ACCOMMODATION AND CONVERGENCE

Department of Ophthalmology

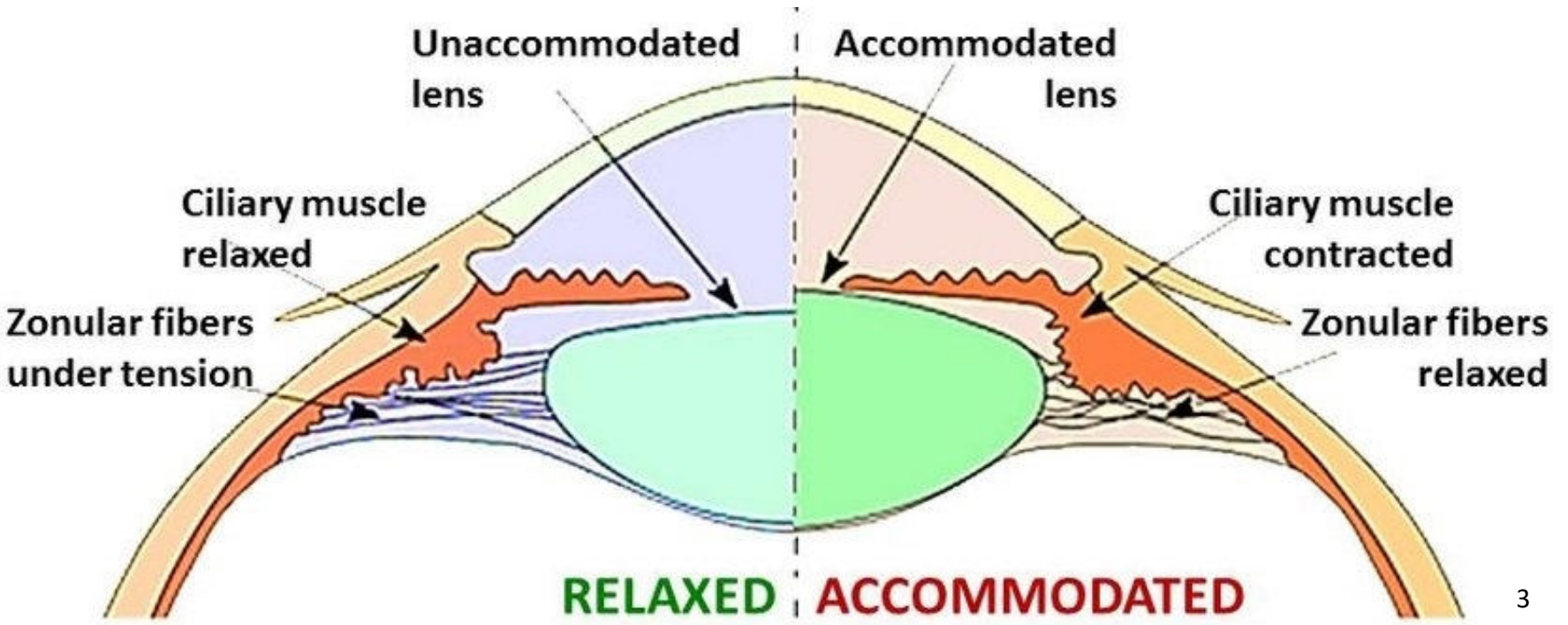
Learning Objectives

At the end of the class, students shall be able to

- Understand the basic mechanism of accommodation and clinical importance of anomalies of accommodation
- Understand the pathway for the near reflex and importance of convergence insufficiency.

ACCOMMODATION

- Definition: Accommodation is the mechanism by which the eye changes its refractive power by altering the shape of the lens in order to focus objects at variable distances.



Mechanism of accommodation

- Increase in the curvature of the lens affects mainly the anterior surface.
- Radius of curvature of anterior surface :**10 mm**

During accommodation

↓

6 mm

This alteration in shape **increases** the converging power of the lens.

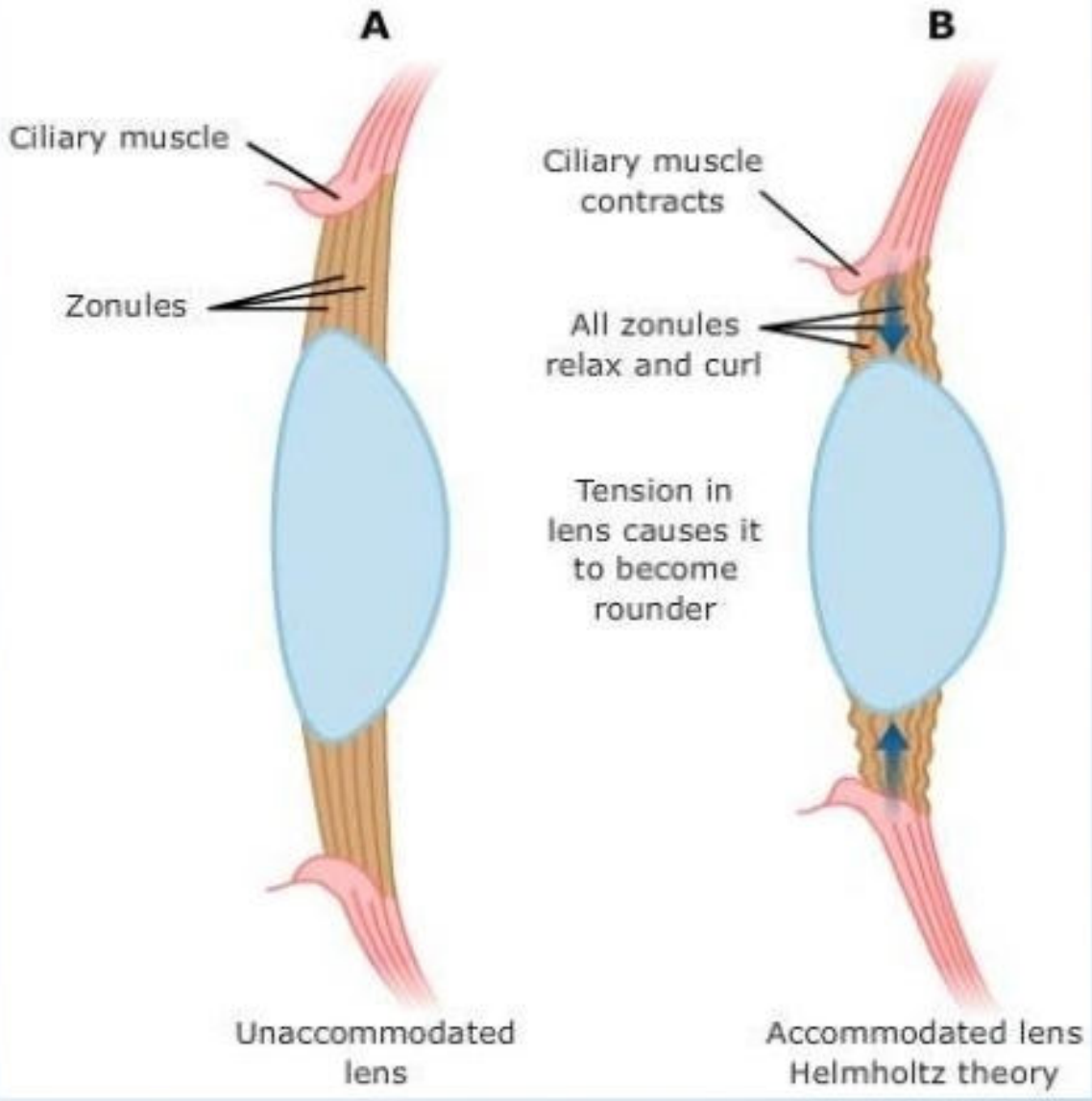
RELAXATION THEORY OF HELMONTZ

- He considered that lens was elastic and in normal state is stretched and flattened by the tension of the suspensory ligament.
- During accommodation:

  Ciliary muscle contracts causing the lens zonules to slacken,

  lens assumes more spherical form increasing thickness and decreasing diameter,

  protrusion forwards at the centre and a relative flattening at the periphery.



NEAR REFLEX

- It has 2 components :
- **Convergence reflex** comprising convergence of the visual axes of the eyes and associated constriction of pupil.

- **Accommodation reflex** includes increased accommodation and associated constriction of pupil.

- The near reflex comprises :

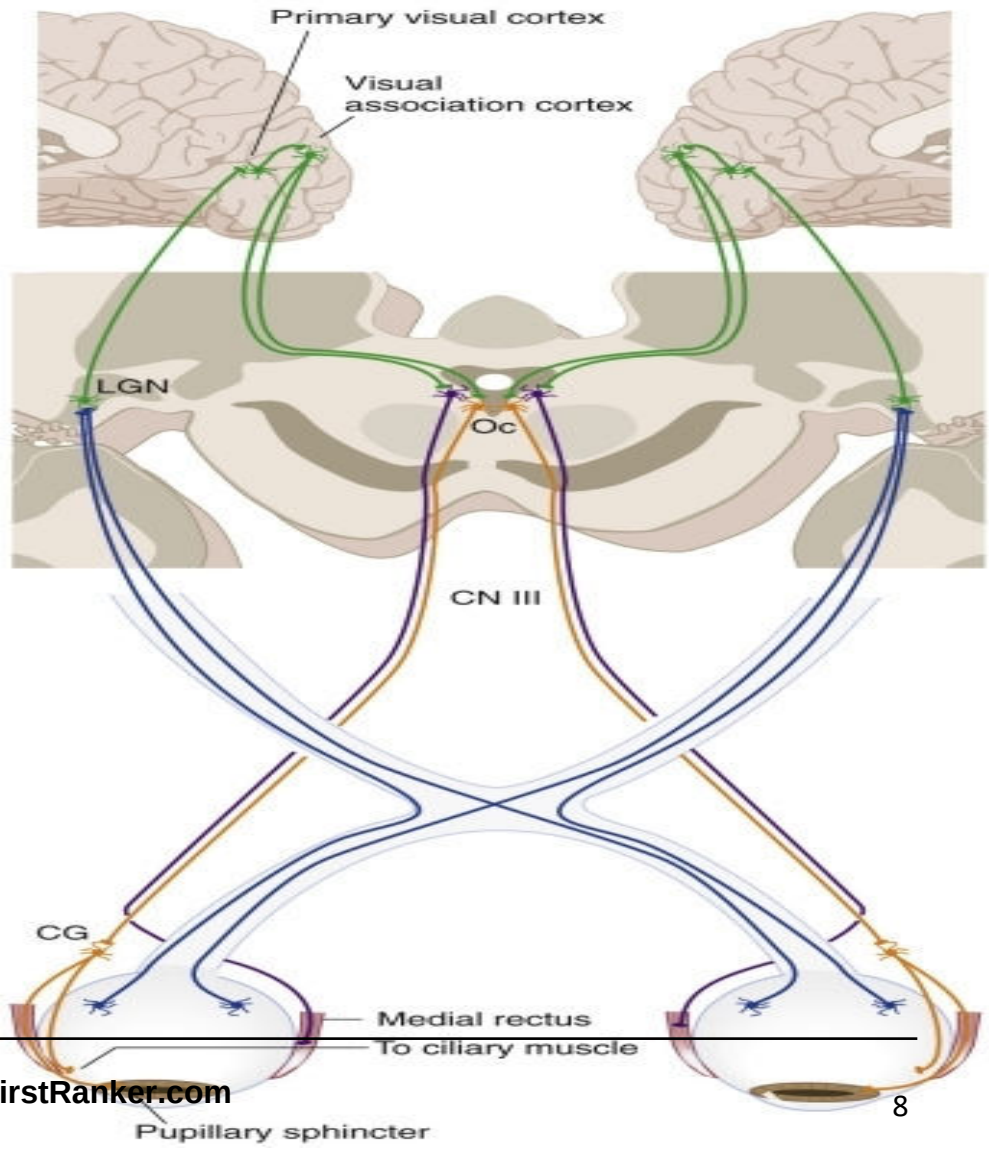
  Accommodation , convergence and miosis.

ACCOMODATION REFLEX

- **Afferent impulses**-from the retina to the parastriate cortex

- **Internuncial fibres** relay impulses from parastriate cortex to Edinger westphal nucleus of both sides

- **Efferent fibres** –from Edinger westphal nucleus the efferent impulses travel along the 3rd nerve and reach the sphincter pupillae and ciliary muscle



Physical and physiological accommodation

Two factors in accommodation

- Ability of lens to alter its shape
- Power of the ciliary muscle

***1.Physical accommodation*- Expression of the actual physical deformation of the lens, measured in dioptres.**

2. Physiological accommodation- *Contractile power of the ciliary muscle required to raise the refractive power of the lens , measured in myodioptres.*

- The **far point** of distinct vision is the position of an object such that its image falls on the retina in the relaxed eye, i.e. in the absence of accommodation. The far point of the emmetropic eye is at infinity.
- The **near point** of distinct vision is the nearest point at which an object can be clearly seen when maximum accommodation is used.

- The **range of accommodation** is the distance between the far point and the near point.
- The **amplitude of accommodation** is the difference in dioptric power between the eye at rest and the fully accommodated eye.

- The amplitude of accommodation is given by the formula
- A = P - R
- where A is the amplitude of accommodation in dioptres
- P is the dioptric value of the near point distance
- R is the dioptric value of the far point distance.

- Applying this formula to the case of an emmetropic eye with a near point of 10 cm,
- P = 10 D (the reciprocal of 0.10 m)
- R = 0 (the reciprocal of infinity is zero)
- A = 10 D

- **Far point and near point** of the eye vary with the static refraction of the eye
- In a **hypermetrope eye** far point is virtual and lies behind the eye
- In a **myopic eye** far point is real and lies in front of the eye.

- In an emmetropic eye
- Far point is at infinity
- Near point varies with age
- About 7 cm at age of 10 years
- About 25 cm at age of 40 years
- 33 cm at age of 45 years

ANOMALIES OF ACCOMMODATION

DIMINISHED ACCOMMODATION

1. PHYSIOLOGICAL (PRESBYOPIA)
2. PHARMACOLOGICAL (Cycloplegia)
3. PATHOLOGICAL

- Insufficiency of accommodation
- Ill sustained accommodation
- Paralysis of accommodation

INCREASED ACCOMMODATION

1. EXCESSIVE ACCOMMODATION
2. SPASM OF ACCOMMODATION

PRESBYOPIA

- Presbyopia is not an error of refraction but a condition of physiological insufficiency of accommodation due to reduced amplitude of accommodation, leading to a progressive fall in near vision.
- This begins between 40 years and 45 years.

- After the age of 40 years ,the NPA recedes beyond the normal reading distance.

- This condition of falling near vision due to age related decrease in the amplitude of accommodation or increase in punctum proximum is presbyopia.

- **Causes of presbyopia :**

❑ Age related changes in lens which include

➢ Decrease in elasticity of lens capsule

➢ Progressive increase in size and hardness (sclerosis) of lens substance.

❑ Age related decline in ciliary muscle power.

- **Causes of premature presbyopia include**

➢ Uncorrected hypermetropia

➢ Premature sclerosis of the crystalline lens

➢ General debility causing presenile weakness of ciliary muscle

➢ Chronic simple glaucoma

- **Symptoms**

➢ Difficulty in near vision : patients start complaining of inadequacy of vision for small print and finer objects at the usual reading distance. Such problems start occurring in the evening, and in dim light.

➢ Asthenopic symptoms due to fatigue of ciliary muscle

➢ Intermittent diplopia at near may develop.

- **Treatment**

Optical correction of presbyopia

Done by supplementing accommodation with convex lens of appropriate power.

The difference between the distance correction and the strength needed for near vision is called the add.

PRESBYOPIC ADD

- If the patient is presbyopic, calculate the likely reading addition and add this to the distance lenses in the trial frame. In practice the reading addition is estimated from the patient's age.

AGE RANGE	READING ADDITION
45-50 YEARS	+1.00 D
50-55 YEARS	+1.50 D
55-60 YEARS	+2.00D
OVER 6O YEARS	+2.50 D

MODES OF PRESCRIBING PRESBYOPIC ADD

- SPECTACLES
- CONTACT LENSES FOR PRESBYOPIA

2.SURGICAL TREATMENT OF PRESBYOPIA

- refractive surgeries

- **Insufficiency of accommodation**

Accommodative power is significantly and persistently below the normal physiological limits for the patient's age

- **Causes**

➢ Premature sclerosis of lens

➢ Weakness of ciliary muscle due to systemic causes such as diabetes mellitus.

Clinical features :

Headache

Fatigue

Blurring of vision for near work

Intermittent diplopia

Treatment :

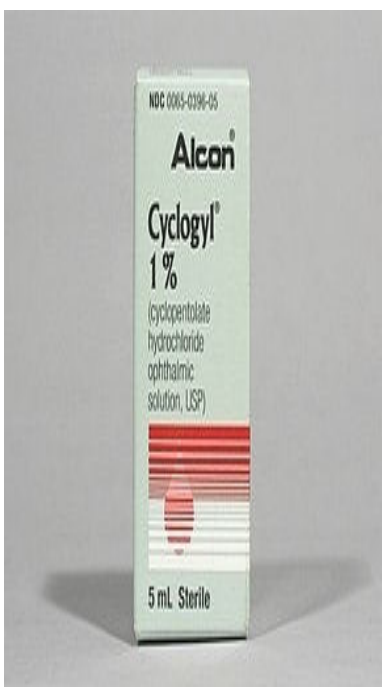
1.Treatment of the systemic cause

2.Near vision spectacles

3.Accomodation exercises

Paralysis of accommodation

- Paralysis of accommodation ,also known as cycloplegia, refers to complete absence of accommodation.



Causes

- Drug induced
- Internal ophthalmoplegia
- Paralysis of accommodation as a component of 3rd nerve palsy.

DRUG	MAXIMUM MYDRIASIS	MAXIMUM CYCLOPLEGIA	DURATION OF MYDRIASIS	DURATION OF CYCLOPLEGIA
ATROPINE 1% TID	30-40 MIN	1 DAY	7-10 DAYS	2 WEEKS
CYCLOPENTOLATE 0.5%-1%	15 MIN	15-30 MIN	1 DAY	24 HRS
HOMATROPINE 2%	30-60 MIN	30-60 MIN	1-2 DAYS	1-2 DAYS
TROPICAMIDE 0.5%-1%	15-30 MIN	20-25 MIN	4-6 HRS	5-6 HRS

- **Clinical features**
  - Blurring of near vision
  - Photophobia (due to mydriasis)
  - Micropsia
  - abnormal receding of near point
  - Signs of 3rd nerve palsy

- **Treatment**
  - Self recovery-drug induced paralysis and in cases when systemic cause is treated.
  - Dark glasses – reduce glare
  - Convex lenses –for near vision if paralysis is permanent.

Excessive accommodation

- A situation in which an individual exerts more than the normal required accommodation for performing a certain near work.
- Excessive near work is an important precipitating factor especially when done in inadequate illumination.

- **Clinical features**

- Varying degrees of blurred vision
- Symptoms of accommodative asthenopia
- Near vision difficulty

- **Treatment**

1. Optical treatment : refractive error to be corrected
2. General treatment : Near work should be minimised and when done should be in proper illumination.
3. The general health of the patient should be improved.

CONVERGENCE

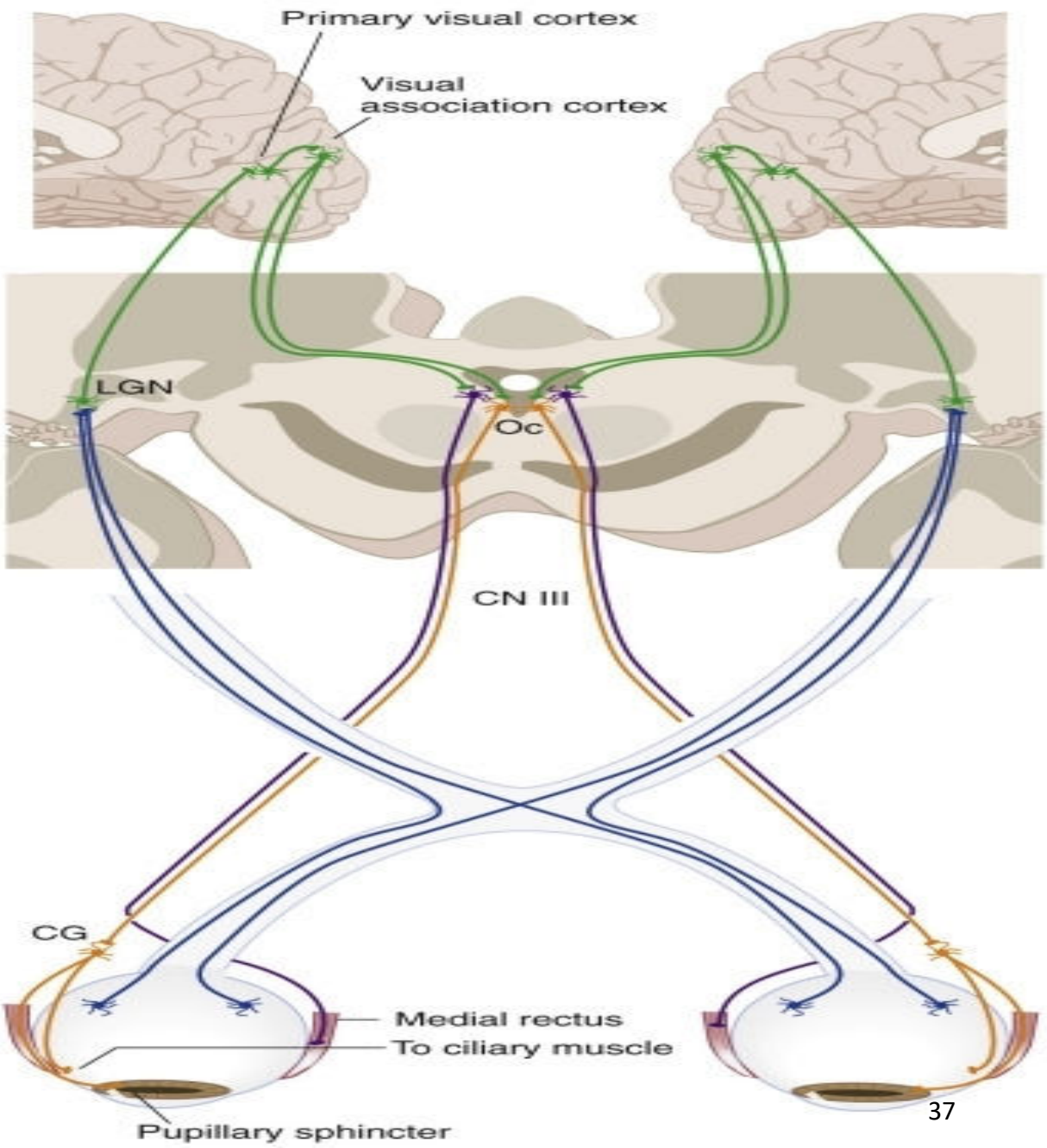
- Definition: Convergence is a disconjugate movement in which both eyes rotate inward so that the lines of sight intersect in front of the eyes.
- Allows bifoveal single vision to be maintained at any fixation distance.
- Convergence does not deteriorate with increasing age.
- The power of convergence can be increased by exercises.

Convergence reflex

- **Afferent pathway** –the afferents from medial recti travel centrally via the 3rd nerve to the mesencephalic nucleus of the 5th nerve, to a presumptive convergence centre in tectal or pretectal region.

- **Internuncial fibres :** from the convergence centre go to the Edinger Westphal nucleus .

- **Efferent pathway**- along the 3rd nerve. From the 3rd nerve efferent fibres of convergence reflex relay in the accessory ganglion, before reaching sphincter pupillae.



- **Angle of convergence**

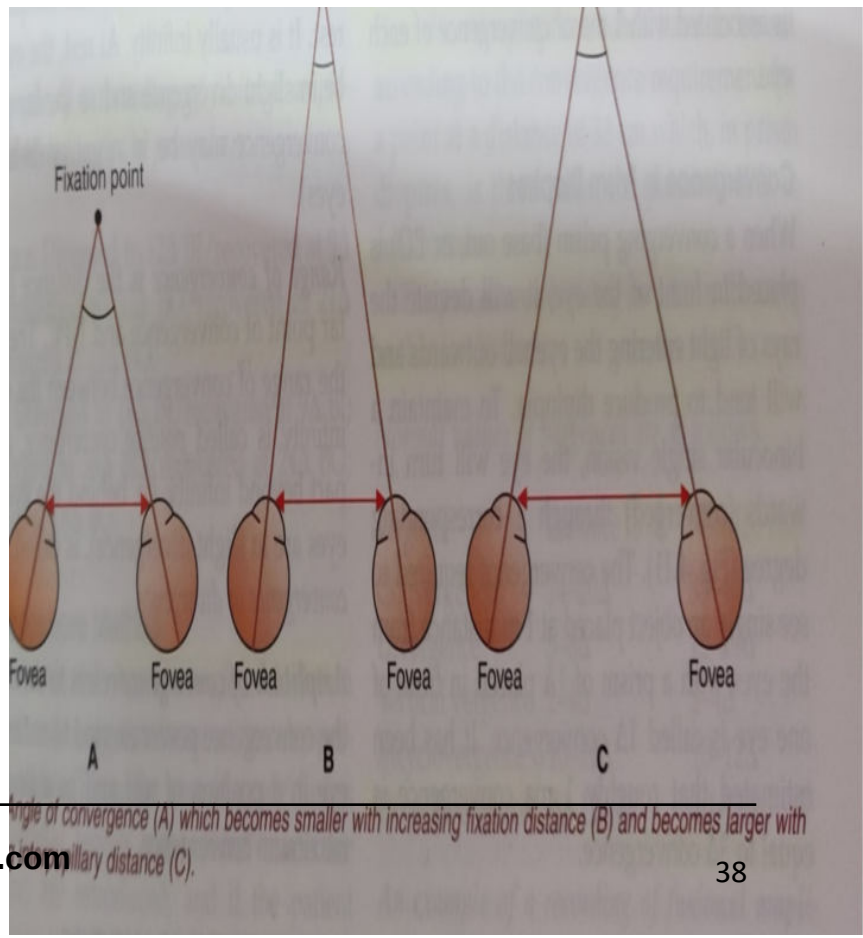
➢ It refers to the angle that is formed between the primary lines of sight during convergence

➢ Its size depends on

➢ the fixation distance

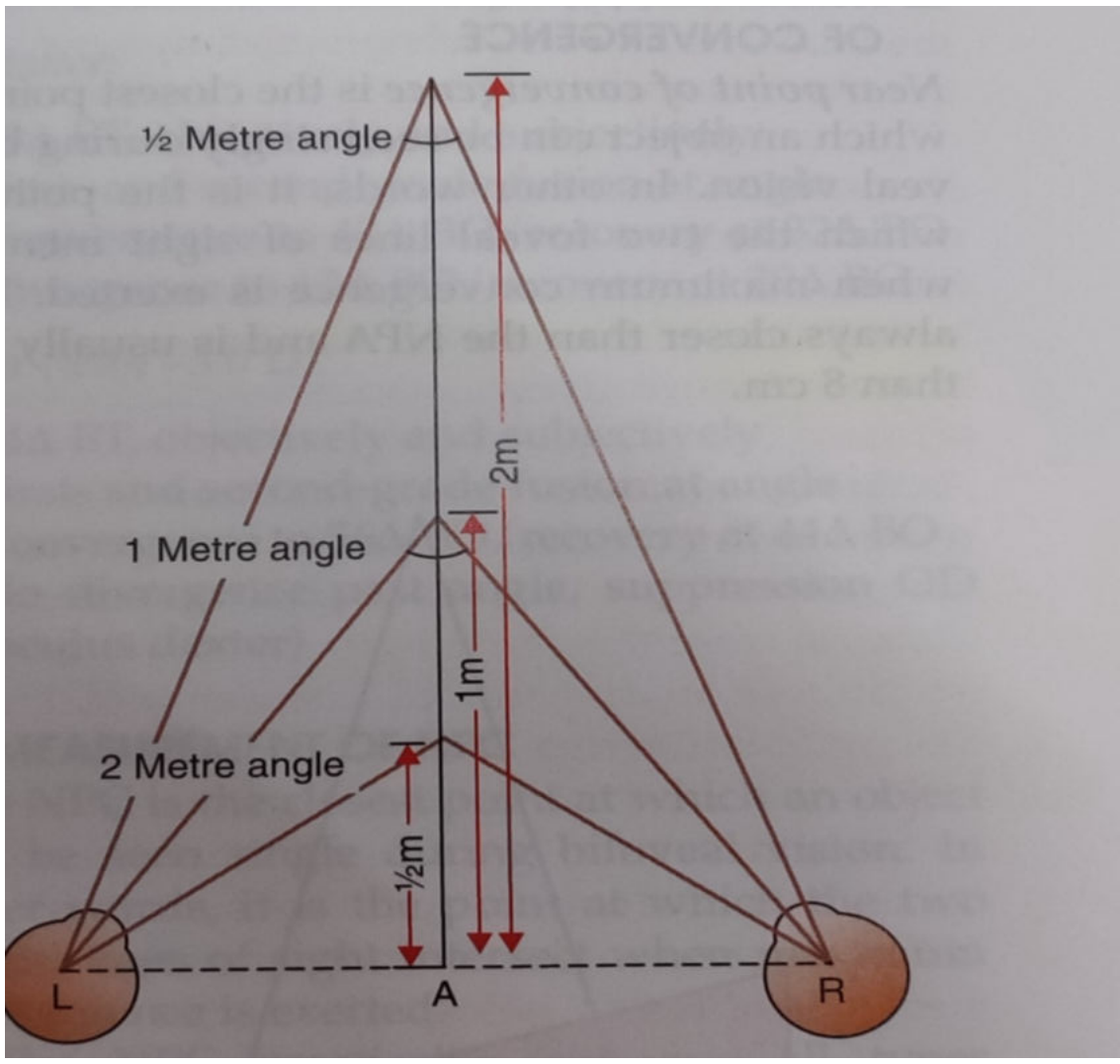
and

interpupillary distance (IPD)



Metre angle

- One metre angle convergence is exerted by each eye when the eyes are directed to object at a distance of 1 m of the meridian line between the two eyes.



- In an emmetropic eye, the number of dioptres of accommodation required to see an object clearly is equal to the number of metre angles through which each eye must converge to see the object singly.
- Thus 1D of accommodation is associated with 1 ma of convergence of each eye

- The **near point** of convergence is the closest point at which an object can be seen singly during bifoveal vision when maximum convergence is exerted.

- The **far point** of convergence refers to relative position of the eyes when they are completely at rest, usually at infinity.

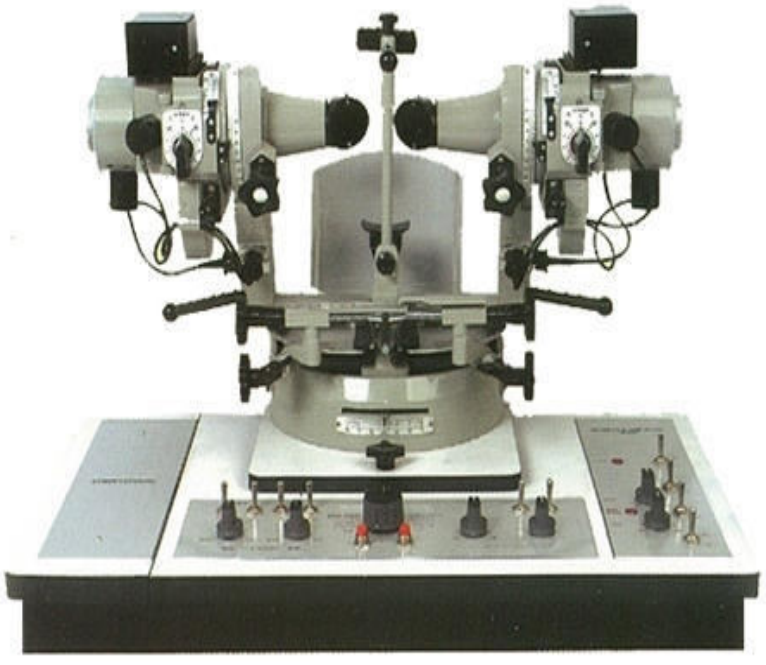
- The **range of convergence** is the distance between the far point and the near point of convergence

- The **amplitude of convergence** is the difference in convergence power exerted to maintain the eye in a position at rest and in a position of maximum convergence.

Measurement of amplitude of convergence

1. Prism bar

2. Synoptophore



Anomalies of convergence

1) Convergence insufficiency

Inability to maintain adequate binocular convergence for any length of time without undue effort.

- ***Aetiology***

A. Primary or idiopathic – wide IPD, general debility, overwork.

B. Refractive errors- uncorrected high hypermetropia and myopia

C. Presbyopia

D. Muscular imbalances- exophoria, intermittent exotropia and vertical muscle imbalances.

Clinical features

1. Symptoms of muscular fatigue

- Eyestrain
- Headache and eye ache
- Difficulty in changing the focus from distant to near
- Itching, burning and soreness of eyes

2. Symptoms due to failure to maintain binocular vision

- Blurred near vision
- Intermittent crossed diplopia

Diagnosis

1. Remote NPC – if NPC > 10 cm, Convergence insufficiency is said to exist.
2. Decreased fusional convergence for near-when measured on synoptophore, if there is difficulty in attaining 30˚ of convergence.
3. Exophoria

Treatment

1. Optical treatment- Myopes are given full correction and hypermetropes undercorrection to stimulate their accommodation and simultaneously convergence.
2. Orthoptic treatment- exercises to increase the near point of convergence (NPC) and also to increase amplitude of fusional convergence.

3. Prism Therapy

Base in (BI) prisms reading glasses or bifocals with prism in the lower segment are useful.

4. Surgical treatment

- Last resort
- Medial rectus muscle resection can be performed.

Convergence paralysis

CAUSES

- Head injury
- Encephalitis
- Tabes dorsalis
- Narcolepsy
- Tumours

- **Clinical features**
- Convergence is completely absent
- Exotropia and crossed diplopia occurs on attempted near vision
- Adduction is normal

- **TREATMENT**

❑ **Base In (BI) prisms**

❑ **Plus lenses with BI prisms**

Summary

- Accommodation is the mechanism by which the eye changes its refractive power by altering the shape of the lens in order to focus objects at variable distances.
- Convergence is a disconjugate movement in which both eyes rotate inward so that the lines of sight intersect in front of the eyes.
- The near reflex comprises : Accommodation , convergence and miosis.