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The impact of optical correction on heterophoria and AC/A ratio

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Abstract

This thesis examines how heterophoria and the AC/A ratio are affected by optical correction in a group of young adults who are visually uncomfortable. When fusional reserves are inadequate, heterophoria—a latent misalignment of the eyes that manifests when binocular vision is impaired—can manifest as symptoms. The goal of the study is to ascertain if providing the right refractive correction will enhance binocular alignment and reduce related discomfort.

This cross-sectional study aims to evaluate patients before and after one month of wearing their optical correction, each one will undergo a refractive correction, visual acuity testing and heterophoria measurements and AC/A ratio calculations.

The therapeutic utility of optical correction as a first-line therapy for symptomatic heterophoria will hopefully be shown in the results. In order to provide efficient and customized visual management, the study also highlights the significance of measuring phoria and the AC/A ratio as part of routine optometric examinations.

Introduction

Proper alignment of the eyes is guaranteed by a normally functioning sensory and motor fusion mechanism. If sensory fusion is artificially suspended by excluding one eye from participating in vision, motor fusion is “frustrated,” and a measurable relative deviation of the visual axes will appear in most patients. When the obstacle to sensory fusion is removed, motor fusion in most patients will return the visual axes to their proper relative positions. The relative deviations thus elicited are called heterophorias, a very useful term. Since heterophorias become evident only when normal cooperation of the eyes is disrupted, they may be defined as deviations kept latent by the fusion mechanism. [1]

Heterotropia occurs when the two eyes are not directed towards the fixation point and this affects about 3% of the population (Adler 2001). Although most people do not have a heterotropia, they will still exhibit a tendency for the eyes to misalign when they are dissociated, such as when one eye is covered. This tendency is defined as a heterophoria (Millodot 2000). Since heterophoria is ubiquitous it would clearly be inappropriate to argue that heterophoria very commonly needs treatment. But heterophoria signifies that a person is having to apply fusional vergence to overcome the dissociated deviation and in some cases this effort can be too much and results in symptoms. Rarely, a patient who has trouble compensating for a heterophoria may avoid symptoms by developing foveal suppression (Tang & Evans 2007). Even though these cases may not have symptoms, they can still require treatment because there is a risk of the heterophoria deteriorating to heterotropia if it is not treated or corrected. A heterophoria that gives rise to symptoms or suppression is defined as decompensated (or uncompensated) heterophoria (Millodot 2000).

The factors that can cause a heterophoria to decompensate. Essentially, there are three factors that can cause a heterophoria to decompensate. First, if the heterophoria is very large (eg an esophoria in a child resulting from high latent hypermetropia) then the heterophoria may just be too much for the motor and sensory fusion to cope. Working at an abnormally close working distance could also cause the heterophoria to increase to an intolerable degree. Second, the motor fusion (fusional reserves) may be inadequate. For example, a person who has a near exophoria may become ill and as his or her general health deteriorates the fusional reserves may weaken to the point when they can no longer comfortably overcome the heterophoria. [2]

It is a real matter that most people are ignorant of it. as studies done on Australian school children showed that , exophoria, not orthophoria, was predominant for near. Exophoria was more prevalent in children of East Asian origin. Longitudinal studies are needed to establish if incident heterotropia is preceded by heterophoria. [3]

Contrary in north-Africa there is not as much prevalence of heterophoria, most people don't even know what it is.

The problematic

Astigmatism and hyperopia are examples of refractive abnormalities that can make it harder for the eyes to stay in alignment. The visual system may be less stressed by rectifying these faults with the right lenses, which might lessen the severity of a heterophoria or enhance the body's capacity to adjust for it. This begs the question: **To what extent can optical correction alone stabilize or improve binocular alignment in patients with symptomatic heterophoria?**

The hypothesis

We say that the optical correction can really improve the binocular alignment if the patient wears his glasses all the time and the optician take in consideration the proper measurements such as the pupillary distance PD to ensure a proper correction.

Chapter I:

Overview of binocular vision

1.1. Anatomy of the Eye:

I.1.1 The Eyeball:

The eye is a small sphere with a diameter of 2.5 cm, comprising the wall of the eyeball and the transparent media of the eye.(1) [4].

The ocular wall consists of 3 concentric tunics:

- Fibrous tunic: It is an outer layer comprising two parts, the cornea and the sclera. They are resistant, thick, and made of collagen fibers. The cornea is located at the front; it is transparent and serves as a window for the eye. The sclera is at the back and is opaque.
- Vascular tunic: It is a musculo-vascular membrane that lines the fibrous membrane, adheres to the deep surface of the cornea while remaining at a distance from the cornea. It includes, from back to front: the choroid, the ciliary body, and the iris.
- Nervous tunic: It is the innermost layer of the layers constituting the eyeball. It includes the retina and the optic nerve . [5]

It contains three dioptric media:

- The lens: It is a transparent biconvex lens located behind the iris and in front of the vitreous body, surrounded by a capsule from which it can be surgically extracted.
 - The aqueous humor: It is a colorless and clear liquid that is constantly renewed, responsible for maintaining intraocular pressure. It fills the two chambers in front of the lens: the anterior and posterior chambers, which communicate with each other and are separated by the iris.
- The vitreous body: It is a transparent semi-liquid substance that fills the ocular cavity behind the lens. It represents 90% of the volume of the eye .

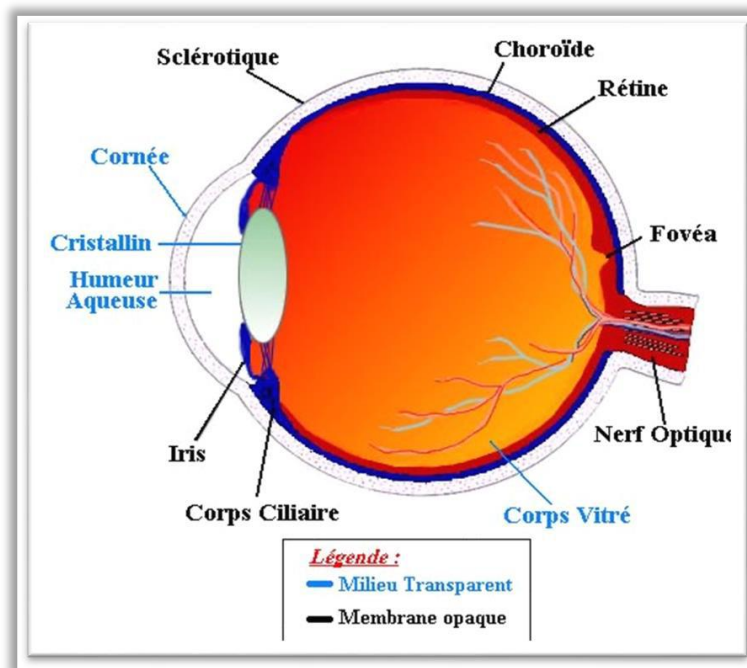


Figure 1: Anatomy of the eye

I.1.2 The Oculomotor Muscles

The oculomotor muscles ensure the mobility of each eyeball individually (ductions) and of both eyes simultaneously (versions and vergences). They guarantee good binocular vision and good stereoscopic vision. They consist of six main muscles:

a. The rectus muscles: There are 4 rectus muscles

- The superior rectus muscle: Mainly allows the eye to move upwards (elevation of the gaze)
- The inferior rectus muscle: Mainly allows the eye to move downwards (depression of the gaze)
- The lateral rectus muscle: Mainly allows the eye to move towards the temple (abduction)
- The medial rectus muscle: Mainly allows the eye to move towards the nose (adduction)

b. The oblique muscles: There are 2 oblique muscles

- The inferior oblique muscle: Allows the eye to rotate on itself towards the temple (extorsion)
- The superior oblique muscle: Allows the eye to rotate on itself towards the nose (intorsion).

[5]

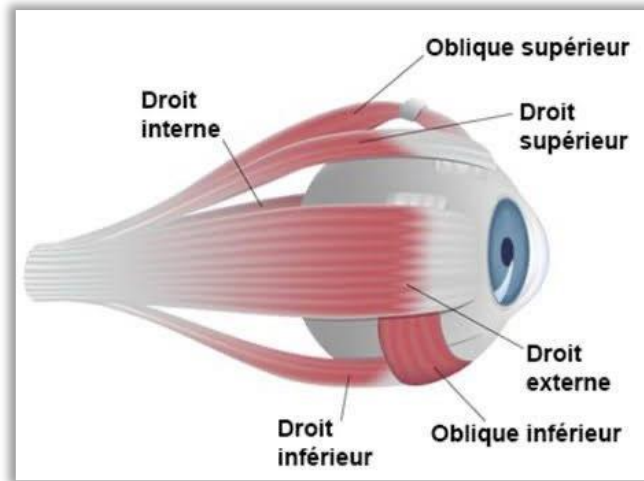


Figure 2: The oculomotor muscles

The table below summarizes the origin and functions of the six oculomotor muscles: [6].

Muscle (cranial nerve)	Origin	Primary Function	Secondary Function	Tertiary Function
Superior Rectus Muscle (III)	Annulus of Zinn	Elevation	Incycloduction	Adduction
Inferior Rectus Muscle (III)	Annulus of Zinn	Depression	Excycloduction	Adduction
Lateral Rectus Muscle (VI)	Annulus of Zinn	Abduction	-----	-----
Medial Rectus Muscle (III)	Annulus of Zinn	Adduction	-----	-----
Superior Oblique Muscle (IV)	Annulus of Zinn via the trochlea	Incycloduction	Depression	Abduction
Inferior Oblique Muscle (III)	Maxillary bone	Excycloduction	Elevation	Abduction

Table 1: The origin and functions of the ocular muscles

Monocular and binocular movements are governed by two laws:

- **Sherrington's Law:** When the agonist contracts, the antagonist relaxes, and vice versa.

- **Hering's Law:** In any binocular movement, the nerve impulse is sent in equal quantity to the muscles of both eyes involved in this movement. [7]

Binocular Vision and Space Perception:

2.1 Definition

Binocular vision is the ability of both eyes to work together in a coordinated manner and to perceive a single, unified image from the two slightly different retinal images received by each eye. While each eye captures its own perspective of the visual scene, the brain fuses these images into one three-dimensional perception, allowing for depth and spatial awareness. [8]

2.2 Development

Binocular vision is not fully present at birth. Most of its development occurs within the first six months of life, although maturation continues progressively until around the age of six.

Full-range ocular motility, allowing eye movements in all directions, becomes functional around **2 to 3 months of age**.

By the **sixth month**, the infant's visual system possesses the **genetic potential to develop binocular vision**, reflected by the formation of **ocular dominance columns**, the emergence of **binocularly responsive cortical cells**, and the appearance of **stereoscopic response cells** in the visual cortex.

Convergence and fusion reflexes, which contribute to binocular coordination, typically emerge between the **first and third month** of life.

The development of **binocular and stereoscopic vision** begins between **3 and 6 months** of age. By the sixth month, **stereoscopic acuity** reaches approximately **1 minute of arc**, marking a significant milestone in visual depth perception. [9]

Accommodation

Beginning as early as three months of age, accommodation is a normal physiological process. It alludes to the "cornea-lens" system's increased optical power, which enables the eye

to create a clear retinal image of objects that are close. This is made possible by the crystalline lens's flexibility, which allows it to change form to boost its refractive power by becoming more convex and curved. Without the lens's accommodating effort, this correction guarantees clear vision of surrounding objects that would otherwise appear hazy.

Three main actors are involved in the accommodation mechanism:

- The ciliary muscle
- Zonule of Zinn
- The crystallin

3.1 The accommodation mechanism:

The accommodation is the alteration of the crystallin's anterior curve. The ciliary muscles will contract, causing the stress on the zonule fibers to relieve itself (since they have elastic properties, they can pull away and compress). Due to the crystallin's increased muscle tension and the elasticity of the capsule containing the zonule, there will be an increase in the crystallin's buckling rayon, which will cause it to converge more. As a result, accommodation varies as well due to the crystallin's movement forward.

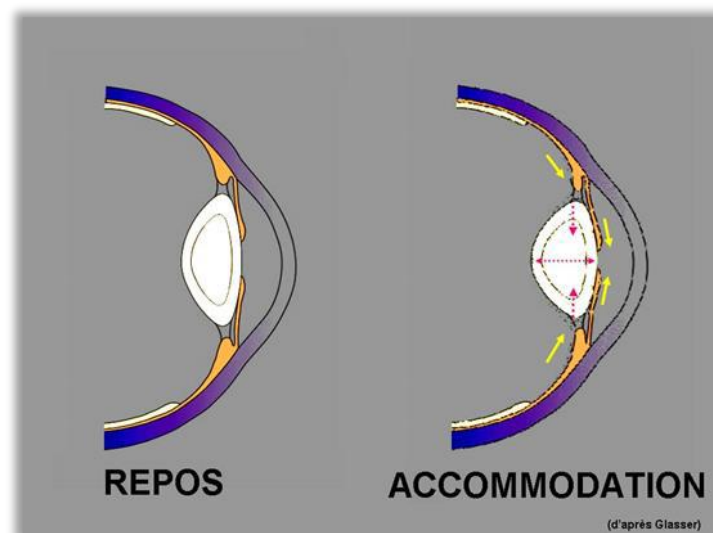


Figure 3: The mechanism of accommodation

3.2 The Accommodative Range

The accommodative range refers to the span within which the eye can maintain clear vision. This range is bounded by two key points:

The punctum remotum (R) – the farthest point at which an object remains in sharp focus without accommodation, and

The punctum proximum (P) – the closest point at which the eye can focus through maximum accommodative effort.

Thus, the accommodative range is the distance between these two points. [10]

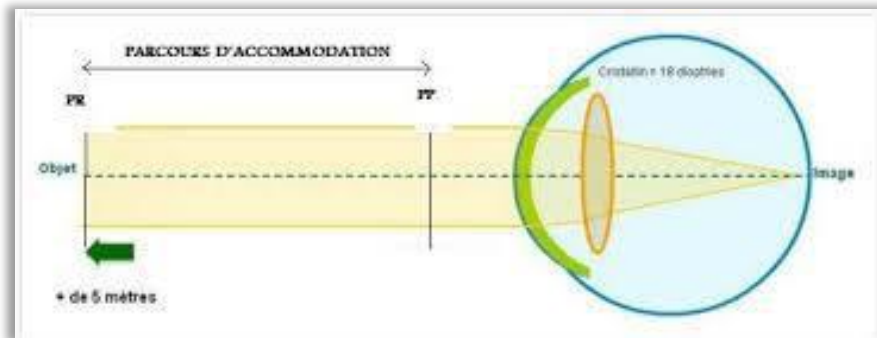


Figure 4: The accommodative range

3.3 Accommodation Anomalies in Non-Presbyopic Individuals

It is recommended to measure the amplitude of accommodation in all patients, regardless of age. However, amplitude alone may not be sufficient to assess the full accommodative function. Even when the amplitude is within age-appropriate norms, dynamic or functional abnormalities may still be present.

If a patient presents with symptoms during near work or when shifting focus between distances (from far to near or vice versa), an accommodative disorder should be suspected — after ruling out other causes such as uncorrected refractive errors or binocular vision anomalies.

3.4 Common Symptoms of Accommodative Disorders in Non-Presbyopes

Although not always specific, the following symptoms may indicate accommodative dysfunction:

Intermittent blurred vision — either at distance, near, or when switching between the two;

- Headaches;

- Visual discomfort: sore, burning, or watering eyes;
- Diplopia (when associated with or leading to vergence problems);
- Difficulty concentrating.

3.5 Classification of Accommodative Disorders (Duke-Elder Classification)

III.5.1 Cases of Increased Accommodation:

- Accommodative Excess
- Accommodative Spasm

III.5.2 Cases of Decreased Accommodation:

- Accommodative Paralysis
- Accommodative Insufficiency
- Accommodative Fatigue
- Accommodative Inertia

It is important to note that presbyopia is not classified as an accommodative disorder, as it represents a normal age-related decline in accommodation. However, it may still contribute to certain near vision problems, particularly those related to binocular vision. [11]

3.6 Accommodation and vergence components

III.6.1 DEFINITION OF VERGENCE

The term *vergence* refers to a type of eye movement in which the two eyes move in opposite directions — such as convergence, divergence, or fusional vergence. These are disjunctive movements, meaning that each eye moves differently, in contrast to *versions*, where both visual axes move in parallel.

Vergence movements either bring the visual axes closer together, which defines convergence, or move them further apart, which defines divergence. Vergence is measured in metric angles, diopters, or degrees, and it corresponds to the degree of alignment needed between the eyes to maintain binocular vision.

Vergence becomes essential when focusing on a near object, ensuring a single, unified visual perception. The convergence angle depends on the distance of the object being observed and the interpupillary distance. The *near point of convergence* is the closest distance at which the eyes can maintain maximum convergence effort. [12]

III.6.2 VERGENCE COMPONENTS:

- **a. Tonic convergence**

Strictly speaking, tonic convergence (or phonic convergence, as it is normally a convergence) is the convergence of the eye pair resulting from the tones of extraocular musculature, in the absence of any visual stimulus. Tonic convergence moves the eye pair from its 'anatomical position' (a theoretical position that can only be noted during death or deep anesthesia) to the 'tonic vergence position', which is also called the 'passive position' or 'physiological resting position'.

In the absence of any visual or proximal stimulus, the eye pair generally converges at an intermediate distance, on average between 1.2 and 2 m in adults

Tonic vergence varies from one individual to another and, for the same subject, can vary depending on circumstances (fatigue, etc.). It has been reported that tonic vergence can be temporarily altered by a visual task or by wearing prisms.

- **b. Disparity vergence (fusional vergence)**

Disparity vergence (or fusional vergence) is the vergence of the eyes occurring in response to a disparity in the retinal images of the object of attention. A disparity in the retinal images exists when the two images do not fall on corresponding retinal points. Fusional vergence is a reflex function that responds to a very strong desire to unify the two ocular images; it is compared to a magnetic force.

It was proposed in 1980 to replace the term 'fusional vergence' with disparity vergence, which more precisely refers to the stimulus for this type of vergence

The term 'fusional vergence' is sometimes used to indicate the total amount or amplitude of fusional vergence, relative to a given reference position. Disparity vergence can be induced (and measured) with prisms or other devices (e.g., stereoscopes, vectograms).

In practice, during unmasking after unilateral masking, for example, it is fusional vergence (or disparity vergence) that moves the eye pair from its dissociated position, the 'passive position' (in the absence of a fusional stimulus), to binocular fixation on the object, or 'active position' (when fusion is active). It is the presence or absence of normal and adequate fusional vergence that makes the difference between a pharyngitis and a tropic.

- **c. Convergence d'accommodation (accommodative)**

Accommodative convergence (or accommodative convergence) is the convergence induced by accommodation

The amount of convergence caused by each diopter of accommodation is expressed by the ratio AGA (Accommodative Convergence/Accommodation). Strictly speaking, we should speak of the ratio CA/A, but the English abbreviations have been retained. The ratio AC/A can be calculated using the gradient method [11]

3.7 ACCOMMODATIVE CONVERGENCE AND THE AC/A RATIO.

A given level of convergence is induced when an individual makes a specific amount of accommodation. Accommodative convergence is the term used to describe such convergence. It would appear that the opposite is also true; for instance, forced convergence with ophthalmic prisms may result in adjustments to accommodation. These accommodations, however, are not clinically significant

The study of comitant strabismus requires a knowledge of the significant physiological effects of the synkinesis between accommodation and convergence on binocular vision in close fixation.

It is logical to believe that accommodating convergence satisfies the fundamental convergence condition. Proximal convergence serves as an additional role to those of tonic and fusional convergence. For every diopter of accommodation (or its equivalent in prism diopters), a normal, emmetropic person should therefore be expected to exert 1 MA of convergence; however, this is not the case. Every person reacts with a certain degree of convergence to a unit stimulus of accommodation, which may be more or less than what the convergence criterion requires. The AC/A ratio can be used to indicate an individual's convergence reaction to a unit stimulus of accommodation. This ratio, which has the dimensions $[_ / D]$, indicates how

receptive an individual's convergence function is to a unit of accommodation stimuli. Fry was the first to properly articulate the idea of a ratio between accommodation and convergence. He later coined the acronym AC/A ratio with Haines²⁰. [13]

Degrees of binocular vision

4.1 Simultaneous Macular Perception

SMP slides on the synoptophore, which show objects that are distinct but mutually agnostic (e.g., giving a picture of a square to one eye and a circle to the other), are used to test this most basic form of binocularity. The butterfly and net, lion and cage, and bird and cage slides are the most often used.

If superimposition happens, target slides of varying sizes must be used in order to produce a more precise assessment.

- Concurrent foveal perception slide: at the nodal point, subtend an angle of one degree
- Concurrent parafoveal perception slides with a 1-3 degree subtend angle
- Concurrent paramacular perception slides with a subtend angle of three to five degrees
- Concurrent peripheral vision slides with a subtend angle larger than five degrees

Bifoveal fixation is not always referred to as simultaneous perception because it can also happen in ARC. It only shows whether suppression is present or not. This word is incorrect since it uses the same meaning for both foveal and parafoveal perception.

IV.1.1 Fusion

The unification of visual excitations from the associated retinal pictures into a single visual percept is known as fusion.

4.1.2.1 Fusion of Sensations

It is the capacity to perceive and interpret two similar images as one, one for each eye. Retinal correspondence is characterized by a single visual picture. In addition to being on the

same retinal regions, the pictures must be sufficiently similar in size, brightness, and sharpness to allow for sensory fusion. Fusion is severely hampered by unequal images.

4.1.2.2 Fusion Motors

It is the capacity to maintain sensory fusion by aligning the eyes in a certain way. Retinal discrepancy outside of Panum's area and the eyes moving in the opposite direction (vergence) serve as the stimulus for these fusional eye movements. Motor fusion is the sole function of the extrafoveal retinal

4.1.2.3 Tests for Fusion:

Fusion is demonstrated by using slides in which similar pictures with different controls are presented to the eyes simultaneously e.g. letter L and F fused into E, rabbit with a tail and rabbit with flower in hand, fused into one rabbit having tail and flower.

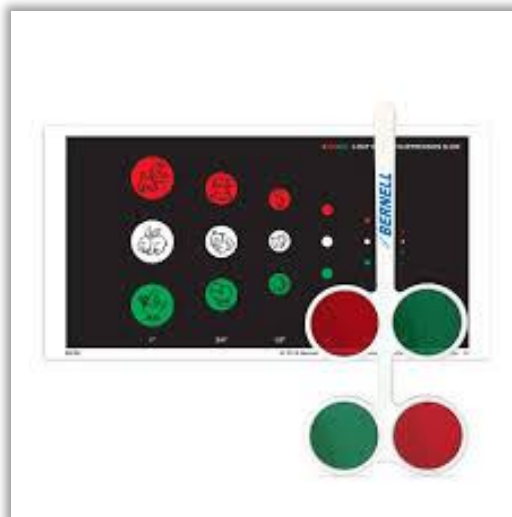


Figure 5: Worth 4 Dot test with Red/Green glasses

Normal fusion amplitudes are :

A) Horizontal vergences :

- Convergence → 35 Δ to 40 Δ
- Divergence → 5 Δ to 7 Δ

B) Vertical vergence:

- Supravergence $\rightarrow 3 \Delta$
- Infravergence $\rightarrow 3 \Delta$

C) Cyclovergence $\rightarrow 2-3 \Delta$

Fusion assessment is essential both for the prognosis and management of strabismus. Fusion is essential for the restoration of BSV. Various tests used to find out the presence of fusion are:

- Worth's 4-dot test
- Synaptophore

IV.1.2 Stereopsis (Disparity Sensitivity)

Stereopsis (Disparity Sensitivity) is the ability to fuse images that stimulate horizontally disparate retinal elements within Panum's fusional area, resulting in binocular appreciation of visual objects in depth, or in the third dimension. Because the eyes are separated in the head's horizontal plane, each eye sees the world in a slightly different horizontal direction. The sensory fusion of these horizontally disparate unequal retinal images results in a three dimensional percept. An object confined to the horopter is perceived as flat because it projects to corresponding retinal regions, causing zero horizontal disparity.

.Non-zero disparities giving rise to stereoscopic depth are divided into crossed and uncrossed.

- Crossed disparities are created by objects in front of the horopter (near objects). The disparity is termed "crossed" because the monocular image of the object when viewed by the right eye is displaced to the left, whereas that viewed by the left eye is displaced to the right.
- Uncrossed disparities are created by objects located behind the horopter (far objects). In this case the monocular image of the objects viewed by the right eye is displaced to the right and that viewed by the left eye is displaced to the left.

IV.1.3 Stereoscopic acuity

It is the smallest binocular disparity that may be readily perceived i.e. it is the minimum difference beyond which no stereoscopic effect is created. Clinical stereoscopic acuity tests are not standardized, although in general, a threshold of 15 to 30 arc seconds can be considered excellent. Since there is a stereoscopic threshold, it follows that stereopsis cannot work beyond a certain critical distance. According to calculations, this distance is between 125 and 200 meters. Additionally, the stereoscopic acuity changes according to the movements of the eyes and the stationary or moving target. For static objects, the stereoacuity threshold falls between 2 and 10 arc seconds.

The threshold rises to roughly 40 arc seconds for targets moving both in and out of the observer's line of sight. In the foveola, stereoacuity peaks at 0.25 degrees from dead center and decreases exponentially as eccentricity increases along the x-axis. Beyond 15 degrees eccentricity, stereopsis is zero. Moving the target in front of or behind the horopter along the y-axis causes stereoacuity to decrease in a similar exponential manner.

Stereopsis is not the only method for spatial orientation, even if it is crucial for depth perception. The different monocular indicators of spatial orientation include:

- Apparent size – Small retinal objects are interpreted as distant objects and large retinal objects as near objects. Objects progressively increase in size as they move towards us (looming).
- Interposition – relatively nearer objects tend to conceal or overlay more distant objects.
- Aerial perspective – water vapor, dust and smoke in the atmosphere scatter light and make distant objects indistinct and relatively color desaturated.
- Shading – light falling on solid objects causes shadows to be cast, and on curved surfaces causes a gradation in the intensity of shadow.
- Geometric perspective – physically parallel lines converge toward a vanishing point at the horizon, e.g. railroad tracks.
- Relative velocity – the image velocity of a moving target in the distance is lower than the image velocity of the same moving target when it is nearby.

Chapter I: Generalities

- Motion parallax – translocation of the head cause the images of near objects to move opposite the head and the images of far objects to move with the head, assuming the fixation point is at an intermediate distance. [14]

Chapter II:

Heterophoria and accommodation convergence to accommodation ratio

Orthophoria

1.1 Definitions

Orthophoria refers to the condition where both visual axes remain aligned on the fixation target, even when fusion is disrupted using methods such as the cover test or Maddox rod. In this case, no movement or shift of images is observed upon dissociation.

However, perfect alignment at both distance and near is not always observed in clinical practice. A slight **exophoria at near** is commonly seen and considered **physiological**. This typically measures between **4 and 6 prism diopters (Δ)** at near, and about **2 Δ** at distance [15].

Heterophoria

The visual problems known as hétérophoria is caused by an imbalance or an irregularity in the eye movements' synchronization.

There is "a strabically latent deviation, manifested by a sufficient dissociation, whose interruption is followed by sensory and motor restitution".

Hétérophorie is distinguished from binocular dysequilibrium by a latent deviation of the visual axes. This change in eye parallélism is thought to be one of the oculomotor imbalances associated with hétérophorie. However, because it is consistently compensated, this deviation remains undetectable.

In hétérophorie, binocular relationships are normal, although retinal correspondence and stéréoscopy are also normal. The difference between the hétérophorie of intermittent strabisme is the existence of anomalies in these two criteria. [16]

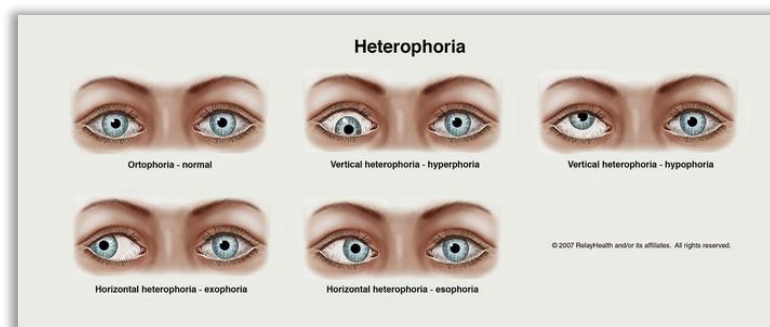


Figure 6: Different types of heterophoria

Motor and Sensory Characteristics

From a **sensory standpoint**, retinal correspondence remains normal in most cases. Binocular fusion is intact under normal conditions. However, if the heterophoria is **decompensated**, some patients may develop **foveal suppression** to avoid diplopia.

Motor function is also typically normal in simple heterophoria. Yet in cases of poor compensation, **vertical components** or instability may occur.

When fusion is re-established, the eyes perform a **recovery movement** to realign, restoring both sensory and motor balance. Although retinal correspondence is generally unaffected, the **quality and strength of fusion** can vary between individuals.

In symptomatic heterophoria, the following are often present:

- **Foveal suppression (neutralization)**
- **Reduced fusional amplitudes**

Different types of heterophoria

4.1 Exophoria

IV.1.1 Definition

An individual is considered **exophoric** when, upon dissociation, the visual axes deviate **outward**, indicating a divergence of the eyes. As with esophoria, there are two types of exophoria:

- **Convergence insufficiency**: where the deviation is **greater at near** than at distance.
- **Divergence excess**: where the deviation is **greater at distance** than at near.

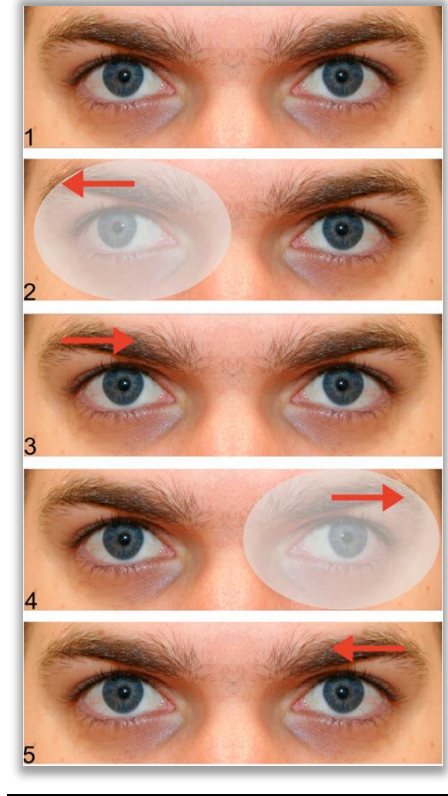


Figure 7: Exophoria

IV.1.2 Onset and Symptoms

Functional symptoms of exophoria tend to develop **gradually**, and patients are often unable to pinpoint when the issues began. Common complaints include:

- **Visual fatigue** and **frontal headaches** during visual tasks, which usually subside with rest.
- **Distance vision issues**, particularly with **depth perception** or **judging distances**.
- **Discomfort at near**, especially during reading. The patient may experience **blurred lines** and may **prefer monocular reading** (closing one eye) when tired.
- **Intermittent diplopia** may also be reported.

4.2 Esophoria:

IV.2.1 Definition

A subject is considered **esophoric** when, upon dissociation, the deviation of the visual axes occurs in **convergence**. There are two main types of esophoria that can be distinguished:

- **Divergence insufficiency type:** where the esophoria is **more pronounced at distance** than at near.
- **Convergence excess type:** where the esophoria is **more pronounced at near** than at distance.

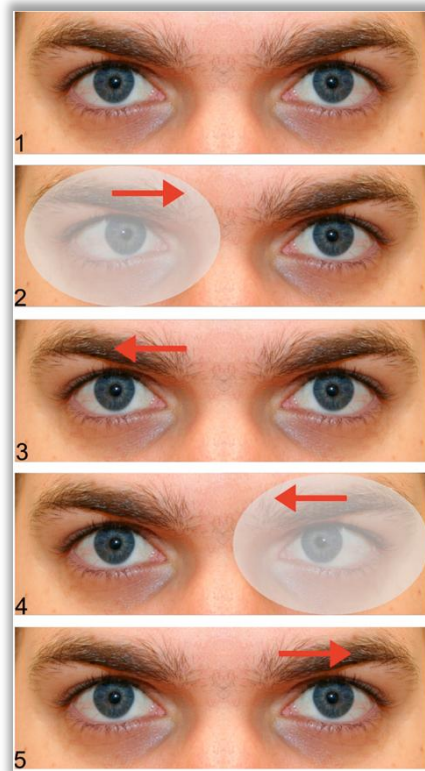


Figure 8: Esophoria

IV.2.2 Onset and Symptoms

Functional symptoms of esophoria generally develop **gradually**, and patients are often **unable to specify the exact onset** of their visual discomfort. Common complaints include:

- **Persistent frontal headaches**
- **Undefined ocular discomfort**

- **Disturbances in panoramic or peripheral vision**
- **Reading difficulties**, often associated with **blurred vision**
- Occasionally, the **awareness of their own nose** in the visual field

When the visual system becomes fatigued, the **compensatory mechanisms may fail**, leading to **partial decompensation**, sometimes accompanied by **intermittent diplopia**, which the patient may or may not consciously perceive.

4.3 Hyperphoria:

IV.3.1 Definition

Hyperphoria refers to a **vertical latent deviation** revealed upon dissociation. The deviation may involve either **elevation** (hyperphoria) or **depression** (hypophoria) of one eye. The term hypophoria is less commonly used; typically, clinicians refer instead to **hyperphoria of the opposite eye**.

Vertical phorias may occur **in isolation** or in combination with **horizontal phorias**. It is essential to distinguish **true hyperphoria** from **alternating hyperphoria**, which corresponds to **dissociated vertical deviation (DVD)** — a condition most often found in **congenital strabismus** with disrupted binocular vision.

IV.3.2 Onset and Symptoms

The **onset** of hyperphoria is often **difficult to pinpoint**, particularly in adults. In older individuals, it frequently develops **gradually**, as the **fusion reserves** diminish with age.

Patients may report:

- **Discomfort in distance vision**, often mistakenly attributed to **inadequate optical correction**
- **Blurred near vision**
- **Frontal headaches**
- In some cases, **intermittent vertical diplopia**

4.4 Hypophoria:

IV.4.1 Definition and Clinical Presentation

When binocular fusion is disturbed, one eye tends to slide lower, a condition known as hypophoria, a vertical heterophoria. Vertical fusional processes control this latent deviation, which manifests itself during dissociation (e.g., Maddox rod or cover test).

When the eye wanders upward, it is the reverse of hyperphoria.

Unless decompensated, hypophoria is often asymptomatic and less frequent..

IV.4.2 Onset and Symptoms

The following can cause hypophoria:

- Unbalanced vertical muscles
- Trauma
- Neurological conditions
- imbalance in the eyes' refractive properties

Patients who have decompensated hypophoria may say:

- Double vision, also known as vertical diplopia
- Asthenopia, or visual exhaustion
- Tilting the head to make up for the mismatch
- difficulty focusing, particularly when fatigued or experiencing visual stress

Additionally, when fusional reserves are poor or a vertical component is introduced to the optical correction (for example, because of prism adaptation or anisometropia), it may become symptomatic.. [17]

Prevalence of heterophoria

In this study it was meant to explore the prevalence of heterophoria and associate factors in Tibetan grade-one students.

Chapter II: Heterophoria and accommodation convergence to accommodation ratio

A cohort study conducted in schools is called the Lhasa Childhood Eye Study (LCES). 1942 stratified cluster sampling was used to randomly choose first-graders from seven primary schools. Participants' eyes were examined for cycloplegic autorefraction, stereoacuity, distant and near visual acuity, and ocular motility. The Maddox rod and prisma were used to quantify the phoria's magnitude, and the close (33 cm) and far (6 m) fixation cover tests were used to distinguish between orthophoria, heterophoria, and heterotropia.

Result of the study:

Overall, 22.9% of children had heterophoria.

4.6% experienced phoria at a distance.

mostly exophoria (4.2%), with a small percentage of esophoria (0.4%).

Near: 22.7% experienced phoria

Esophoria (0.4%) and exophoria (22.3%) predominate.

No vertical phoria was seen.

Average quantity of phoria:

Close: around -7.6Δ (mainly exo)

About -4.8Δ is the distance (mainly exo).

Connections to visual issues:

Children with hyperopia and amblyopia were more likely to have esophoria.

Children with myopia were more likely to exhibit exophoria at close range.

Children with near phoria had lower stereoacuity (3D vision) at 23% than children without phoria (18%).

Conclusion

“In Lhasa, grade-one pupils have a lower prevalence of heterophoria. Near exophoria was associated with myopia, while esophoria was related to hyperopia and amblyopia both near and distance. Heterophoria may be one of the affected factors for reducing stereoacuity.” [18]

Etiology of Heterophoria :

6.1 Anatomical causes:

Orbital asymmetry , abnormal interpupillary distance (IPD) mild weakness of extraocular muscles, etc.

6.2 Physiological causes:

Esophoria is found in greater accommodation (hyperopes), exophoria in decreased accommodation (myopes), excessive or decreased use of convergence, and in dissociated tasks¹

6.3 SENSORY OBSTACLES TO FUSION

Observations in older patients leave no doubt that interference with fusion may precipitate a manifest deviation in predisposed patients. The interference maybe of peripheral or central origin and produce sensory or motor obstacles to fusion. Among the peripheral sensory obstacles are conditions that materially reduce the vision in one eye or the patching of either eye. A result of patching is well illustrated by the following example.

This is illustrated in the following case described by von noorden (1996) “A 14-year-old boy had a large chalazion of the right lower lid. After removal of the chalazion, he wore a bandage over the eye for 2 days. When the bandage was taken off he complained of diplopia. He now had an alternating esotropia of 40 Δ. The visual acuity was 6/6 in each eye and a hypermetropia of 5.0 sphere D was present OU. He was given the refractive correction which he had never worn before and ft-over base-out prisms that restored single binocular vision. The strength of the prisms was reduced every 2 or 3 days. After 2 weeks the manifest deviation had entirely disappeared, but an esophoria remained for distance of about 20 Δ . This Case demonstrates that a peripheral sensory obstacle, in this instance brief occlusion of one eye, is capable of precipitating a large manifest deviation when ordinarily a well functioning fusion mechanism would prevent such an anomaly. A similar problem may also be caused by centrally acting factors .” [19]

As for another example involving a head injury described by von noorden (1996) “A 17-year-old girl was thrown from her bicycle when it struck a tree. She sustained bruises and

Chapter II: Heterophoria and accommodation convergence to accommodation ratio

was somewhat dazed, but there were no serious injuries. As soon as she recovered from the initial shock, she noted diplopia. Examination on the day of the accident revealed standard visual acuity in each eye with her correction for myopia, no sign of a paresis or paralysis of an extraocular muscle, and an alternating exotropia of 18 Δ for distance. Single vision could be readily obtained with prisms. After a few days, spontaneous single binocular vision with good amplitudes and stereopsis was reestablished, but an exophoria of 15Δ was evident on dissociation of the eyes. This case is an example of transient or permanent impairment of the fusion mechanism from traumatic or toxic causes.” [19]

optical: Under-, over- or uncorrected refractive errors. Wrongly prescribed spectacles. Ill fitting spectacles. Aniseikonia.

Medical: Poor general health. Fatigue..Drugs affecting accommodation. Alcohol. Dissociative/monocular viewing. Visual field loss.

For a more specified explanation here is every phoria and its known causes

HETEROPHORIA AND SYMPTOMS ASSOCIATED WITH IT :

- headaches
- asthenopia
- blurring of print
- intermittent diplopia and confusion if the deviation has become manifest.
- poor general health
- general fatigue and change in refractive error

[20]

SHEARD CRITERION :

The sheard criterion is defined as a rule that helps make sure the eyes work together comfortably in more specify definition it states that the fusional reserves should be double the heterophoria so that this last could be compensated for example if a patients occurs to have an exophoria of “5” his positive fusional reserves should be at least the double so that we say 12.

PERCIVAL CRITERION :

To simply define this criterion, PERCIVAL studied the balance in between the divergence and convergence systems, for his criterion he says that the smallest range resulting of this two systems should be at least equal to both convergence and divergence added together. For an example :

If we say we found a patient that converge 7 unites and diverge 13 units, the total of this range should be 20

The Percival criterion says that if the smallest range (which is 7 in our case) doesn't equal to the half of the total range (20) the patient will result to a visual discomfort also known as eyes strain.

Sheard and Percival's Criteria :

Sheard's and Percival's criteria are useful for determining binocular vision abnormalities. Sheard's criteria are accurate in diagnosing near exophoria, while Percival's criteria are more accurate in diagnosing near esophoria. As a result, these criteria provide useful hints and predictions for diagnosing binocular vision impairments. [21]

HETEROPHORIA AND FIXATION DISPARITY :

Fusion is one of the visual system's functions that allows for a single, steady vision. The fusion system keeps the images from both eyes as close as possible to the corresponding spots. However, fusion is not always precise: there may be a mismatch between the physical position of the target and the point fixed by the eyes, the intersection of the two visual axes during binocular fusion. This difference is known as fixation disparity. [22]

“The possibility that a relationship exists between fixation disparity and heterophoria was suggested many years ago by Ames and Gliddon⁴ who used the term ‘retinal slip’ to describe what is now known as fixation disparity. They found fixation disparity associated with heterophorias”. [19]

WHEN DO WE TREAT HETEROPHORIA :

Chapter II: Heterophoria and accommodation convergence to accommodation ratio

When both visual axes are not directed towards the fixation point and deviate. Generally the treatment of heterophoria is considered when the patient appears to have or complain about the symptoms that were mentioned earlier such as headaches or asthenopia some trouble maintaining a good binocular vision, there some cases when heterophoria become apparent such as a person being tired we occasionally remark an eso or exo deviation by the end of the day depend on the ametropia the patient has or doesn't know the existence of it . In those cases we switch into another question that would be titled as ' how do we treat it ' .

How do we treat heterophoria :

According to a lot of literatures heterophoria has many ways to be treated we begin with:

IN ADULTS:- only if the patient has any symptoms.

IN CHILDREN:- If the phoria tends to decompensate into a manifest deviation, regardless of whether symptoms are present.

➤ FOUR TYPES OF TREATMENT ARE THERE FOR TREATING HETEROPHORIA:-

OPTICAL CORRECTION:-

1. Optical correction may eliminate the phoria in some patients.
2. Prescription guidelines for glasses:-
3. Differences in refractive error between two eyes should be eliminated.
4. Both the eyes may be under-correct by an equal amount of spherical plus power in exophoria.
5. The optimum spherical plus correction gives the best visual acuity in esophoria.
6. Bifocal glass, for near vision with the patient having esophoria of convergence excess type.
7. Optical correction by decentred to achieve the prismatic effect, relieving the stress on vertical vergence in hyperophoria.
8. In cyclophoria, correction of astigmatic refractive error.

ORTHOPTIC TREATMENT (VISION THERAPY):-

1. It is indicated in patients with heterophoria without refractive error and in those where heterophoria and /or symptoms are not corrected by glasses.

Chapter II: Heterophoria and accommodation convergence to accommodation ratio

2. The aim is to improve fusional reserve so that the foveal single vision can be maintained without effort.

ORTHOPTIC EXERCISE FOR ESOPHORIA:- (DIVERGENCE EXERCISE WITH PRISM)

1. Base-In prism in front of one eye while the patient fixates on an object where the esophoria is maximum.
2. Trained to maintain single vision by relaxing the convergence (for a few minutes at each week visit).

DIVERGENCE EXERCISE ON SYNOPOPHORE:-

1. Using stereopsis slides provides a strong stimulus to fusion.
2. Trained to maintain a single vision by relaxing convergence (5minutes at each week visit).

OTHER METHODS FOR ORTHOPTIC EXERCISE FOR ESOPHORIA:-

1. Exercise using diploscope.
2. Exercise using Remy separator.
3. Reading bar exercise.

ORTHOPTIC EXERCISE FOR EXOPHORIA:- (CONVERGENCE EXERCISE WITH PRISM)

1. Base-Out prism in front of one eye while the patient fixates an object where the exophoria is maximum.
2. Trained to maintain single vision by relaxing the divergence (for a few minutes at each week's visit).

CONVERGENCE EXERCISE ON SYNOPOPHORE:-

1. Using stereopsis slides which provides a strong stimulus to fusion.
2. Trained to maintain a single vision by relaxing divergence (5minutes at each week's visit).

PRESCRIPTION OF PRISM IN GLASSES:-

1. It may be tried in selected cases of hyperphoria and in troublesome cases of esophoria and exophoria.
2. Prism is prescribed with an apex toward the direction of phoria to correct only half or at the most two-thirds of heterophoria.

SURGICAL TREATMENT:-

1. Indication:- surgery becomes necessary only when symptoms cannot be relieved by another method like optical correction, orthoptic exercise, or using miotic.
2. Aim of the surgical management is to strengthen the weak muscle or weaken the strong muscle. [23]

HETEROPHORIA AND AC/A RATIO :

The AC/A ratio must be calculated in order to analyze optometric data effectively. The AC/A finding is an important factor in determining the final diagnosis. It is also one of the most important findings used to determine the best management strategy for any given situation.

“This is the amount of accommodative convergence that is induced by each dioptre of accommodation exerted and is measured in prism dioptres. It is a fixed relationship, so that an equal amount of convergence occurs for each dioptre of accommodation. This is inborn and remains virtually unchanged from childhood to at least presbyopic age, provided that the stimulus to accommodate is kept within narrow limits (Breinin & Chin 1973). The normal range is 3–5:1 (gradient) (Ogle et al. 1966). The amount of accommodative convergence exerted depends on the interpupillary distance and distance of the object from the eyes. The AC/A ratio can be modified permanently by surgery of the extraocular muscles and temporarily by drugs and lenses that reduce the accommodation requirement and hence the resulting accommodative convergence.” [20]

14.1 For the gradient method :

We measure the patient near phoria using a Maddox rod test, then adding concave (increases accommodation) or convex (reduces accommodation) lenses and repeat the same method of the phoria measurement which leads us to the formula

$$AC/A \text{ RATIO} = \frac{\text{change in phoria } (\Delta)}{\text{Lens power (D)}}$$

The calculation of the ratio is very simple :

$$“AC/A = IPD \text{ (cm)} + \frac{NEAR \text{ PHORIA } (\Delta) - DISTANCE \text{ PHORIA } (\Delta)}{AMOUNT \text{ OF ACCOMODATION}}$$

where

Chapter II: Heterophoria and accommodation convergence to accommodation ratio

IPD = interpupillary distance in centimeters

NFD = near fixation distance in meters

Hn = near phoria (eso is plus and exo is minus).” [24]

For a normal AC/A ratio, additional lenses have a moderate effect on the angle of departure. Adding lenses can help with basic esophoria, but horizontal prisms and vision treatment are generally required as well. Vision therapy is commonly used to treat basic exophoria and fusional vergence dysfunction, but our main goal in this study is to investigate the ratio of correction lenses used in the phoria treatments. [24]

CA/C RATIO :

this ratio indicates the degree of convergence driven accommodation it helps in understanding the relation between the accommodation system and vergence.

The calculation steps are based on first is to take note on the near point of accommodation (NPA) then we measure the convergence reserves of the patient using a base out prism,

After this second step we calculate the patient accommodation again and take note of the accommodation change after the convergence stimulus.

Which it takes us to our final formula :

$$\text{CA/C RATIO} = (\text{change in accommodation (D)}) / (\text{change in convergence (} \Delta \text{PD)})$$

ABNORMAL AC/A RATIO :

The Duane classification system gives us the ac/a ratio changing at near and distance and its relation with the deviation :

category	Deviation	AC/A
INSUFFICIENCY OF CONVERGENCE	Exo more important in near vision	< 6
EXCESS OF DIVERGENCE	Exo more important in distance vision	> 6
BASIC EXO DEVIATION	Exo similar in near and distance vision	≈ 6
DIVERGENCE INSUFFICIENCY	Eso more important in distance vision	< 6
EXCESS OF CONVERGENCE	Eso more important in near vision	> 6
BASIC ESO DEVIATION	Eso similar in near and distance vision	≈ 6

Table 2: Duane classification

Chapter III:

Clinical diagnosis of heterophoria and AC/A ratio

The various techniques for measuring heterophoria:

1.1 Prism alternate cover test:

The prism alternate cover test is a clinical method used to quantify ocular deviations, such as phoria or tropias, by disrupting binocular fusion and measuring the compensatory eye movements using prisms; it is considered a reliable and objective technique to determine the magnitude and direction of a latent or manifest deviation by neutralizing the eye movement observed during alternated occlusion.

For this test we would need:

- ❖ An occluder
- ❖ A fixation target (it depends on which phoria we are measuring a 5m or 40cm distance)
- ❖ A prism bar
- ❖ The patient distance correction in place

This illustration shows us two prism bars a vertical and horizontal and an occluder



Figure 9: Alternate cover test material

The procedure of the test is very simple and easy to apply

First, we ask the patient to fixate a target, either at distance or near. We cover one eye then quickly switch to cover the other and keep alternating so that the patient can't fuse the image.

While doing this we watch how the uncovered eye moves to take up the fixation. If there is a movement that means there is a phoria. Second, depending on the movement we witnessed, we place the prism bar as for an exophoria we put an base in prisms, and base out for esophoria also base up for hypo base down for hyper-phoria in front of one eye and we adjust the strength

(increase the power) until there is no movement when we alternate the cover. Finally the prism value of neutralization tells us how much deviation the patient has

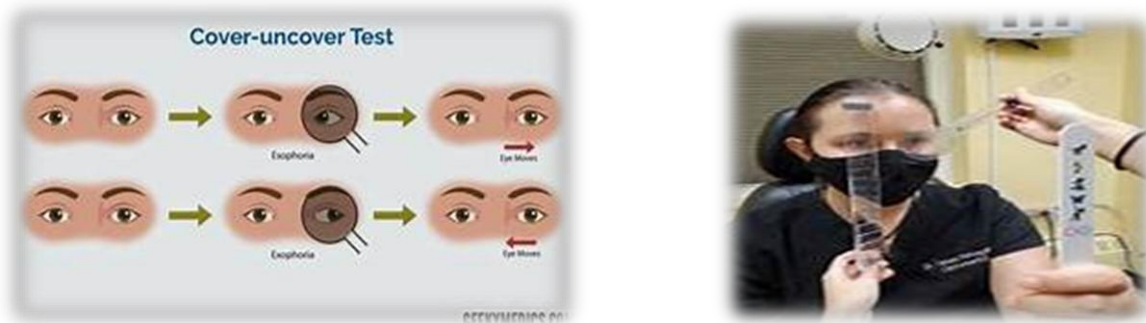


Figure 10: Cover-Uncover test

1.2 The Maddox rod test:

The Maddox rod test is a simply and quick method used to detect and measure phoria, especially horizontal or vertical misalignments by dissociating binocular vision. It works by placing a series of parallel cylinders (the Maddox rod) in front of one eye (the right eye by convention) which transforms a point of light into a straight line. This visual dissociation prevents fusion and allows any hidden misalignment between the eyes to be revealed

For example, if the line is seen to the left or right of the light it indicates a horizontal phoria

(exo or eso) and if it appears above or below, it shows a vertical misalignment. The degree of the deviation can then be measured by placing prisms in front of the eye until the line and the light appear aligned to the patient. [25]



Figure 11: Requirement for Maddox rod test

1.3 The modified Thorington test:

The modified Thorington test is a subjective method used to measure the magnitude and direction of heterophoria at both distance and near. It is considered a quick, reliable, and easy to administer test that provides consistent results when performed correctly.

The procedure requires the use of a Maddox rod, a Thorington card, and a light source.

To perform the test we would need the patient to wear their habitual correction and hold the Thorington card at 40cm, the Maddox rod placed on the right eye by convention while the other eye view the light directly. While the eye continues to see the point source of light the patient reports the relative position of the line in relation to the scale on the Thorington card which helps us to determine if the deviation is vertical or horizontal



Figure 12: Modified Thorington procedure 01

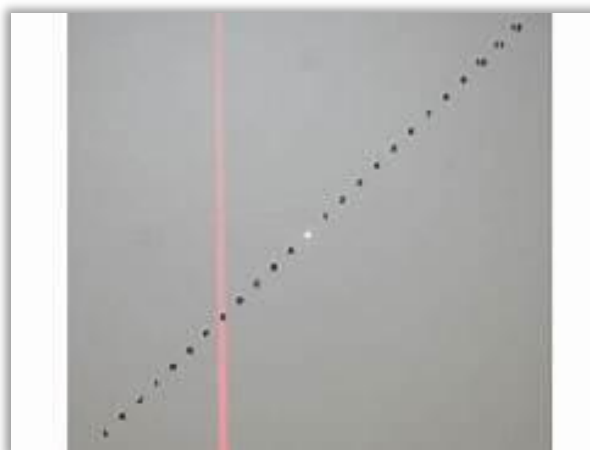


Figure 13: The patient point of view

1.4 The Von Graefe technique :

The Von Graefe technique is a clinical method used to measure latent eye deviations that appears when binocular vision is disrupted.

To start with, the patient looks at a single letter or target, one eye is presented with a vertical prism (6 prism diopters base-up) and the other with a horizontal prism (12 prism diopters base-in or out depending on the direction of measurement) these prisms would allow the images to appear in different locations one appearing up and the other on the side.

We would ask the patient to report when the two images appear aligned vertically (for horizontal phoria) and above each other (for vertical phoria).

The amount of prisms needed to align the images reflects the magnitude of the phoria.

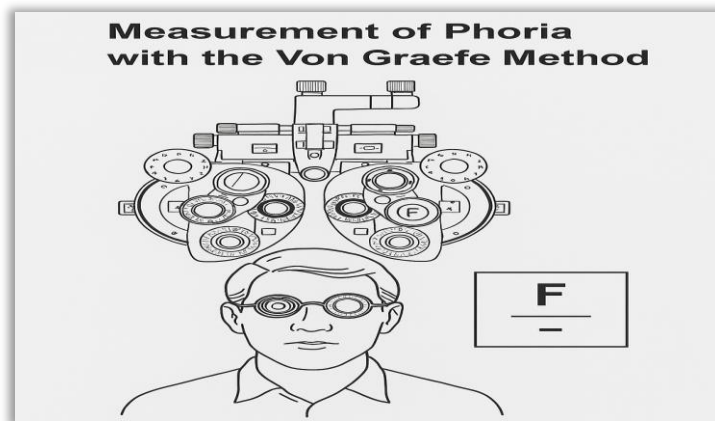


Figure 14: Drawing of the Von Graefe method

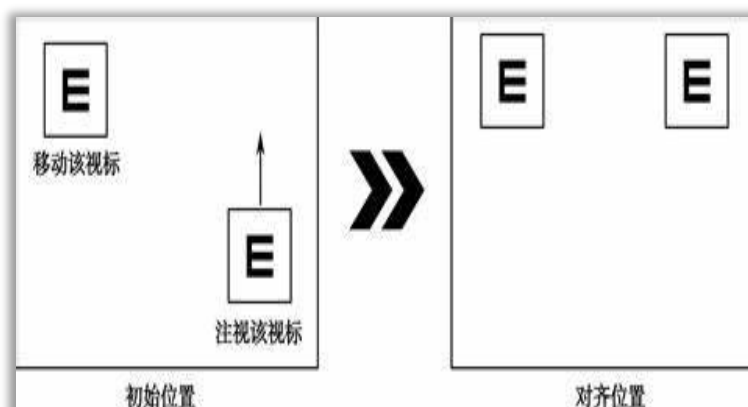


Figure 15: Patient with vertical phoria

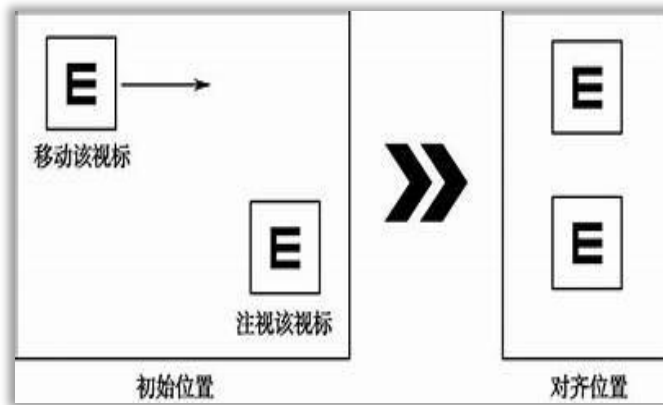


Figure 16: Patient with vertical phoria

1.5 The Howell card test:

The Howell card test is a clinical method used to measure horizontal and vertical phorias at both distance and near. It's a dissociative test, meaning it breaks binocular fusion to reveal any latent deviation between the two eyes. The test is quick, and doesn't require a phoropter.

Its objective is to detect and quantify the amount of phoria by aligning two dissociated images seen through a prism.

We place a 6Δ base-down prism in front of the right eye then we ask the patient to look at the Howell card, the prism creates two horizontal lines one for each eye, after that the patient tells us which number the top line is aligned with in conclusion that number indicates the amount and direction of the phoria in prism diopters.

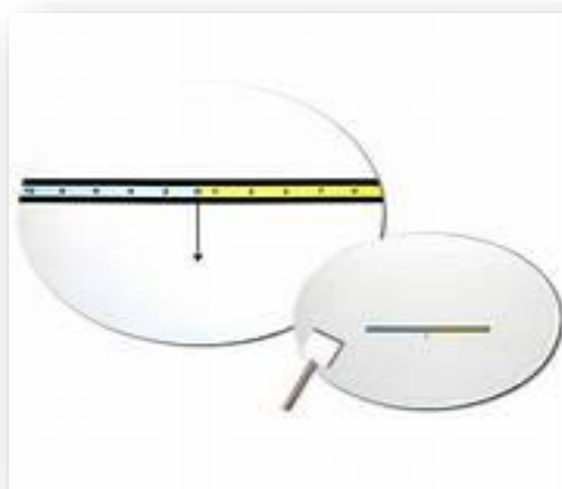


Figure 17: Howell card test for near and distance

1.6 THE MADDOX WING

The Maddox wing is a subjective dissociative test employed in clinical optometry and orthoptics to quantify latent ocular deviations at near fixation, it provides measurements of horizontal vertical and torsional deviations under natural viewing conditions without engaging accommodative effort.

- For **horizontal alignment** , we ask where the red horizontal arrow is pointing on the horizontal scale. A value to the left of zero usually indicates an exophoria , while a value to the right suggests as esophoria.
- For **vertical deviations**, we check the vertical arrow and depending on whether it points above or below the zero mark, we can identify a right or left hyperphoria
- The device also includes a torsional scale to detect cyclophoria, where the patient describes the orientation of a curved arrow and whether it aligns with the numbers shown.



Figure 18: The Maddox Wing test

1.7 THE SYNOPTOPHORE

The synoptophore is a specialized instrument used primarily in the field of orthoptics and optometry to assess and manage binocular vision anomalies. It is designed to evaluate how well the two eyes work together and to detect problems such as strabismus (eye misalignment), amblyopia (lazy eye), or difficulties with fusion and stereopsis.

Structurally, the device consists of two optical tubes that can be adjusted horizontally, vertically, and torsionally. Each tube presents a separate image to one eye, allowing the practitioner to control the level of dissociation or alignment between the two images. This setup enables the measurements of both motor and sensory fusion capacities.



Figure 19: Synoptophore

Reliability, repeatability and agreement between different heterophoria method :

“Distance and near horizontal heterophorias of 20 visually-normal adults were measured with the alternating prism cover test, von Graefe prism dissociation, Howell Card and Maddox Rod by two examiners at two separate visits using standardized instructions and techniques. We investigated inter- and intra-examiner variability using repeatability and reproducibility indices, as well as Bland-Altman analysis with acceptable limits of agreement defined as $\pm 2\Delta$.”

In conclusion “The low repeatability of many standard clinical heterophoria tests limits the ability to reliably detect a 4Δ difference. The Howell Card provided the most repeatable and reproducible results indicating that this technique should be used to detect small changes in heterophoria magnitude and direction.” [26]

Chapter IV

**Practical part and clinical
cases**

Introduction to the Practical Section

The purpose of this thesis' practical component is to investigate how optical correction affects heterophoria in young adults with uncorrected refractive problems. It is frequently difficult to identify heterophoria, which is a hidden deviation of the eyes controlled by fusional systems. Heterophoria can, however, occasionally manifest as symptoms, such as headaches, blurred vision, visual fatigue, and even sporadic diplopia, particularly when there are refractive abnormalities or excessive near work present.

This study aims to assess the effects of a full optical correction customized based on the patient's refractive status on the amplitude of phoria at close range and at a distance, as determined by the Maddox Rod test. This test is still crucial for assessing and identifying latent abnormalities in the vertical and horizontal planes in clinical optometry. The Maddox Rod's simplicity, impartiality, and repeatability make it particularly well-suited for before-and-after comparisons in clinical studies.

Each participant's name, age, phone number, refractive index, and measurements of heterophoria were documented in a clinical file that will be located in the annexes after a comprehensive eye examination that included refraction and a binocular vision evaluation.

The heterophoria values were obtained before and during a month of consistent usage of the suggested optical correction.

By employing this time study approach, it seeks to increase understanding of how appropriate visual correction may improve binocular alignment and reduce compensatory stress on the visual system.

The study aims to further knowledge of how proper visual correction might enhance binocular alignment and lessen compensatory stress on the visual system by using this method.

Objective of the Study

The main objective of this practical investigation is to:

- Assess the influence of optical correction on the measured values of heterophoria (distance and near) after a period of consistent wear;

- Compare heterophoria values before and after one month of wearing glasses to each subject's full refractive correction;
- Explore correlations between the type and magnitude of ametropia (myopia, hyperopia, astigmatism) and the reduction or persistence of phoric deviations;
- Determine the relation between AC/A ratio and its development after having the refractive correction and wearing the glasses.
- Determine whether correcting refractive errors leads to a decrease in symptomatic heterophoria and improves visual comfort.

This investigation aims not only to verify changes in measurements but also to provide clinical insight into the benefits of full optical correction for patients with binocular vision instability.

Population Studied

The study included a sample of young adults selected from individuals in “Adda vision entreprise” for optometry and “the Hamou Boutelilis clinic in ORAN” and others from our community presenting for routine visual assessments or reporting symptoms such as visual fatigue, eye strain, or reduced reading endurance.

Each participant underwent:

- Full objective and subjective refraction
- Binocular vision testing (including Maddox Rod phoria assessment)
- Checking for strabismus and eye health
- A follow-up examination after 4 weeks of wearing their newly prescribed glasses or lenses.

All measurements were carried out in a controlled clinical setting by the same examiner, using a consistent protocol for standardization and reproducibility of data.

To be included in this study, participants had to meet the following conditions:

Inclusion Criteria

Demographic and Clinical Criteria:

- Age between 17 and 38 years
- Good general and ocular health, with no major ocular diseases (e.g., keratoconus, glaucoma, maculopathies)
- No history of ocular surgery, especially no previous refractive surgery (e.g., LASIK, PRK)
- No manifest strabismus (i.e., all participants had motor fusion at baseline)

Refractive Error Criteria (in at least one eye):

- Myopia of at least -0.50 diopters
- Astigmatism of at least 0.75 diopters
- Hyperopia of at least +0.75 diopters

These thresholds were chosen to ensure that participants had clinically significant refractive errors, which could impact binocular balance and phoria. All corrections were prescribed fully (not under-corrected), and all lenses were adapted to daily use for the entire 30-day period.

Protocol and Methodology

All patients were subjected to the same protocol in order to evaluate the effect of optical correction on heterophoria. A controlled clinical setting with constant lighting and testing distances was used for the evaluation. To guarantee inter-examiner reliability, the same optometrist conducted each test.

5.1 Refractive Correction

An interrogation to clarify:

The identity: family name, first name and Age

Personnel antecedentes: such as

Ocular diseases , ophthalmological traits, epilepsy crisis , date of last consultation , date of port of the initial optical correction , regular or not

V.1.1 Raw visual acuity measurement:

The raw acuity is recorded for each eye:

Starting with the monocular measurements in the right eye, then taking both eyes using the Snellen E scale or numbers or letters.

Or, for a former wearer, measure corrected visual acuity with both monocular and binocular lenses.

5.1.2 Measuring ocular refraction:

By taking an objective measurement of refraction using an autorefractometer

5.1.2.1 Motor assessment:

Perform the following tests:

- ☐ Hirschberg corneal reflex test: This check whether the reflections on the two corneas are symmetrical or not.
- ☐ Unilateral/alternating cover test: This allows you to identify deviations, whether latent (phoria) or present (tropia).
- ☐ Ocular motility test for the nine gaze directions.

5.1.2.2 Sensory Assessment:

- ☐ Red filter test or Worth test to ensure that there is no neutralization in one eye.
- ☐ Accommodative function tests: duochrome test.
- ☐ Phoria test: Maddox rod.
- ☐ Measure the AC/A ratio.

5.2 Measurement Timeline

Two time points were used to quantify phoria:

****Baseline (T0)**:** Before the new optical correction was dispensed.

****Follow-up (T1)**:** Following 30 days of consistent, full-time use of the recommended remedy.

Each session included distance and near Maddox Rod testing under consistent lighting and fixation condition

Data collection and data entry:

Data were gathered based on the distribution of genders and ages. A complete optometric evaluation, including an assessment of the AC/A ratio, was performed on each patient, there is a clinical file that was made to enter all our patient's data that you can check it in the annex section, and they were entered in the excel microsoft to manufacture charts and tables.

Results:

The study included 9 clinical cases (5 males and 4 females), aged between 17 and 28 years.

Gender and Age Distribution:

Total participants: 9

Gender:

- Male: 6 (66.7%)
- Female: 3 (33.3%)

Age Range: 17–28 years

Average Age: ~23 years

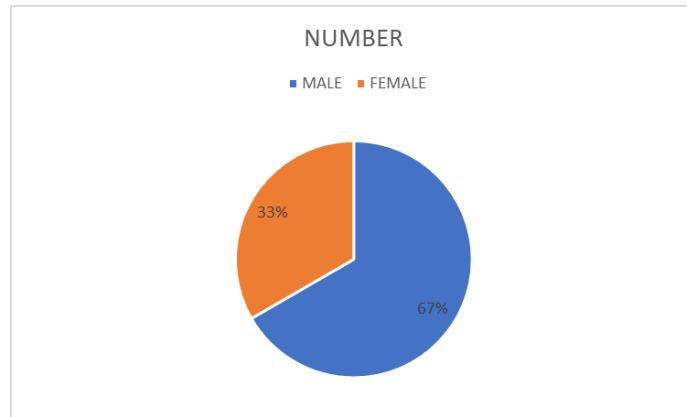


Figure 20: Gender distribution

The study included 9 clinical cases (5 males and 4 females), aged between 17 and 28 years, with an average age of 23.3 years.

Phoria distribution:

Phoria type	Before correction	After correction
Distance phoria	3 ortho 3 exophoria 3 esophoria	4 ortho 3 exophoria 2 esophoria
Near phoria	3 ortho 2 exophoria 2 esophoria	4 ortho 4 exophoria 2 esophoria

Table 3: Phoria distribution table

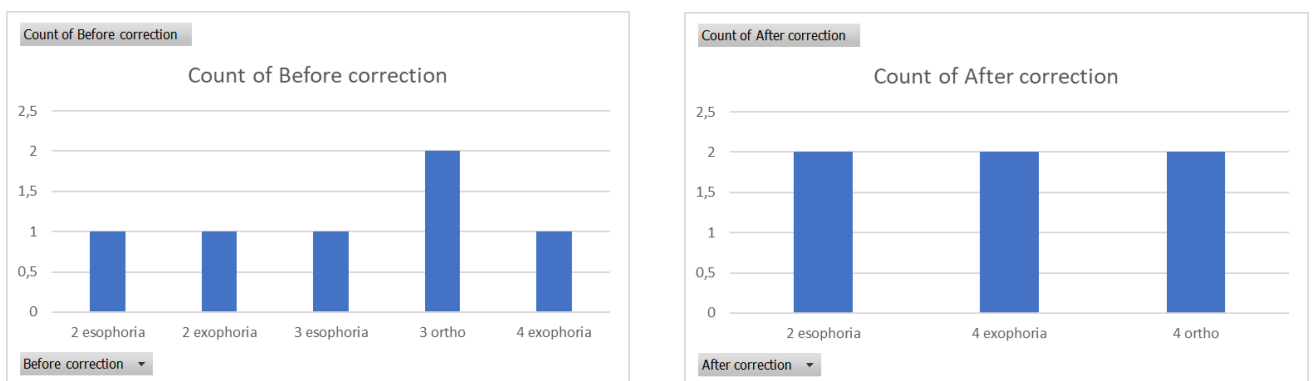


Figure 21: Count before and after correction

Refractive error (Ametropia) distribution:

Refractive error	Right eye	Left eye
Myopia	0 cases	3 cases

Astigmatism myopia	5 cases	4 cases
Hyperopia	1 case	0 cases
Astigmatism Hyperopia	3 cases	1 case

Table 4: Refractive error distribution

Distance phoria:

Before correction, participants were evenly split between ortho, exo-, and esophoria.

After correction, orthophoria increased slightly, indicating better binocular balance.

Near phoria:

Most participants had some degree of near exophoria. After correction, many showed improvement with reduced values.

Average phoria measurements:

Measurement	Before Correction (mean)	After Correction (mean)
Distance phoria	1.56 Δ base in	1.06 Δ base in
Near phoria	4.22 Δ base in	3.11 Δ base in

Table 5: Average phoria measurements

A mean reduction of 0.5–1 prism diopter (Δ) was observed post-correction, especially at near, reflecting improved visual comfort and alignment.

AC/A Ratio Evolution:

Despite incomplete post-correction data, phoric improvements—particularly in patients with high AC/A ratios—suggest that optical correction positively impacted accommodative-convergence dynamics.

The clinical cases

As it was mentioned before our study was conducted in Hamou Boutelilis clinic and Adda vision entreprise we found 10 patients that had all the inclusions criteria

Clinical case 01:

Gender: female

Age :23

Chief complaint headache and visual fatigue by the end of the day and dry eye

Visual acuity RE 10/10 – LE 9/10

Refraction

RE: +0,75

LE: +0,75 (-0,50) 165°

Prescribed correction:

RE: +0,50

LE: +0,50 (-0,50) 165°

AC/A ratio: before: 5,90 after: 5.90

	Before correction	After correction
Distance heterophoria	1 base out	1 base out
Near heterophoria	ORTHO	ORTHO

Discussion: This patient most likely had symptom alleviation as a result of decreased accommodative demand after hyperopic correction, even though there was no change in phoria readings. The stabilizing effect of the lenses is supported by a high AC/A ratio, especially for close work.

Clinical case 02:

Gender: male

Age: 21

Chief complaint: headache and blurred vision by the end of the day

Visual acuity: SC:8/10

CC:10/10

Refraction

RE: - 0,50 (-0,50) 30°

LE: -0,50

Prescribed correction

RE: -0,25 (-0,50) 30°

LE: -0,25

AC/A ratio: before: 3.4 after:4.2

	Before correction	After correction
Distance heterophoria	2 base in	ortho
Near heterophoria	10 base in	6 base in

Discussion: After correction, this patient's distance exophoria and near esophoria significantly improved, exhibiting a characteristic convergence excess profile. The mild improvement in eye clarity and AC/A probably helped to lessen problems.

Clinical case 03:

Gender: Male

Age: 23

Chief complaint: blurred vision and visual fatigue

Visual acuity 6/10

Refraction: RE: -1,75 (-1,00)160°

LE: -2,25 (-0,25) 155°

Prescribed correction:

RE: -1,50(-1,00) 160°

LE: -1,75

AC/A ratio: before: 7.5 after: 7.5

	Before correction	After correction
Distance heterophoria	0,50 base in	0.50 base in
Near heterophoria	ORTHO	Ortho

Discussion: Phoria stability was unaffected by a high AC/A ratio. Blur was more likely to be the cause of the patient's complaints, which became better after refraction. Good fusional control is indicated by stable phoria readings..

Clinical case 04:

Gender: female

Age 25

Chief complaint

Visual acuity 9/10

Refraction: RE: -0,25 (-1,00) 25°

LE: -0,75 (-0,75) 175°

Prescribed correction: RE: Plan (-0,50) 30°

LE: Plan (-0,50) 170°

AC/A ratio: before: 4.2 after:4.6

	Before correction	After correction
Distance heterophoria	0,5 base out	0.5 base out
Near heterophoria	4 base in	3 base in

Discussion: A slight improvement in near exophoria is in line with a better balance between accommodation and convergence. Better close control may be reflected in the modest rise in AC/A.

Clinical case 05:

Gender: male

Age: 25

Chief complaint: blurred vision and headaches and difficulties in near vision

Visual acuity: 5/10

Refraction:

RE: +3.75 (-1.00) 180°

LE: +5.00(-2.75) 10°

Prescribed correction: RE: +2.75 (-1.00) 180°

LE: +3.75 (-2.50) 10°

AC/A ratio:

Before: 3.7 after:2.5

	Before correction	After correction
Distance heterophoria	ORTHO	Ortho
Near heterophoria	4 base in	7 base in

Discussion: Unexpected rise in near exophoria after correction, perhaps as a result of adaptation or undercorrection. A weaker accommodative-convergence response is indicated by a decreased AC/A.

Clinical case 06 :

Gender: female

Age: 17

Chief complaint: vision difficulties

Visual acuity 9/10

Refraction: RE: -0.25

LE: Plan (-0.75) 45°

Prescribed correction: RE: PLAN

LE: PLAN(-0.50) 45°

AC/A ratio: before:6.3 after: 6.3

	Before correction	After correction
Distance heterophoria	3 base in	2 base in
Near heterophoria	3 base in	3 base in

Discussion: Persistent close exophoria but some improvement in distant phoria. The remaining phoria may need near addition or vision treatment if there is little correction.

Clinical case 07:

Gender: male

Age: 24

Chief complaint:

Visual acuity: 10/10

Refraction: RE: +1.25 (-0.50) 175°

LE: PLAN (-1.00) 175°

Prescribed correction: RE: +0.50

LE: +0.50(-0.50) 85°

AC/A ratio: before:8.6 after:6.6

	Before correction	After correction
Distance heterophoria	6 base out	3 base out
Near heterophoria	12 base out	4 base out

Discussion: Phoria values have significantly improved, particularly recently. Accommodative strain was successfully decreased by hyperopic correction and a high AC/A ratio. likely substantial alleviation of symptoms.

Clinical case 08:

Gender: MALE

Age: 24

Chief complaint

Visual acuity: 10/10 - 9/10

Refraction: RE: -0.50(-0.75) 80°

LE: -0.50(-0.25) 50°

Prescribed correction: RE: Plan (-0.75) 80°

LE: -0.25

AC/A ratio: before: 4.3 after:4.3

	Before correction	After correction
Distance heterophoria	Ortho	Ortho
Near heterophoria	6 base in	6 base in

Discussion: Vergence posture was unaffected by the correction. Chronic near exophoria can still be uncomfortable, particularly while using displays or reading. poor AC/A response, most likely. Additional treatments are required, such as near addition or vision therapy.

Clinical case 09:

Gender: male

Age: 28

Chief complaint: Eye fatigue in the left eye to be specific and difficulty in distance vision

Visual acuity: before correction: 8/10

After correction: 13/10

Refraction: RE: -0.50 (-1.00) 60°

LE: -1.00 (-1.25) 80°

Prescribed correction: -0.50 (-0.75) 60°

LE: -1.00 (-0.50) 80°

AC/A ratio: before: 8.9 after: 8.9

	Before correction	After correction
Distance heterophoria	6 base in	6 base in
Near heterophoria	ortho	ortho

Discussion: Despite high AC/A and improved visual acuity post-correction, distance exophoria persisted. Symptoms may persist due to high convergence effort and require further management.

Case	Distance heterophoria before	Distance heterophoria after	Near heterophoria before	Near heterophoria after	AC/A ratio before	AC/A ratio after
01	1 BO	1 BO	ORTHO	ORTHO	5.9	5.9
02	2 BI	ORTHO	10 BI	6 BI	3.4	4.2
03	0.5 BI	0.5 BI	ORTHO	ORTHO	7.55	7.55
04	0.5 BO	0.5 BO	4 BI	3 BI	4.2	4.6
05	ORTHO	ORTHO	4 BI	7 BI	3.4	2.5
06	3 BI	2 BI	3 BI	3 BI	6.3	6.3
07	6 BO	3 BO	12 BO	4 BO	8.6	6.6
08	ORTHO	ORTHO	6 BI	6 BI	4.3	4.3
09	6 BI	6 BI	ORTHO	ORTHO	8.9	8.9

Table 6: Table grouped all data gathered from all the clinical cases

General discussion:

Depending significantly on the kind of refractive defect, the AC/A ratio, and the baseline phoria, optical correction produced varying alterations in heterophoria and symptoms in each of these nine clinical instances.

- Strong improvements were frequently linked to high AC/A ratios, particularly in hyperopic individuals (e.g., Cases 01, 07). Plus lenses improved phoria management by lowering accommodative demand.
- Less consistent alterations were seen in cases with normal or low AC/A ratios (Cases 02, 05, 08). In several instances, phoria even got worse (for example, near eso in Case 05), which might have been brought on by delays in adaption or under-correction.

- There was little change in cases with low refractive error (such as Case 06), indicating that optical correction was not enough on its own and that vergence training could be necessary.

In general, optical correction proved helpful, especially when customized to the accommodative-convergence profile of the patient. Long-term success requires follow-up, AC/A monitoring, and full cycloplegic refraction. Additional therapies, including prism correction or vision therapy, can be required in situations with phorias that are symptomatic or chronic.

Conclusion:

In this study, a group of young individuals with symptomatic binocular vision abnormalities were examined to see how optical correction affected their heterophoria and AC/A ratio. A thorough examination of nine clinical cases revealed that proper refractive correction by itself can have a major impact on binocular alignment, particularly when the underlying phoria is connected to accommodative effort.

The findings supported the original theory:

The accommodative demand is decreased when refractive defects like hyperopia and astigmatism are corrected, which lessens the convergence effort required to keep alignment. This frequently causes the heterophoria to lessen or the patient's capacity to compensate for it to improve.

Notably, phoric readings improved more in patients with high AC/A ratios, which suggests a significant connection between accommodation and convergence, especially at close fixation. On the other hand, those with modest refractive error or low or normal AC/A ratios tended to exhibit little to no change, or in rare instances, a worsening of near phoria. This implies that when non-accommodative processes or weak fusional reserves are present, optical correction alone has little impact.

Furthermore:

- After wearing the recommended correction for a month, the average amount of distance and near heterophoria reduced.
- Numerous patients reported significant alleviation of symptoms, including headaches, blurred vision, and visual fatigue.
- However, further treatment, including vision therapy, can be necessary in some circumstances, particularly if there is increased post- correction phoria or chronic near exophoria.
- For the patients who didn't improve maybe one month was not enough time to see actual results so maybe if they had more time we could have seen some improvements.

In conclusion, this study ends by showing that optical correction is a basic and frequently adequate initial step in the management of symptomatic heterophoria. It highlights how crucial it is to perform a thorough examination of binocular vision, including phoria testing and AC/A

measurement, before writing a prescription. Refractive correction can be crucial in helping patients with high AC/A ratios or symptoms associated with convergence regain both functional binocular stability and visual comfort.

Annex:

CLINICAL FILE



☐ PATIENT INFORMATION

NAME :

FAMILY NAME :

SEX : MALE

FEMALE

AGE : yrs

PHONE NUMBER :

☐ CLINICAL EXAMINATION DATA

OBJECTIVE REFRACTION :

SPH CYL AXES

OD

OS

SUBJECTIVE REFRACTION :

SPH CYL AXES

OD

OS

PUPILLARY DISTANCE : mm

NEAR HETEROPHORIA :

DISTANCE HETEROPHORIA :

AC/A RATIO CALCULATED :

EXAMINATION DATE : \ \

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