# UNIT 12 MUSCLES AND MOVEMENTS OF THE EYE

## Structure



## 12.0 OBJECTIVES

After studying this unit, you will be able to understand:

- actions of the extra-ocular and intra-ocular muscles;
- uni-ocular and binocular movements;
- laws governing ocular muscles; and
- different types of squint.

## 12.1 INTRODUCTION

The eye is comprised of extra-ocular and intra-ocular muscles. The extra-ocular muscles are comprised of 4 recti and 2 obliques. The rectus muscles originate in the common tendinous ring that is attached at the apex of the orbit around the optic foramina and medial part of the superior orbital fissure. The nerve supply for the lateral rectus (LR) is by the 6th cranial nerve, the superior oblique (SO) by the 4th cranial nerve and all other extra-ocular muscles are supplied by the 3rd nerve. The intra-ocular muscles include the sphincter pupillae, the dilator pupillae, and the ciliary muscle.

In normal eyes, the visual axes are parallel to each other in the primary position of gaze. This position is usually maintained but in the case of squint (strabismus) there is a misalignment of the visual axis. There are three different types of squint—latent (heterophoria), manifest (heterotropia), and apparent (pseudo-squint).

# 12.2 EXTRA-OCULAR MUSCLES

There are, as you know, six extra-ocular muscles. Out of these, four are recti(straight) and two are oblique. They control the position and movement of the eye balls.

## 12.2.1 Recti and Oblique Muscles

The extra-ocular muscles are mainly involved in the maintenance of postural tonicity and performance of quick contractions. These muscles rotate the eye around the centre of rotation (13.5 mm behind the cornea, 1.6 mm nasal to the geometric centre of the eye).

The insertions of the extra-ocular muscles are at the sclera at different distances from the limbus:

a) **Recti Muscles:**

| Muscle | Insertion in mm Behind Limbus | Main Action |
|---|---|---|
| Medial Rectus (MR) | 5.5 | Adduction |
| Lateral Rectus (LR) | 6.9 | Abduction |
| Inferior Rectus (IR) | 6.6 | Elevation and Intorsion |
| Superior Rectus (SR) | 7.7 | Depression and Extorsion |

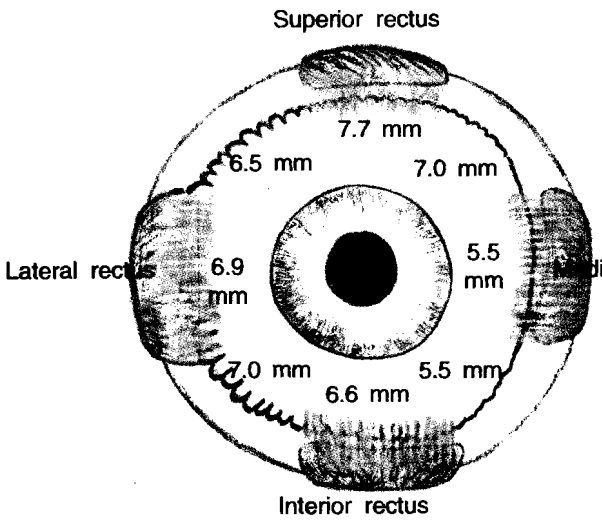



Fig. 12.1: Insertion of recti

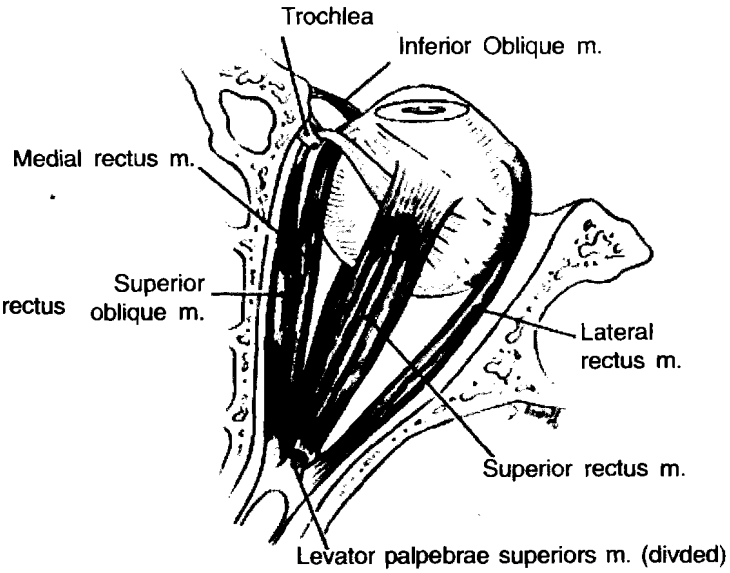



Fig. 12.2: Extraocular muscles

b) **Oblique Muscles:**

| Muscle | Origin | Insertion | Nerve Supply | Actions |
|---|---|---|---|---|
| Superior Oblique | Body of sphenoid and medial part of optic foramina | Upper and outer part of sclera behind the equator | 4th cranial nerve | Intorsion and Depression |
| Inferior Oblique | Orbital plate of maxilla | Lower and outer part of sclera behind the equator | 3rd cranial nerve | Extorsion and elevation |

| Muscle | Primary action | Secondary action | Tertiary action |
|---|---|---|---|
| Medial Rectus | Adduction | — | — |
| Lateral Rectus | Abduction | — | — |
| Superior Rectus | Elevation | Intorsion | Adduction |
| Inferior Rectus | Depression | Extorsion | Adduction |
| Superior Oblique | Intorsion | Depression | Abduction |
| Inferior Oblique | Extorsion | Elevation | Abduction |

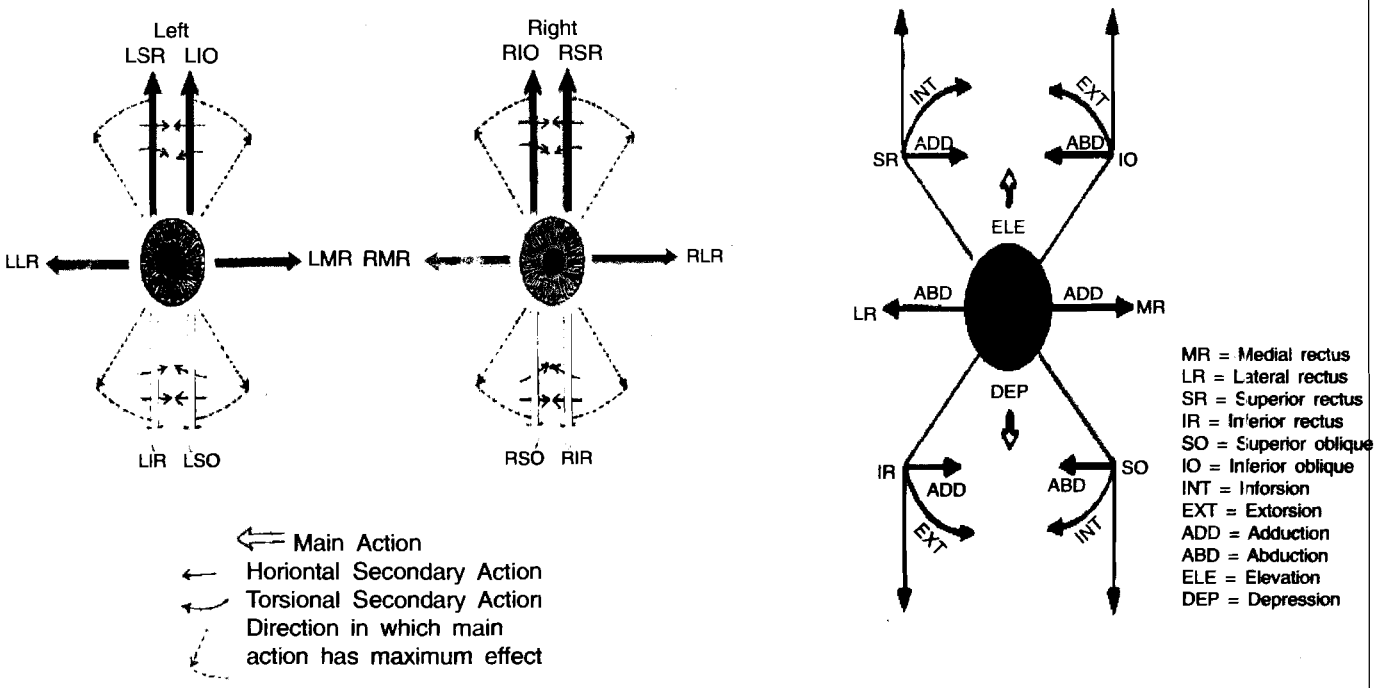
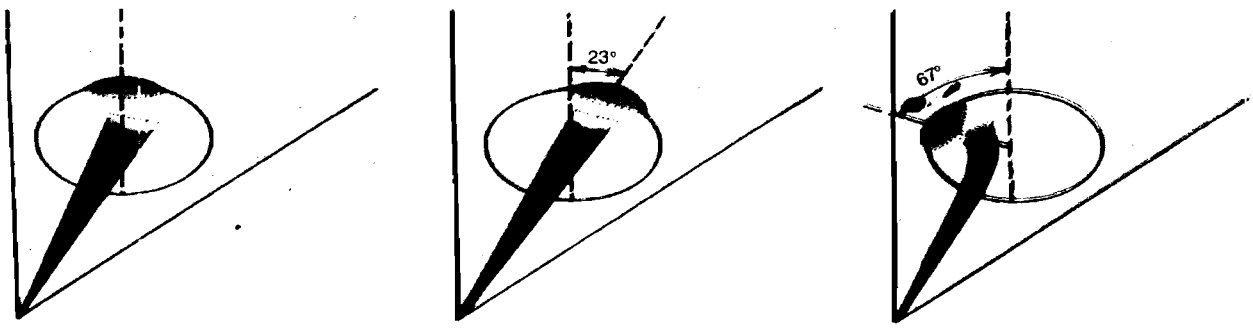



**Fig. 12.3: Actions of extra-ocular muscles**

## 12.2.2 Planes of Muscles

### Recti

The planes of superior and inferior recti in primary position form an angle of about 23° with the Y-axis. Therefore, the axis of rotation of these muscles does not coincide with the X-axis. In primary position of the eye, the superior rectus not only elevates and adducts the globe but also rotates it around the antero-posterior Y-axis, which then causes intorsion.




**Primary position** **Globe adducted 23°** **Globe abducted 67°**

**Fig. 12.4: Actions of superior rectus muscle**

### Obliques

The superior and inferior oblique muscles form an angle of about 51° with the optical axis. The oblique muscles produce cyclorotation because of the large angle formed in the primary position of the eye.

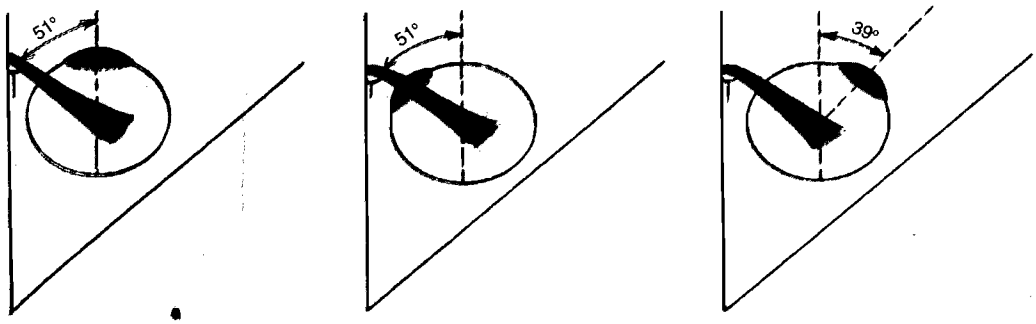



**Fig. 12.5: Actions of superior oblique muscle**

**Check Your Progress 1**

1) What is the function of extra-ocular muscles?

.....

.....

.....

.....

2) What is the primary action of the lateral rectus?

.....

.....

.....

.....

## 12.3 INTRA-OCULAR MUSCLES

The intra-ocular muscles consist of the sphincter pupillae, dilator pupillae muscles, and ciliary muscles. The sphincter pupillae muscle functions in the constriction of the pupil and is supplied by the parasympathetic 3rd cranial nerve. The dilator pupillae muscle dilates the pupil and obtains its nerve supply from the sympathetic long ciliary nerve. Lastly, the ciliary muscle functions in accommodation and is supplied by the parasympathetic short ciliary nerve.

**Check Your Progress 2**

What are the intra-ocular muscles?

.....

.....

.....

.....

.....

.....

# 12.4 UNI-OCULAR MOVEMENTS

Uni-ocular movements are the movements of one eye studied at a time. That means, when left eye is covered, then movements of uncovered right eye are studied; and the same for the other eye. Uni-ocular movements are called "ductions".

### Listing's Plane

Listing proposed that only horizontal movements of the eye are performed around a vertical axis in the equatorial plane and vertical movements are performed around a horizontal axis in the equatorial plane. The Listing's Plane can thus be defined as the imaginary plane containing both the vertical (Z-axis) and horizontal axis (X-axis), around which the horizontal and vertical movements respectively take place.

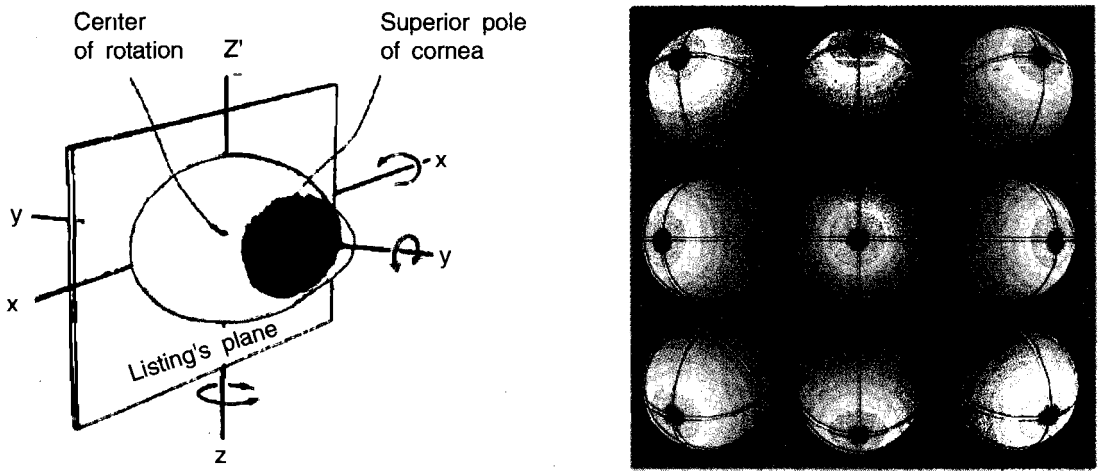



**Fig. 12.6: Axes of fick, center of eotation and listing's plane**

### Axes of Fick

The Axes of Fick show that any eye position can be specified as the amount of rotation around a set of axes fixed in the orbit:

1) **Vertical Axis:** Z-axis → Horizontal movements take place around it. Horizontal movements consist of adduction (inward) and abduction (outward) movements.
2) **Horizontal Axis:** X-axis → Vertical movements take place around it. Vertical movements consist of elevation (upward) and depression (downward) movements.
3) **Antero-Posterior Axis:** Y-axis → Torsional movements take place around it. Torsional movements consist of intorsion (inward rotation) and extorsion (outward rotation) movements.

### Uni-ocular Movements

In each eye, for every movement there is an agonist, antagonist, and a synergist. An **agonist** is the main muscle that is active in carrying out the movement. A **synergist** is another muscle in the same eye that along with the agonist produces an effect. An **antagonist** is a muscle in the same eye that acts in the opposite direction to the movement. **Adduction** is the inward movement along the vertical axis. **Abduction** is an outward movement along the vertical axis. **Elevation** is an upward movement along the horizontal axis and **depression** is a downward movement along the horizontal axis. **Intortion** (Incycloduction) is a rotatory movement along the antero-posterior axis in which the superior pole of the cornea moves medially. **Extortion** (Excycloduction) is a rotatory movement along the antero-posterior axis in which the superior pole of the cornea moves laterally.

**Check Your Progress 3**

1) What is the name given to uni-ocular movements?

.....

.....

.....

.....

2) Which muscle is antogonist of right medical rectus?

.....

.....

.....

.....

## 12.5 BINOCULAR MOVEMENTS

Binocular movements are those when the relative movements of both eyes are studied together in the directions, e.g., right or left.

There are two types of binocular movements — versions and vergences. In versions (conjugate movements) both eyes move in the same direction. In vergences both eyes move in opposite directions.

Yoke muscles (contralaterals) have the same **version** movements in both eyes.

**Versions**

Versions are movements of both eyes in the same direction.

a) **Dextroversions:** Movements of both eyes to the right side.

b) **Levoversions:** Movements of both eyes to the left side.

c) **Supraversions:** Upward movement of both eyes.

d) **Infraversion:** Downward movement of both eyes.

e) **Dextrocycloversion:** Superior pole of the cornea of both eyes tilt towards the right side.

f) **Levocycloversion:** Superior pole of the cornea of both eyes tilt towards the left side.

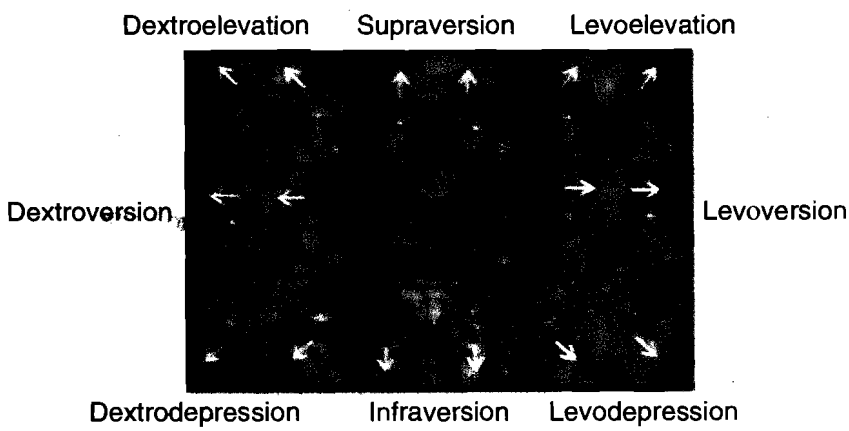



**Fig. 12.7: Diagnostic positions of gaze. Primary position (e); Secondary position 8 (b, d, f, h); Teriary positions (a, c, g, i); Cardinal positions (a,c,d,f,g,i)**

**Vergences**

Vergences are movements of both eyes in opposite directions—right/left.

a) **Convergence:** Inward movement of both eyes.

b) **Divergence:** Outward movement of both eyes.

In both the above, one eye moves towards right and other eye towards left side.

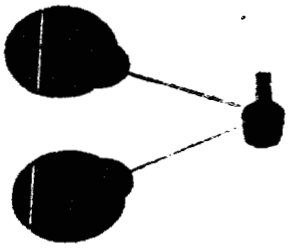


**Fig. 12.8: Convergence: The eye is turned in toward the Midline**

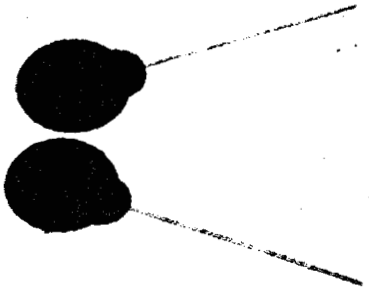


**Fig. 12.9: Divergence: The eye is turned out, away from the Midline**

## 12.5.1 Laws Governing Ocular Movements

Hering's Law of Equal Innervation states that equal and simultaneous innervation flows from the brain to yoke muscles in all binocular movements.

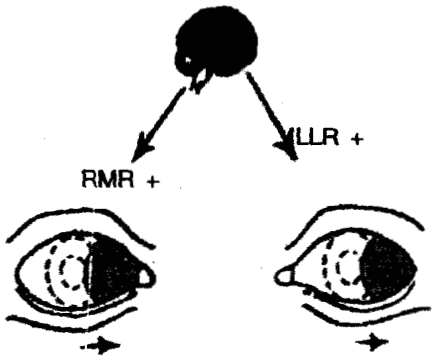



**Fig. 12.10: Herring's law of equal innervation**

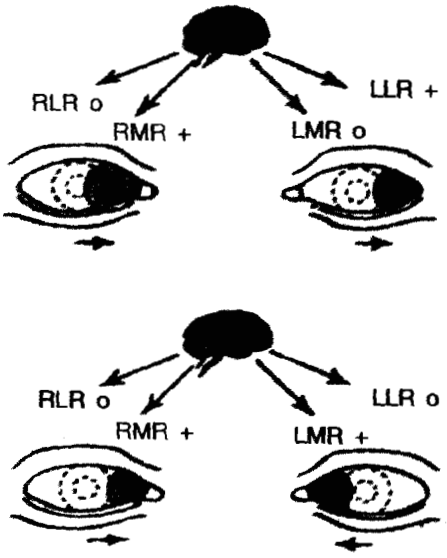



**Fig. 12.11: Sherrington's law of reciprocal innervation**

Sherrington's Law of Reciprocal Innervation states that during ocular motility, there is an increase in flow of innervation to the contracting muscle and a decreasing flow of innervation to the antagonist muscle.

**Check Your Progress 4**

What are the two types of binocular movements?

.....

.....

.....

.....

# 12.6 ABNORMALITIES OF GAZE

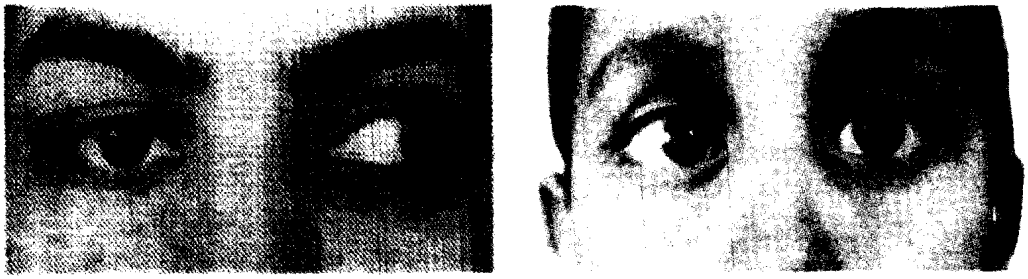
Normal gaze is when visual axes both eyes are parallel in primary gaze. But, when visual axes are not parallel in primary gaze, it is abnormal gaze or squint (strabismus), Squint can be latent, manifest or pseudo-squint.

## 12.6.1 Latent Squint (Anisophoria or Heterophoria)

This eye condition occurs when the balance of extra-ocular muscles is altered. There is a tendency of the eye to deviate form its normal position when the corrective fusion reflex is withdrawn. Latent squint is called "Phoria". Within the latent squint category there are five subtypes:

1) Esophoria
2) Exophoria
3) Hypophoria
4) Hyperphoria
5) Cyclophoria.

Latent squint is seen commonly as exophoria in infancy and presbyopic age and esophoria in childhood. Hypermetropes can have esophoria and myopes, exophoria. This type of squint can be accompanied by anatomical defects in muscle, fascia and ligament structure as well as organic muscular or nervous system diseases such as Myasthenia gravis. Most patients develop severe headaches, eye-ache, blurring of vision and/or intermittent diplopia with this condition. To diagnose latent squint a cover test, Maddox rod, Maddox wing, or a synaptophore can be used. The treatment for latent squint includes refraction, orthoptic treatment to increase muscle power and fusion range, and operative intervention.



Primary Exotropia Exotropia

**Fig. 12.12: Manifest Squint**

## 12.6.2 Manifest Squint (Heterotropia)

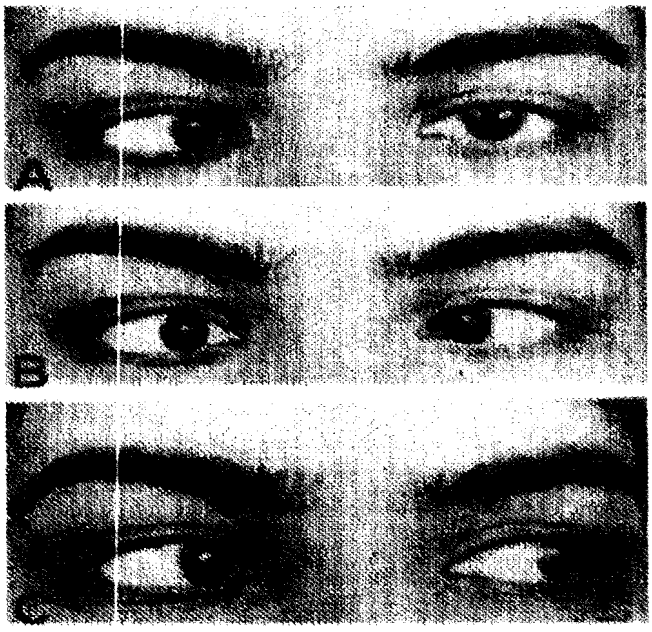
Manifest squint is a deviation of one eye from the normal position when the fusionreflex is present. The subcategories of manifest squint are concomitant (non-paralytic) and non-concomitant (paralytic). Concomitant is a constant deviation of the eye in all directions of gaze. It can either be divergent, convergent or vertical. Manifest squint may be seen to be uni-ocular or alternating between either eye. Manifest squint is also called "tropia".

### Concomitant or Non-Paralytic Squnit

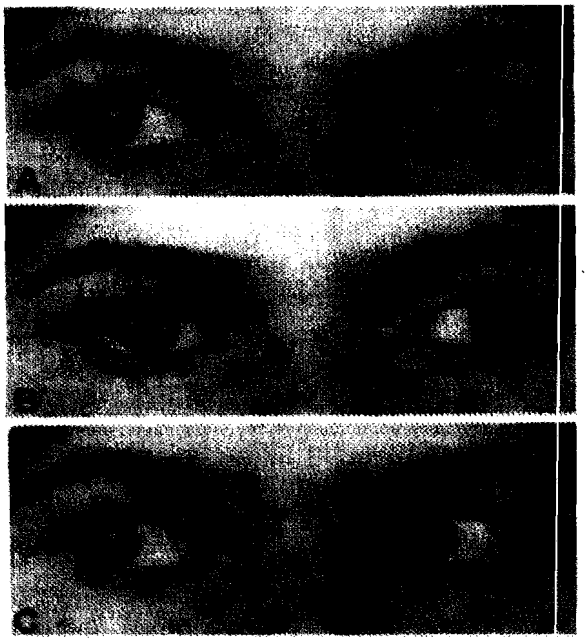
This type of squint usually occurs when there is an obstacle in the sensory pathway of binocular reflex such as refractive errors, opacities, retinal or optic nerve disease. Other causes consist of faulty position of the eye, decompensation of heterophoria, and disharmony in the accommodation-convergence relationship. This condition arises between the age of 0 to 5 years. Symptoms and signs are failure of binocular vision, deviation of the eye, equal primary and secondary deviation, and lack or limitation of eye movements. It can be diagnosed by history, cover test, analysis of ocular movements, vision and refraction, status of BSV, and

measurement of angle of squint. Treatment for non-paralytic squint is correction of refractive error, occlusion therapy to cure amblyopia, fusional exercises to improve binocular vision, andoperative intervention occlusion therepy tocure amblyopia, fusional exercises to improve binocular vision, and operative innervation.

Concomitant squint is also called comitant squint. It means "I follow you", i.e., in all directions of gazes, the squinted eye follows the normal (fixating) eye with same degree of angle of squint. In this, primary angle is equal to secondary angle. Primary angle is angle of deviation of squinted eye when normal eye fixates. Secondary angle is angle of deviation of normal eye (under cover) when squinted eye is made to fixate by covering the normal eye.




**Right Lateral Rectus Palsy**
A-Right Esotropia in Primary Gaze
B-Esotropia Increases in Right Lateral Gaze
C-Becomes Orthotropic in Left Gaze




**Right Medial Rectus Palsy**
A-Right Esotropia in Primary Gaze
B-Which Increases in Left Gaze
C-Becomes Orthotropic in Right Gaze

**Fig.12.13: Paralytic Squint**

### Non-concomitant or Paralytic Squint

This subdivision of manifest squint occurs when there is a deviation of the eye in different directions. The causes for non-concomitant squint are lesions of the cranial nerve that supply the eye muscle or a lesion of the muscle itself. The symptoms are diplopia in the direction of action of the paralyzed muscle, vertigo, and nausea. The signs include deviation of eye in paralyzed muscle, greater secondary than primary angle of deviation, restriction of eye movement, normal visual acuity, compensatory head tilt, and false orientation. Non-concomitant squint is diagnosed through patient history, head posture, ocular position, cover test, ocular movement, and a diplopia test. It can be treated by occlusion of affected eye, vitamin B addition, and operation.

## 12.6.3 Pseudosquint (Pseudo-false)

Pseudosquint is the condition when despite the visual axis being parallel, there appears to be a squint. Pseudosquint can be convergent or divergent. Convergent pseudo-esotropia occurs when the angle between the visual and assumed optical axis (angle K) is large and negative. This is seen in subjects with a prominent epicanthal fold or a broad nasal bridge.

It may be divergent pseudo-exotropia when the angle K is large and positive. This is seen when there are widely separated eyes, narrow lateral canthi or hypertelorism.

**Check Your Progress 5**

1) What is Phoria?

.....

.....

.....

2) What is the other name of Paralytic squint?

.....

.....

.....

## 12.7 LET US SUM UP

The six extra-ocular muscles are the medial rectus, lateral rectus, superior rectus, inferior rectus, superior oblique, and inferior oblique. The intra-ocular muscles include the sphincter pupillae, the dilator pupillae, and the ciliary muscles. In each eye, for every movement there is an agonist, anagonist, and a synergist. There are two types of binocular movements—versions and vergence. In versions (conjugate movements) both eyes move in the same direction. In vergence both eyes move in opposite directions. Hering's Law of Equal Innervation states that equal and simultaneous innervation flows from the brain to yoke muscles in all binocular movements. Latent squint occurs when the balance of extra-ocular muscles is altered. Manifest squint is a deviation of one eye from the normal position when the fusion reflex is present. In next unit you will study about the light sense, right vision and colour vision.

## 12.8 ANSWERS TO CHECK YOUR PROGRESS

**Check Your Progress 1**

1) The extra-ocular muscles are mainly involved in the maintenance of postural tonicity and performance of quick contractions.

2) The primary action of lateral rectus is abduction.

**Check Your Progress 2**

The intra-ocular muscles are sphincter pupillae dilator muscles and ciliary muscles.

**Check Your Progress 3**

1) Ductions

2) Right Lateral rectus

**Check Your Progress 4**

Versions and vergences are the types of binocular movements.

**Check Your Progress 5**

1) Latent squint

2) Non-concomitant, or Non-comitant squint