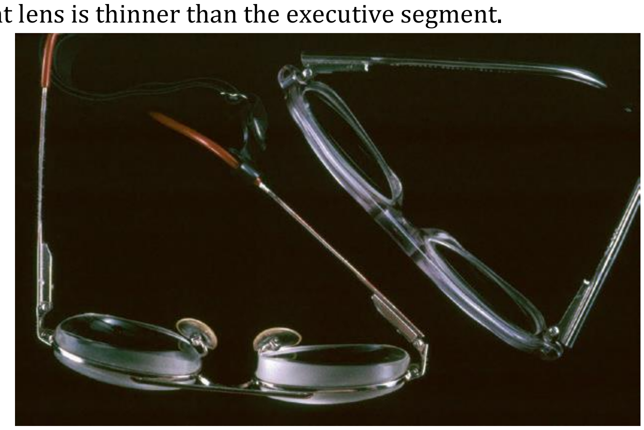


Fig. 14: Two pair of spectacles with equal prescriptions, +5.00sph OU with add +2.50. the pair on the upper right is a wide D-segment which is thinner and lighter than the pair on the lower left is an executive bifocal which is thicker and heavier.(21)

The Protocol of weaning out bifocal

In many cases, the bifocal can be abolished by 10 to 12 years of age. There is a solid (but unconfirmed) idea that a child can expand the need of a bifocal if it is gradually decreased in strength a little bit at a time instead of abruptly going from a +2.50 add to no bifocal at all. Some physicians report good results using a randomly approach like decreasing the power of the bifocal by 0.50 or 0.75 diopters each year, irrespective of what effect that appears to have during the outpatient clinic exam.

kushner keep a child in the full-strength bifocal for 2–3 years and then try to decrease its strength. On each subsequent yearly exam, he can see the effect of −0.50 or −0.75 diopters held over the bifocal on the alignment at near. If control remains good, and the increase in the angle is small (usually 10 Δ or less), he can decrease the bifocal strength accordingly.(21)

Although bifocals may be successfully discontinued in a majority of patients at an average age of 9.5 years, a significant percentage require long-term wear, some, despite surgery. The only factor that predicted long-term bifocal wear was a relatively high AC/A.(23)

Drawbacks of bifocals

Bifocals have many significant drawbacks. Even when suitably made, a bifocal can interfere with the active lifestyles of many children. They can make normal children seem clumsy when on the playground or walking down steps. They are also cosmetically not preferred. Because of these considerable disadvantages, most ophthalmologists would like to take most of the high AC/A patients out of bifocals, but are not been able to do that to avoid potentially harming their binocular development.(25)

Although bifocal may preserve the binocular development they did not improve sensory outcomes in children with high AC/A accommodative esotropia who else responded to the full hyperopic correction. Patients who are tropic at near with a 3.00 D add appear to be at highest risk of having a deprived outcome with bifocals.

The costs and logistic difficulty of bifocal therapy could be abolished by treating patients with high AC/A accommodative esotropia with a single-vision lenses, not bifocals, which would reduce the cost of care while standing the quality of treatment outcomes(27)

Also bifocals were founded to be associated with large near deviation and decompensation of distance deviation to more than 10 PD and so increased risk of surgery at Follow-up (27)

The prism adaptation test (PAT) role in partly accommodative esotropes both with and without a high AC/A

Prism adaptation is prescribing press-on base out prism for the residual esotropia with full hypermetropic correction. The patient is reassessed after wearing the prisms for about 2 weeks. If the esotropia has increased, then the prisms are increased. This regimen continues at 1- to 2-week intervals until the deviation has stabilized. The surgeon operates on the larger prism-adapted angle as confirmed by the press-on prisms so the under correction rate is decreased and success rate of operation is increased.

The disadvantage of prism adaptation is that it is time consuming and costly. Another disadvantage that was observed by some surgeons is that prism adaptation may create or produce a larger deviation, rather than uncover a larger latent deviation.(21)

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