1

An Overview of Strabismology

Binocular single vision (BSV) is one of the hallmarks of the human race that has bestowed on it the supremacy in the hierarchy of the animal kingdom. It is not without reason that about 60% of the brain tissue and more than half of the twelve cranial nerves subserve the eyes. BSV is accomplished by a perfect sensorimotor coordination of the two eyes both at rest and during movement. The two two-dimensional images of an object of interest formed at the fovea of each eye, transmitted to the respective visual cortex are processed and perceived as one three-dimensional (3-D) percept (Fig. 1.1). This requires constant and controlled activity of the appropriate eye muscles to maintain fixation of the two eye-cameras on the concerned object, irrespective of the movement between it and the observer. It also requires the accommodational mechanism to maintain clear view even as the object moves closer or farther.

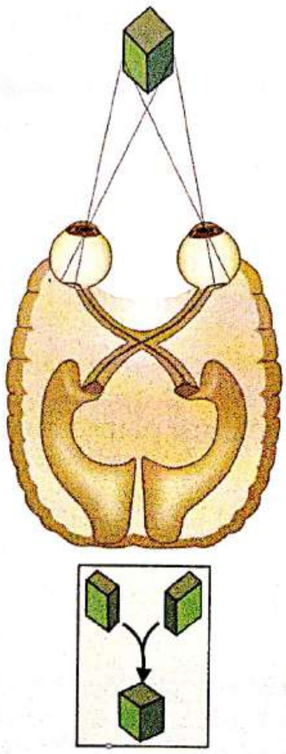

Fig. 1.1: A schematic diagram showing how we see the three-dimensional world. Inset shows two two-dimensional figures seen by each eye, having some disparity are fused together to become one three-dimensional percept.

EXTRAOCULAR MUSCLES

Each eye is equipped with six extraocular muscles (EOM) for this purpose (Figs 1.2 and 1.3).

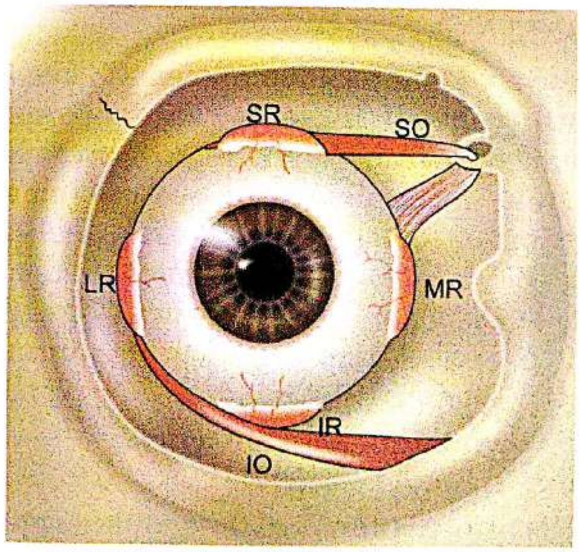

Fig. 1.2: Front view of right eye in orbit. Superior rectus: SR, Inferior rectus: IR, lateral rectus: LR, Medial rectus: MR, Superior oblique: SO and Inferior oblique: IO.

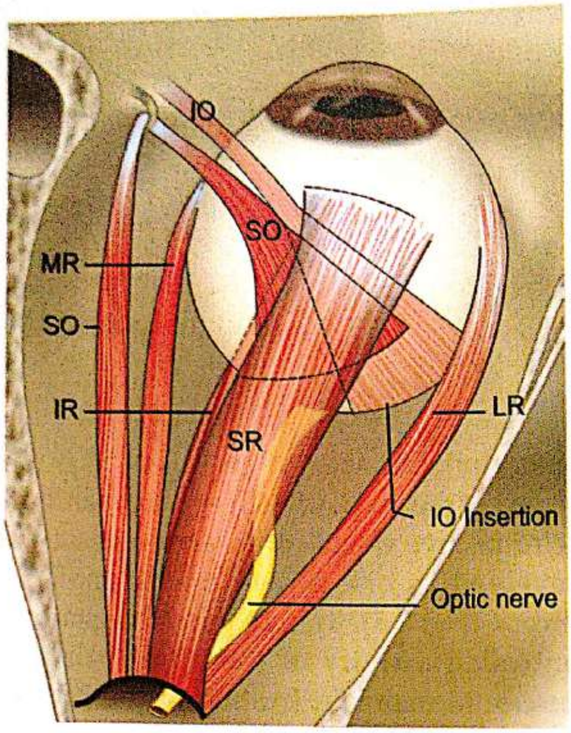

Fig. 1.3: An overview of right eye from top.

- Two horizontal recti: **Medial** and **lateral recti**.
- Two vertical recti: **Superior** and **inferior recti**.
- Two obliques: **Superior** and **inferior obliques**.

PLANES AND AXES

These six EOM together allow each eye free motility in all the three dimensions in innumerable planes and axes. For convenience we take three planes of eye movement, **(Listing's planes)** and their three respective axes **(Fick's axes)** perpendicular to the planes: Listing's plane is vertical plane that indudes 'X', 'Z' and oblique axes that pass through center of eye (Fig. 1.4).

- **Horizontal plane:** Horizontal eye movements around Z-axis
- **Vertical plane:** Vertical eye movements around X-axis (in three vertical planes: eyes in primary position, eyes in adduction and eyes in abduction)
- **Torsional:** Torsional eye movements around Y-axis, which is anteroposterior.

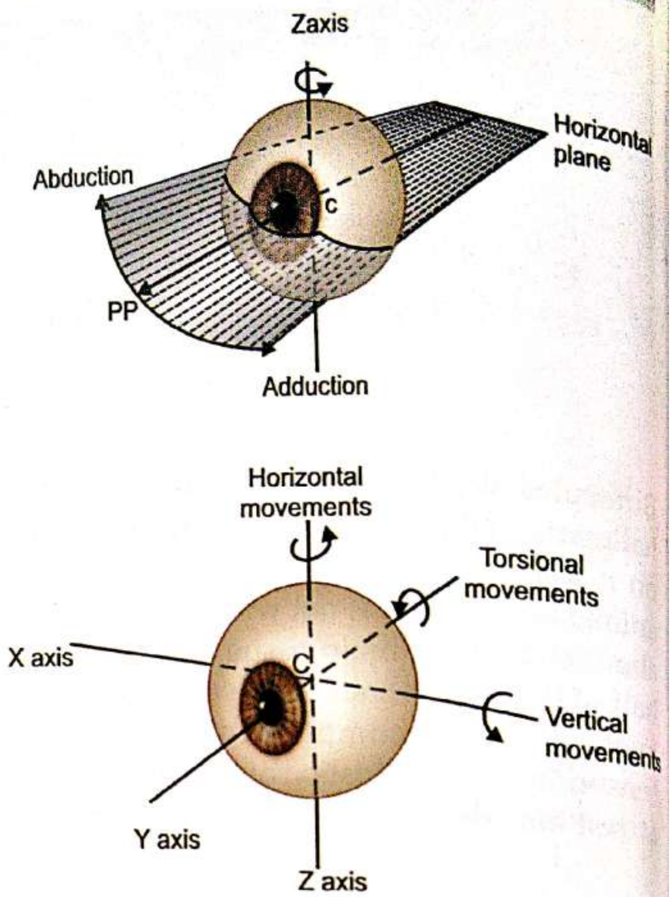

Fig. 1.4: Planes and axes for different eye movements.

DUCTIONS AND VERSIONS

The eye movements when tested uniocularly are called **ductions** and when tested binocularly are called **versions**.

Ductions

Ductions in the three planes mentioned above are (Fig. 1.5):

- **Adduction** (nasally directed horizontal movement)
- **Abduction** (temporally directed horizontal movement)
- **Sursumduction** or **elevation** (upward movement): It can be in primary position, in adduction, or in abduction.
- **Deorsumduction** or **depression** (downward movement): Like sursumduction it can also be in primary position, in adduction, or in abduction.
- **Incycloduction** or **intorsion** (nasally directed tilting of 12 o'clock meridian)

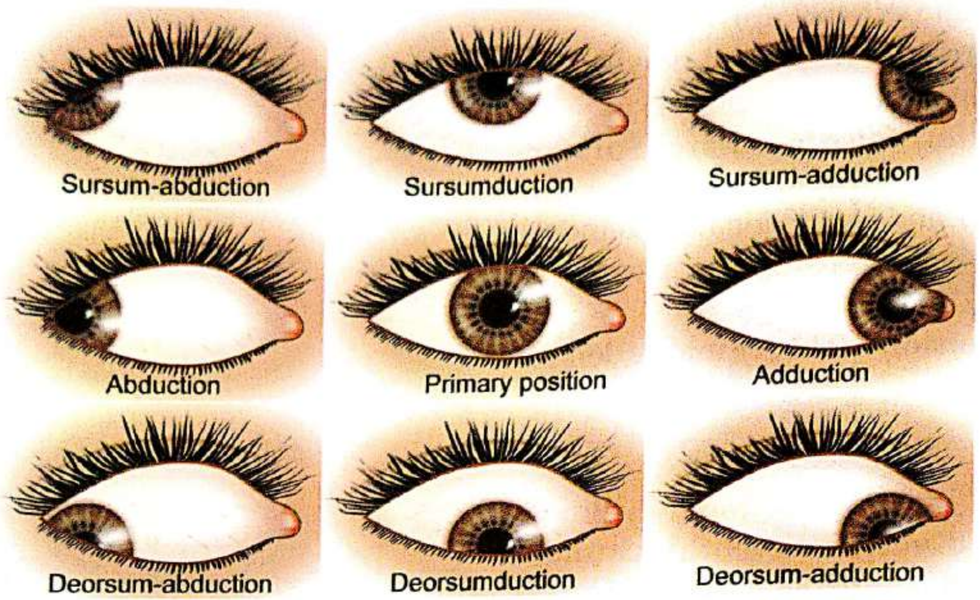

Fig. 1.5: Duction movements of right eye.

- **Excycloduction** or **extorsion** (temporally directed tilting of 12 o'clock meridian)

Ductions give a good idea of the ability of excursion of eyes in different directions, but have a disadvantage in case of paresis (partial loss of power of eye muscles), when normal ductions may be observed. This is due to extra innervation called in to compensate for the paresis. In case of versions, however, this extra innervation also goes to the yoke muscle of the other eye, which would show an overaction. **Thus a paresis missed on duction is picked up in a version.**

Versions

Versions are binocular eye movements that are in the same direction (conjugate eye movements). Binocular eye movements in the opposite directions (**disjugate** eye movements) are called **vergences**.

Versions are labelled in the three diagnostic planes (Fig. 1.6) as.

- **Dextroversion** (right sided binocular horizontal movements)
- **Levoversion** (left sided binocular horizontal movements)
- **Dextroelevation** (right and up)

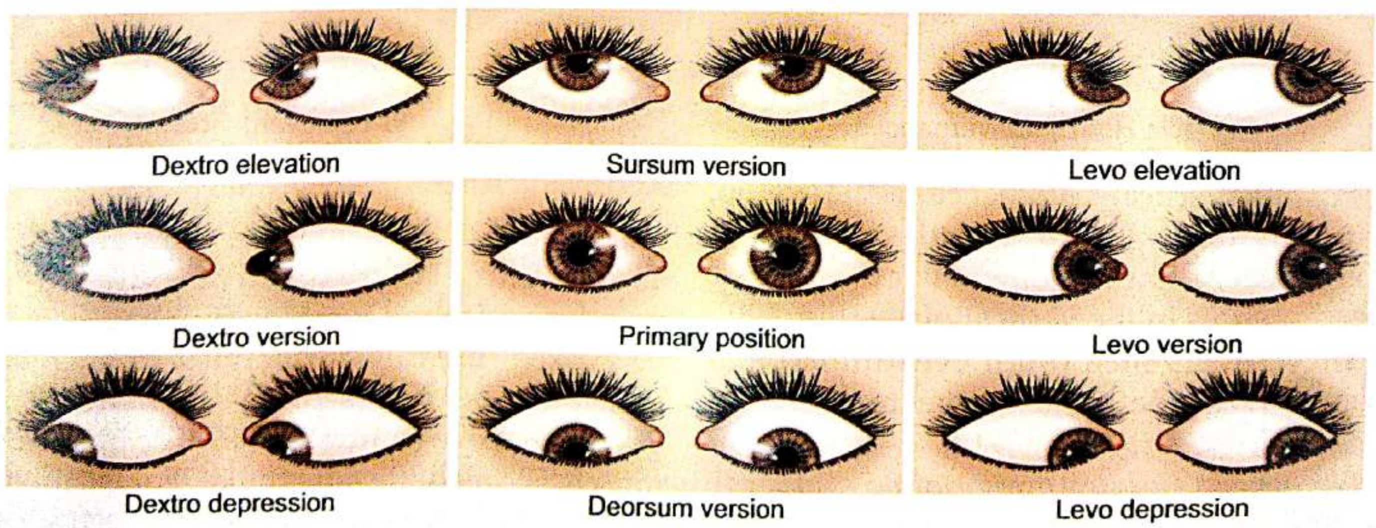

Fig. 1.6: Version movements in nine gaze positions.

- **Levoelevation** (left and up)
- **Dextro-depression** (right and down)
- **Levo-depression** (left and down).

Other positions also used are: Sursum-version (straight up), deorsum-version (straight down), and for torsional movements:

- **Dextrocycloversion** (right eye extorts, left eye intorts),
- **Levocycloversion** (right eye intorts, left eye extorts).

Vergences

Vergences are **convergence** (both eye move nasally) and **divergence** (both eye move temporally) in the horizontal plane (Fig. 1.7).

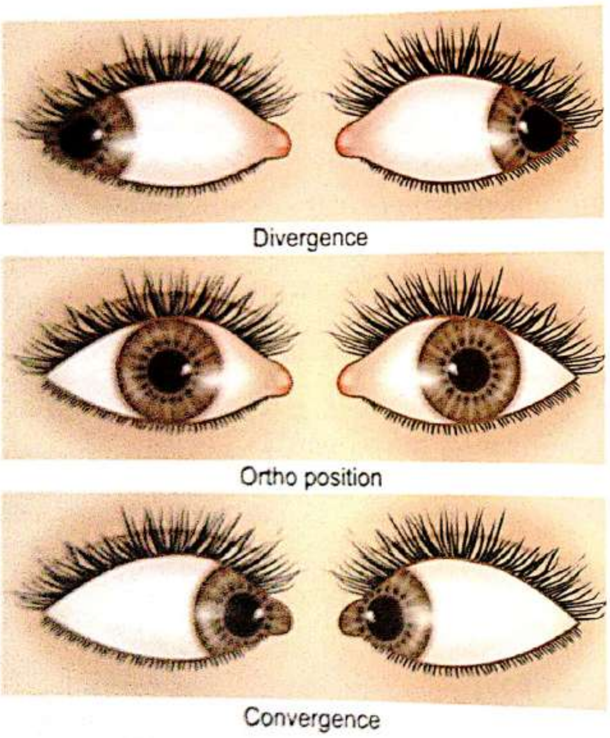

Fig. 1.7: Horizontal vergences.

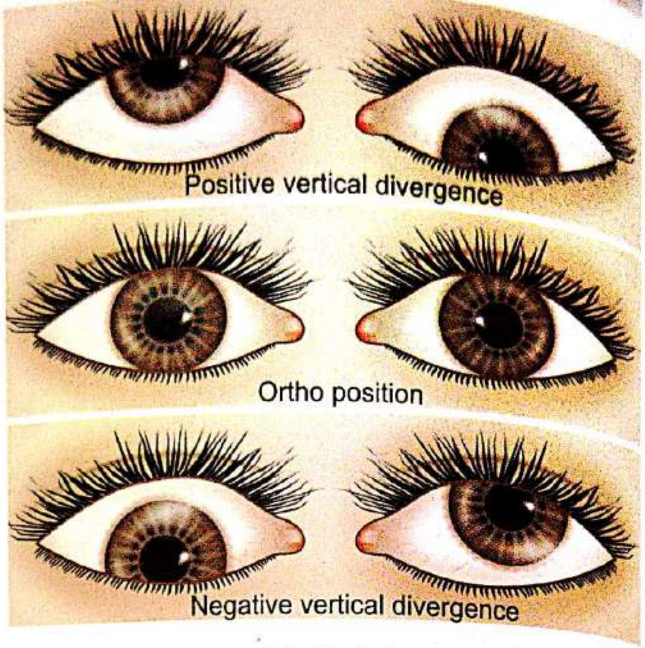

Fig. 1.8: Vertical divergence.

Positive vertical divergence (right eye up, left eye down) and **negative vertical divergence** (right eye down, left eye up) are the vergences in the vertical plane (Fig. 1.8).

Incyclovergence (both eyes intort) and **excyclovergence** (both eyes extort) are the torsional vergences (Fig. 1.9).

Vergences are very important as they can be helpful in keeping a tendency of squint under control **(fusional vergences)**.

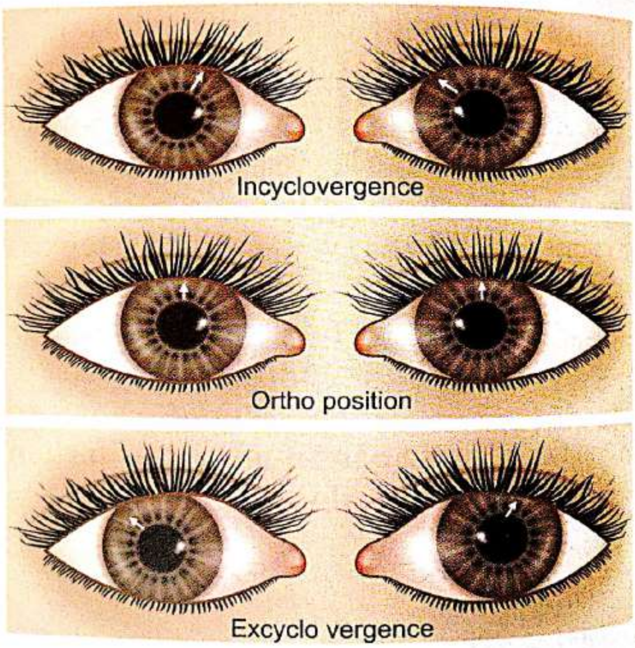

Fig. 1.9: Cyclovergence.

AGONISTS AND ANTAGONISTS

It is obvious that the two eyes work in unison as one unit. The respective extraocular muscles which are working in pairs, said to be "yoked" are called **synergists** or **agonists** which may be of the same eye **(ipsilateral)** or of the other eye **(contralateral)**. The opposing muscle is called the **antagonist**. For example, due to a dextroversion, right lateral rectus has left medial rectus as its contralateral synergist and right medial rectus as its ipsilateral antagonist. However, for a convergence the right and left medial recti become the synergists and the two lateral recti become the antagonists.

It would be desired that for the two eyes to look at the same object, the synergists should move equally in the desired direction. Indeed this happens so, and this is governed by the **Hering's law of equal innervation which states that for any movement the synergists receive equal and simultaneous innervation. In addition the respective antagonists are inhibited to facilitate a smooth and unobstructed movement, inhibition not innervation the Sherrington's law of reciprocal inhibition.**

CORRESPONDENCE

Having two eyes would necessitate a normal sensory system to collect the two visual images at the corresponding visual cortices and further to co-ordinate the two informations to make a single percept. Each fovea has a primary visual direction (the direction of its straight-ahead gaze), and the two fovea share a **common visual direction**. Any object imaged on the visual direction of either of the fovea would be superimposed and seen in the common visual direction, which is of neither eyes but of an imaginary **cyclopean eye** (Fig. 1.10).

The two foveas are said to have a **normal retinal correspondence (bifoveal correspondence)**. The other areas of the retina have a relationship with their fovea, and also correspond with a specific retinal area of the other eye **(corresponding point or area)**. Objects imaged on the corresponding areas are seen binocularly single (Fig. 1.11).

An imaginary plane on which the corresponding points are projected is called the **horopter**. A little area on either sides of the horopter, which allows the sensory fusion despite the disparity is called the **Panum's area of fusion**. This fusion despite disparity,

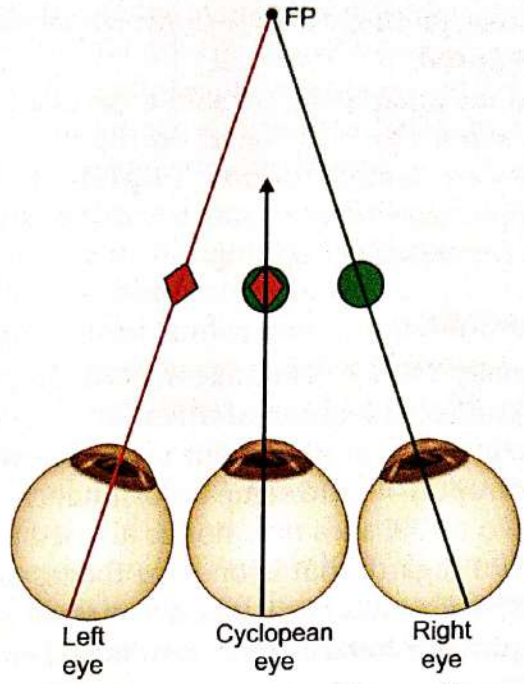

Fig. 1.10: Bifoveal correspondence with normal alignment while fixating on a fixation point. FP two objects located separately in space but on the visual directions appear in one line of common visual direction of cyclopean eye.

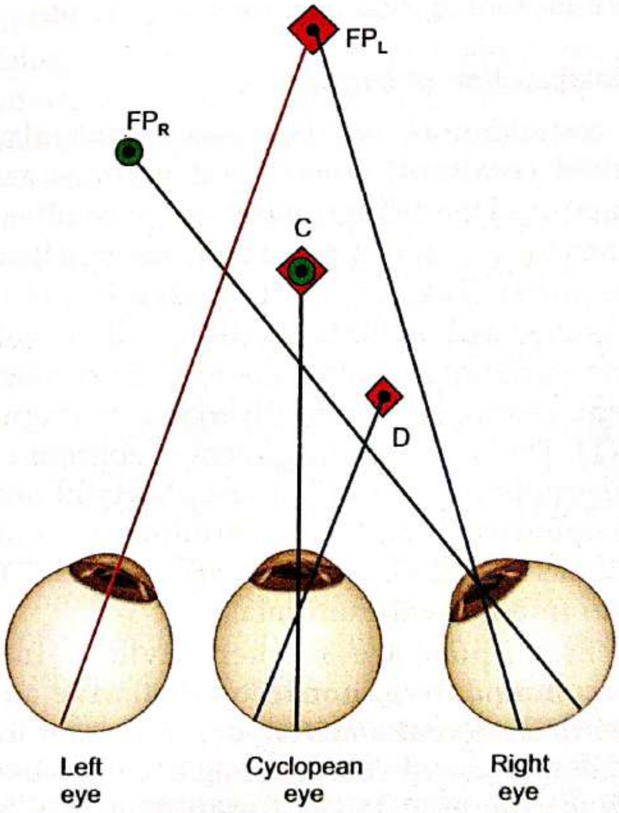

Fig. 1.11: Bifoveal correspondence with convergent strabismus of right eye. Confusion (C) due to two fixation points of each eye, FP_L& FP_R. Diplopia (D) due to projection of the FP_L in right eye.

however, produces a three-dimensional vision (stereopsis).

All the other areas are said to be disparate points and objects imaged on the disparate points are seen as double **(diplopia)**. This diplopia is binocular and is not perceived under monocular conditions.

STRABISMUS

Normally the two visual axes meet at the point of regard or the object of attention. The eyes are said to be in alignment (**orthophoria** or **orthotropia**). Due to some unfortunate reason the two visual axes may not be aligned to the point of regard, that is one eye fixates at the point but the other eye does not. A **strabismus or squint or heterotropia** results. When this tendency is overcome by the fusional vergences the subject does not manifest squint. This **latent squint** is called **heterophoria.** When the squint is present at times and controlled at other times, it is called **intermittent** as against a **constant** squint.

Classification of Strabismus

The strabismus may be **concomitant** (also called **comitant)** when the deviations are equal in all the different gazes, and **incomitant** when the deviations are more in one gaze than the other. The concomitant strabismus is classified as: **horizontal, vertical, or torsional.** The horizontal strabismus may be **convergent: esotropia (ET), or divergent: exotropia (XT)**. The corresponding latent strabismus or heterophorias are called: **esophoria(E) and exophoria(X),** and the intermittent heterotropias are called: **intermittent esotropia E(T)** and **intermittent exotropia X(T)**.

Esotropias are further divided into **accommodative, nonaccommodative** and **partially accommodative** depending on the role of accommodative element in its causation. A more detailed classification will be described in the relevant chapters.

Vertical concomitant strabismus is described as **hypertropia** (upward deviation) and **hypotropia** (downward deviation). But since whenever one eye is hypertropic, the other eye would be hypotropic, by convention vertical strabismus is designated by the hypertropic eye, that is we would talk of right hypertropia–RHT (right eye up) and left hypertropia–LHT (left eye up). In short we may also describe the squint as R/L or L/R.

Torsional squints or **cyclotropia** or **cyclodeviations** are described as: **incyclotropia** (12 o'clock meridian intorted or turned in) or **excyclotropia** (12 o'clock meridian extorted or turned out) of the respective eye.

The **incomitant strabismus** can be subdivided into **paralytic, restrictive** and **spastic,** depending on the cause of underaction in the first two conditions and overaction in the third type. The paralytic type can be **neurogenic (supranuclear, infranuclear** or **nuclear)** or myogenic. Specific nerve lesions are designated as the nerve supplying it like: **third nerve (oculomotor), fourth nerve (trochlear),** or **sixth nerve (abducens)** paralysis.

A **paralysis** implies a total involvement and **paresis** implies a partial involvement.

Consequences of Strabismus

Whenever a strabismus occurs, only one eye can fix at the object of regard, the other gets fixated elsewhere so that the two fovea receive two different images, each producing rival cortical perceptions, this is called **confusion**. Fortunately the cortex has strong foveal rivalry which immediately decides for one perception and suppresses the other image, so that this "confusion" actually causes no confusion. Because of the misalignment of the eyes the same object is imaged on some other retinal area of the other eye, which has a different projection value in space, so that an object gets projected at two different positions in space, this is called **diplopia** or double vision. Diplopia is a troublesome thing, the asset of binocular vision of the two eyes for once becomes a liability.

The **motor system** tries to overcome the consequences of strabismus by **fusion,** converting a tropia into phoria, if that is possible, as in intermittent exotropia. When the fusion mechanism is overwhelmed, and if there is incomitance, that is the deviation is less in a particular gaze position, a **head posture** is assumed to once again regain the paradise lost. Head posture may at times be assumed such that the deviation is aggravated so much so that the other image falls in the retinal periphery, which can be easily ignored. Unusually the other image may fall (or made to fall in an incomitant esotropia) on the **blind spot** of the retina alleviating the double image. These are called the **motor adaptations of strabismus.** In adult onset strabismus these are the usual "remedial" steps.

The **sensory system** also gears up to face the challenge of a strabismus by the **sensory adaptations.** These are mainly two: **suppression** and **anomalous retinal correspondence.** In suppression the cortex disregards the other image from cognition. Thus under binocular conditions the other eye does not actively participate in perception, though each eye may retain its full potential under monocular conditions. Suppression is generally possible easily when the other image is weak, that is imaged in the retinal periphery. But when the deviation is small angle, the other image being strong cannot be easily set aside by suppression, so the sensory system tries to have a readjustment, so that the fovea of one eye can now have a correspondence with the extra-foveal area which shares the same image due to the strabismus. This is called **harmonious anomalous retinal correspondence.** This is like recalibrating the interocular relationship (*resetting the scale to adjust for the zero error*). An analogy may be simple to understand: if you have a difference of opinion with some one, you ignore him if he is ignorable, but otherwise you try to readjust your relationship with him. The sensory adaptations are possible only during the stage of plasticity of the neurodevelopment, that is early childhood, up to 6–7 years of age. In adults though suppression does not occur a **visual ignorance** is usually possible to avoid the troublesome double image.

The suppression in childhood can be **facultative** or **obligatory,** the former is only under the binocular conditions, with no residual effect under monocular conditions. The obligatory suppression carries on under monocular conditions also, like an undesirable hangover. The effect of the obligatory suppression is **amblyopia,** which results in a functional diminution of vision of the suppressed eye. Thus amblyopia would be most likely to occur in the sensitive age group of plasticity of the neural development.

THE ROLE OF A STRABISMOLOGIST

Let us now understand the role of a strabismologist in dealing with his patients which may be in any age group but more so in the pediatric age group. This is a desirable thing from the view of maximal effectivity as binocular vision can be ensured only in the younger age group, the younger the better. A strabismologist's role is:

1. Assessment of **vision of each eye** and proper correction of refractive error, if any, by suitable optical means in order to achieve good, equal and maintainable visual acuity in each eye. This is to restore and maintain a normal balance between the two eyes so that a normal binocular vision with good stereopsis is maintained.
2. Assessment of the **accommodation** and **convergence relationship**, and correction of the same if any required, with glasses, prisms or exercises.
3. Defect of vision in the form of **suppression** or **amblyopia** with or without eccentric fixation may require occlusion and other measures to correct amblyopia in order to restore and maintain equal vision in both eyes.

1

4. When the motor fusional reserves are low, orthoptic treatment in the form of fusional exercises, with anti-suppression measures when required. This is to overcome the heterotropia and maintain heterophoria, so that the two eyes can function together asymptomatically.
5. And finally the assessment and correction of significant ocular deviations by prisms, chemical denervation or surgery on one or more of extraocular muscles as may be required to re-establish the normal ocular motor co-ordination.
6. Many cases of squint may have systemic problems like thyroid disorder, or may have an underlying neurological disturbance, over-looking of which can be fatal for the patient, and a gross negligence on the part of the doctor. A high index of suspicion, attention to details and a thorough but relevant investigation is desired.

Thus the **practice of strabismology** shall entail the clinician taking up the role of a pediatrician, a refractionist, an orthoptist, a neuro-ophthalmologist and last but not the least an eye-surgeon with the ability to investigate, interpret and integrate all the ocular and systemic findings for re-establishing the three-dimensional world of the patient, *to regain the paradise lost*.

Suggested Reading

1. Noorden GK von. Binocular Vision and Ocular Motility. Theory and Management of Strabismus, Fifth Edition. The CV Mosby Company, St. Louis 1996.
2. Lyle TK and Wybar KC Lyle and Jackson's Practical Orthoptics in the Treatment of Squint (and other anomalies a binocular vision) 15th Edition. HK Lewis & Co. Ltd., London, 1970.
3. Helveston EH. Surgical Management of Strabismus. An Atlas of Strabismus Surgery ed. 4. St. Louis, 1978.
4. Duke Elder S and Wybar K System of Ophthalmology, vol. 6, Ocular Motility and Strabismus, St. Louis. 1973, Mosby—Year Book Inc.
5. Lancaster WB "Terminology" with extended comments on the position of rest and fixation. In Allen JH editor. Strabismus Ophthalmic Symposium St. Louis. 1950. The CV Mosby Co.

2

Applied Anatomy and Physiology of Extraocular Muscles

An appraisal of relevant applied anatomy and physiology of the extraocular muscles is pertinent before we undertake the examination.

ANATOMY

There are six extraocular muscles: Four recti and two obliques on either sides. They are named based on their location, thus: **medial, lateral, superior** and **inferior recti;** and **superior** and **inferior, obliques** (Figs 2.1 and 2.2).

The distance between the adjacent recti varies between different sets of the recti muscles. It is about 7–8 mm (this limits the

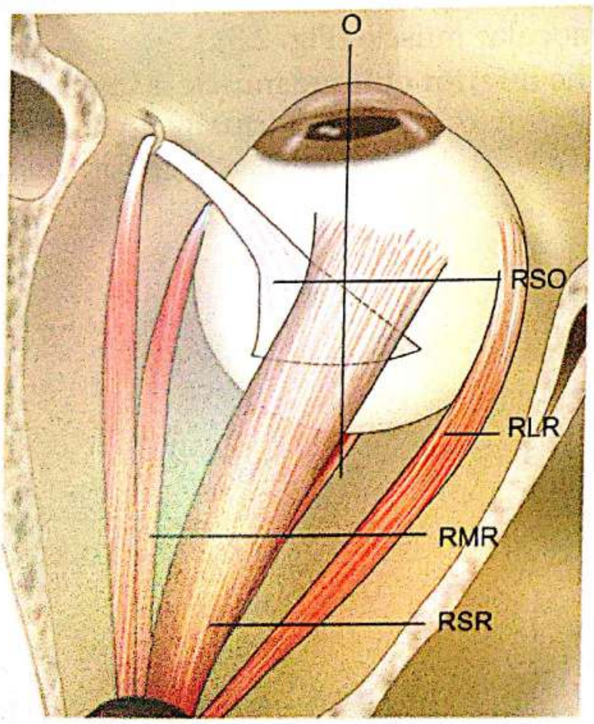

Fig. 2.1: Extraocular muscles.

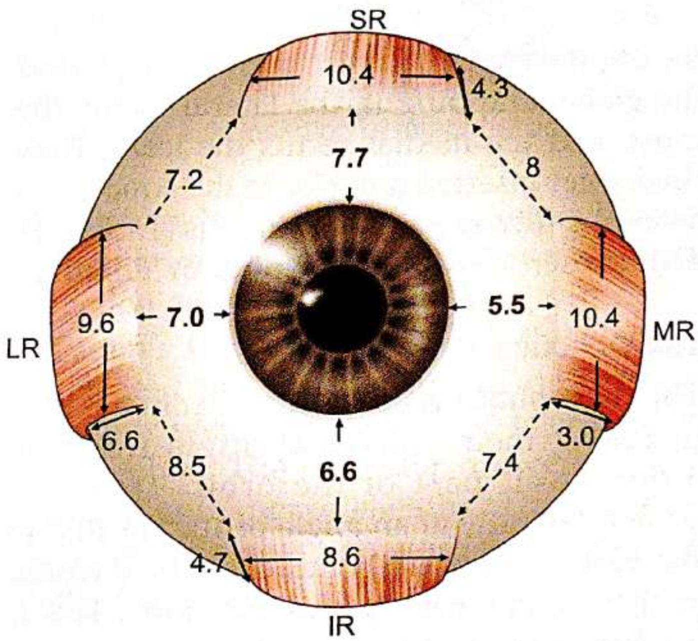

Fig. 2.2: Facts and figures of the four recti muscles of EOM insertions in relation to limbus, and to each other, as also tendon length and tendon width.

transposition horizontally or vertically). The table summarizes the anatomic features of the four recti (Table 2.1).

The Recti

All the recti take origin from the annulus of Zinn, which surrounds the optic canal and in part the superior orbital fissure. While the medial rectus runs almost straight, parallel to the sagittal plane, the lateral rectus runs anterolaterally. It makes an angle of about 40°–45° with the sagittal plane. The two vertical recti make an angle of about 23° with

Table 2.1: Anatomic features of the four recti

Muscles	*Medial rectus*	*Lateral rectus*	*Superior rectus*	*Inferior rectus*
Length of muscle	37.7 (32.0–44.5)	36.3 (27.0–42.0)	37.3 (31.0–45.0)	37.0 (33.0–42.5)
Length of tendon	3.0 (1.0–7.0)	7.2 (4.0–11.0)	4.3 (2.0–6.0)	4.7 (3.0–7.0)
Width of insertion	10.4 (8.0–13.0)	9.6 (8.0–13.0)	10.4 (7.0–12.0)	8.6 (7.0–12.0)
Distance of limbus from mid-insertion	5.3 (3.6–7.0)	6.9 (5.4–8.5)	7.9 (6.2–9.2)	6.8 (4.8–8.5)

Note: All figures in mm, mean and ranges in parentheses
Courtesy: Length of muscle and tendon from Lang and co-workers and Distance from limbus from Apt as cited in von Noorden's Binocular Vision and Ocular Motility,1996

the sagittal plane. The recti then curve around the globe strapping it, the lateral rectus the most, and the medial rectus the least. They finally get inserted anterior to the equator, at a varying distance from the limbus (Table 2.1). These insertions form the **spiral of Tillaux.**

The Obliques

The two oblique muscles differ from the recti in taking their functional origin from the anteronasal part of the orbit. They run posterolaterally at an angle of 100° to 105° to the vertical recti. On contraction, they would pull the globe nasally and outwards. This is an important fact that on slippage, they are not lost retro-orbitally, like the recti. When taut, they do not retract the globe. And to test their tautness during forced duction test (FDT) the globe needs to be pushed backwards!

The **superior oblique** actually arises from the superomedial part of the optic foramen, runs parallel close to the upper part of the medial wall up to the trochlea, where it turns around and runs posterolaterally making an angle of 54° with the sagittal plane. For practical purposes, the **trochlea** acts like its functional origin, and is formed medially by the trochlear fossa of frontal bone and laterally by a cartilaginous tissue. A bursa like structure between the saddle and the superior oblique tendon is postulated. Anomalies of this structure result in Brown's superior oblique sheath syndrome. About 10 mm of the distal **pre-trochlear** part, the **trochlear** part (4–6 mm), and the **post-trochlear** part is tendinous. The post-trochlear part becomes fan-shaped, passes beneath the superior rectus and gets attached posterior to the equator. The anterior and lateral end is about 4 mm posterior to the lateral end of superior rectus. The posterior and medial end is about 14 mm posterior to the medial end of superior rectus. The width of the insertion is about 11 mm (range 7–18 mm). **The posterior fibres of the fan are primarily responsible for depression and the anterior fibres are responsible for intorsion.** The total length is 60 mm, 40 mm being pre-trochlear and 20 mm post-trochlear. It is the longest extraocular muscle (Fig. 2.3).

The **inferior oblique** muscle is the shortest of all, just 37 mm with virtually no tendon or just about 1–2 mm. Its origin is in the

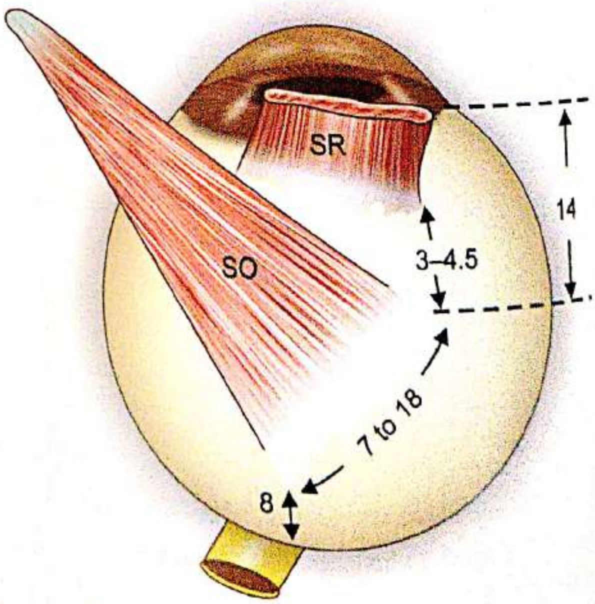

Fig. 2.3: Insertion of superior oblique.

anteroinferior angle of the bony orbit in a shallow depression in the orbital plate of the maxilla. From here it runs posterolaterally 51° to the sagittal plane, passing below the inferior rectus, inserting in a fan shaped manner. The insertion is about 9 mm wide (range: 5–14 mm). Its anterior end is located about 9.5 mm behind and 1–2 mm lateral to the macula. Some of its fibres merge with the fascia surrounding the optic nerve, responsible for pain on elevation in optic neuritis. **Its posterior fibres are primarily responsible for elevation and the anterior fibres for extorsion** (Fig. 2.4).

The fascia of the inferior oblique and inferior rectus get meshed to form the suspensory ligament of Lockwood (Fig. 2.5).

Some of the fibres of the lower lid are also attached to this and a large recession of IR without separating these fibres causes drooping of the lower lid. Similarly with a large resection there is a narrowing of the palpebral fissure. A similar effect, though less pronounced is seen in the position of the upper lid on large recession and resections of the superior rectus, without separating the fibrous attachment between the upper lid and the superior rectus. A recession causing a retraction and a resection causing a ptosis.

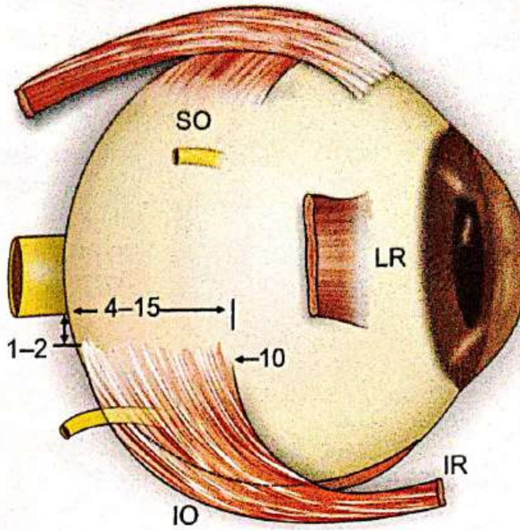

Fig. 2.4: Insertion of inferior oblique.

Tenon's Capsule (Fig. 2.6). If the globe is enucleated the anterior orifice of Tenon's capsule is seen, attached to the sclera 2 mm from limbus. The posterior orifice is fused with the optic nerve sheaths. The muscles enter through slits and vortex veins make small openings.

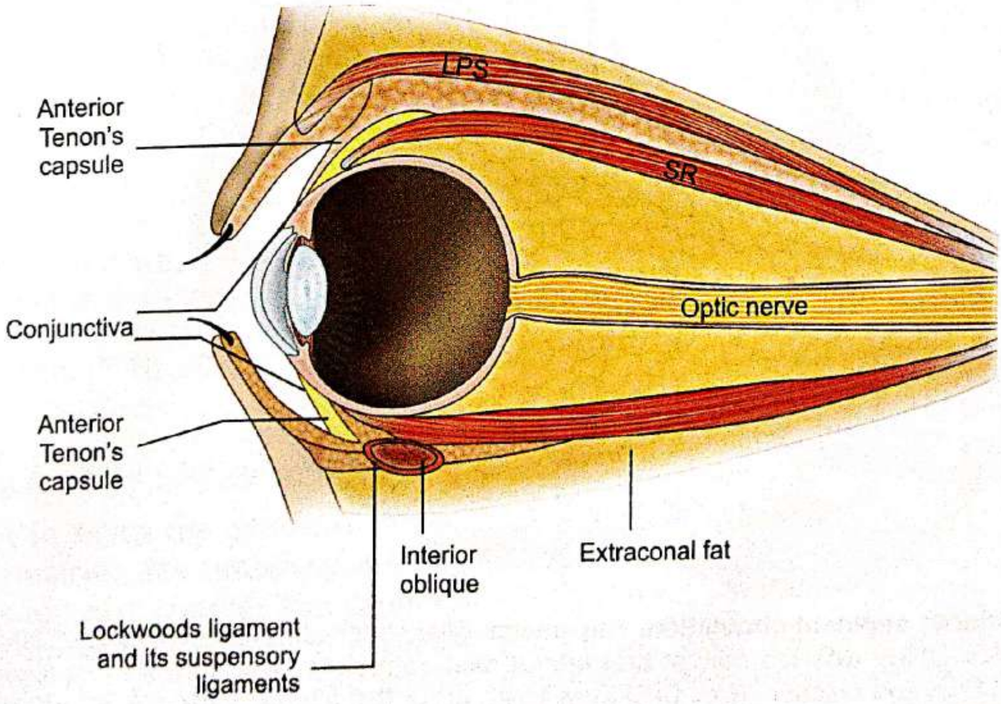

Fig. 2.5: A longitudinal section of the eye showing the fascial connections.

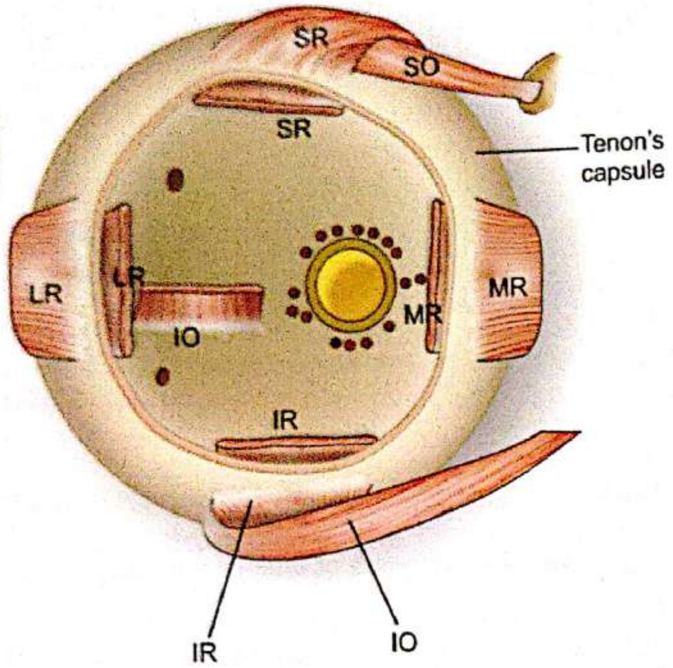

Fig. 2.6: Anterior and posterior orifice of Tenon's capsule (Charpy, 1912).

Each extraocular muscle has an extracapsular (outside Tenon's) and intracapsular portions. In the extracapsular portion it is encased in a muscle sheath: a reflection of Tenon's capsule running backwards for a distance of 10–12 mm. The muscle sheaths of the four recti are connected by a fascial formation called the intermuscular septum. The intracapsular portion has no muscle sheath.

Blood Supply

All the recti and superior oblique get their vascular supply and innervation on its inner aspect at the junction of the middle and distal third. The inferior oblique gets its innervation and blood supply as it crosses the nasal border of the inferior rectus. The obliques do not contribute to the anterior ciliary circulation Each of the recti, except the lateral rectus, contributes two anterior ciliary arteries (Fig. 2.7).

The lateral rectus gives only one. In addition there is a significant contribution by the medial long ciliary artery on the medial

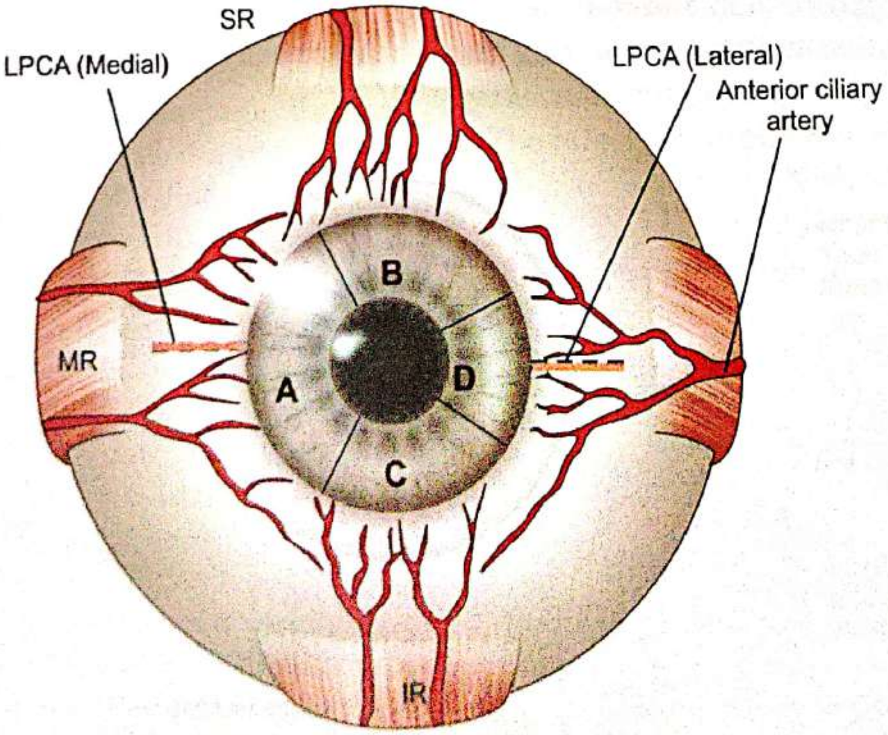

Fig. 2.7: Anterior segment circulation. The anterior ciliary arteries, two per recti except lateral rectus. The long posterior ciliary arteries medial and lateral also contribute. The perfusion of sectors of iris are (A): medial LPCA and anterior ciliary (AC) of MR, (B): AC of SR, (C): AC of IR, (D): AC of LR and AC of SR and IR overlap with very little contribution by lateral LPCA.

aspect, sparing the burden from the medial rectus to some extent. But the supply of the lateral rectus anterior ciliary artery is crucial, **thus a surgery on the two vertical recti along with the lateral rectus can cause anterior segment ischemia.**

Nerve Supply

The **oculomotor nerve** (third cranial) supplies to superior rectus, medial rectus, inferior rectus, inferior oblique and also the levator palpebrae superioris and the intraocular muscles: sphincter pupillae, dilator pupillae and ciliary muscles. The **abducens nerve** (sixth cranial) supplies the lateral rectus. And the **trochlear nerve** (fourth cranial) supplies the superior oblique (Fig. 2.8).

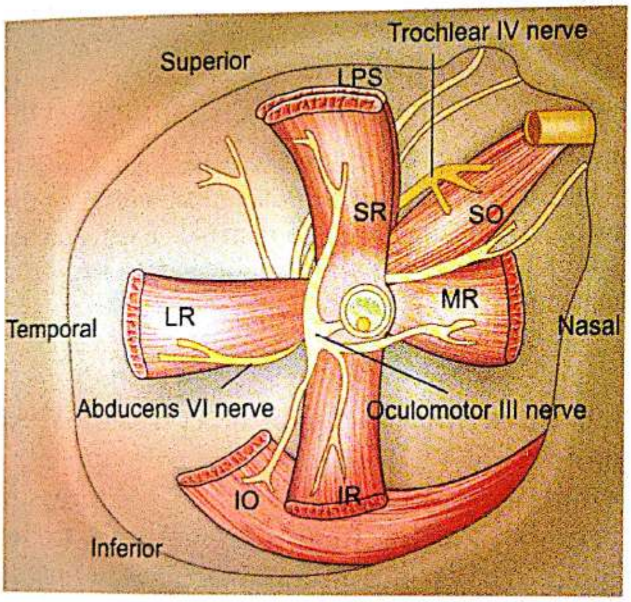

Fig. 2.8: Nerve supply to extraocular muscles, Oculomotor (IIIN) superior division (LPS, SR), inferior division (MR, IR, IO, ciliary ganglion); Abducens (VI N) LR, and Trochlear (IV N) (SO).

THE PHYSIOLOGY OF EYE MOVEMENTS

If one keeps in mind the anatomy of the extraocular muscles, the understanding of their actions appears simple. The primary action of the **horizontal recti** is to perform abduction (lateral rectus) and adduction (medial rectus) in the primary position. But in the extreme upgaze, they would have a vector acting downwards also causing depression as a secondary action. Similarly in extreme downgaze they would also cause elevation as a secondary action (Figs 2.9 and 2.10).

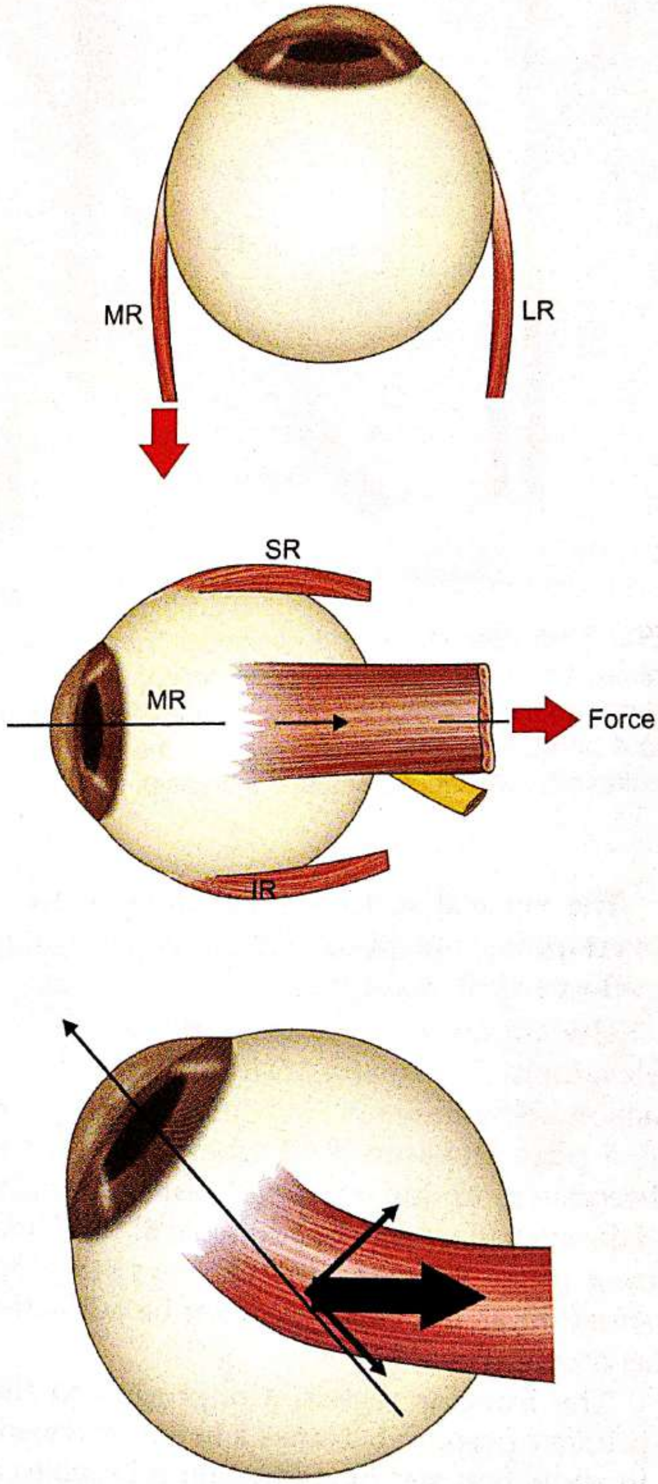

Fig. 2.9: Horizontal muscles act in horizontal plane. If eyeball elevated the horizontal force has significant vertical vector component.

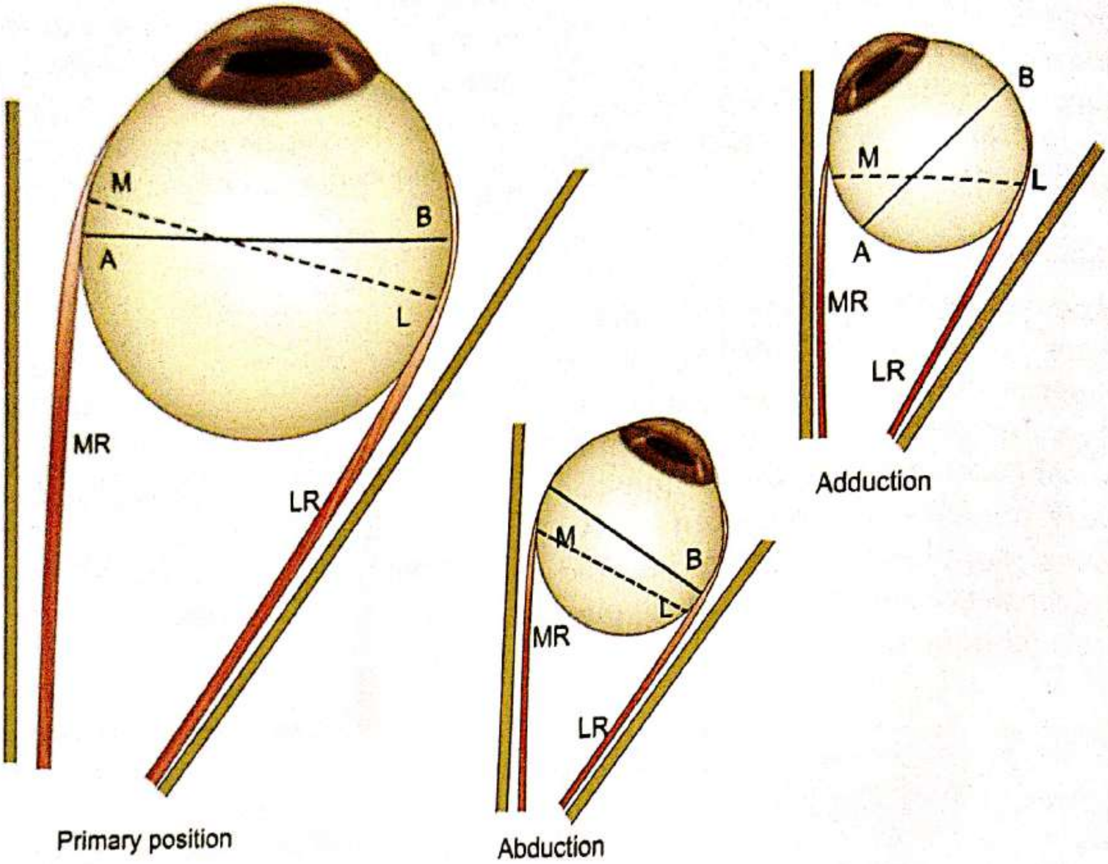

Fig. 2.10: Anatomical and functional equators. Anatomical equator, AB is the widest horizontal diameter, about 13–14 mm from limbus. Functional equator, ML, varies in different gaze positions depending on the arc of contacts. M is the tangential point for MR and L, that of LR. In the primary position M is 2 mm anterior to A and L is 2–4 mm posterior to B, the functional equator ML is obliquely placed. In adduction the arc of contact for MR decreases and increases for LR. In abduction reverse occurs.

The **vertical recti** and the **obliques** have overlapping functions and can be termed as **cyclo-vertical muscles.**

The **superior rectus** primarily acts as an elevator in the **primary position,** its secondary action being intorsion. When **abducted 23°** it is a pure elevator. And when adducted it becomes more and more an intorter, especially if the eyeball were to be **adducted 67°** it would be a pure intorter (this is a hypothetical situation as the eyeball cannot be adducted as much) (Fig. 2.11).

The inferior rectus, a depressor in the primary position becomes a better depressor in abduction and on adduction it becomes a better extorter.

The superior oblique (Fig. 2.12) is primarily an intorter in the primary position, if adducted it becomes more and more a depressor. When **adducted 54°**, it becomes a pure depressor, remember superior oblique is a depressor because of its insertion being posterior to the equator. When abducted progressively it becomes an intorter, and it is a **pure intorter at 36° abduction.** Similarly the **inferior oblique,** primarily an elevator and extorter becomes a pure elevator at 51° adduction, and a pure extorter in 39° abduction.

In the **primary position** the elevation is done by both the superior rectus and the inferior oblique in a 60–40 ratio. And depression by the inferior rectus and the superior oblique in a 60–40 ratio. Both the recti act as adductors in the primary position and **adduction,** but act as abductors when abducted more than 23°.

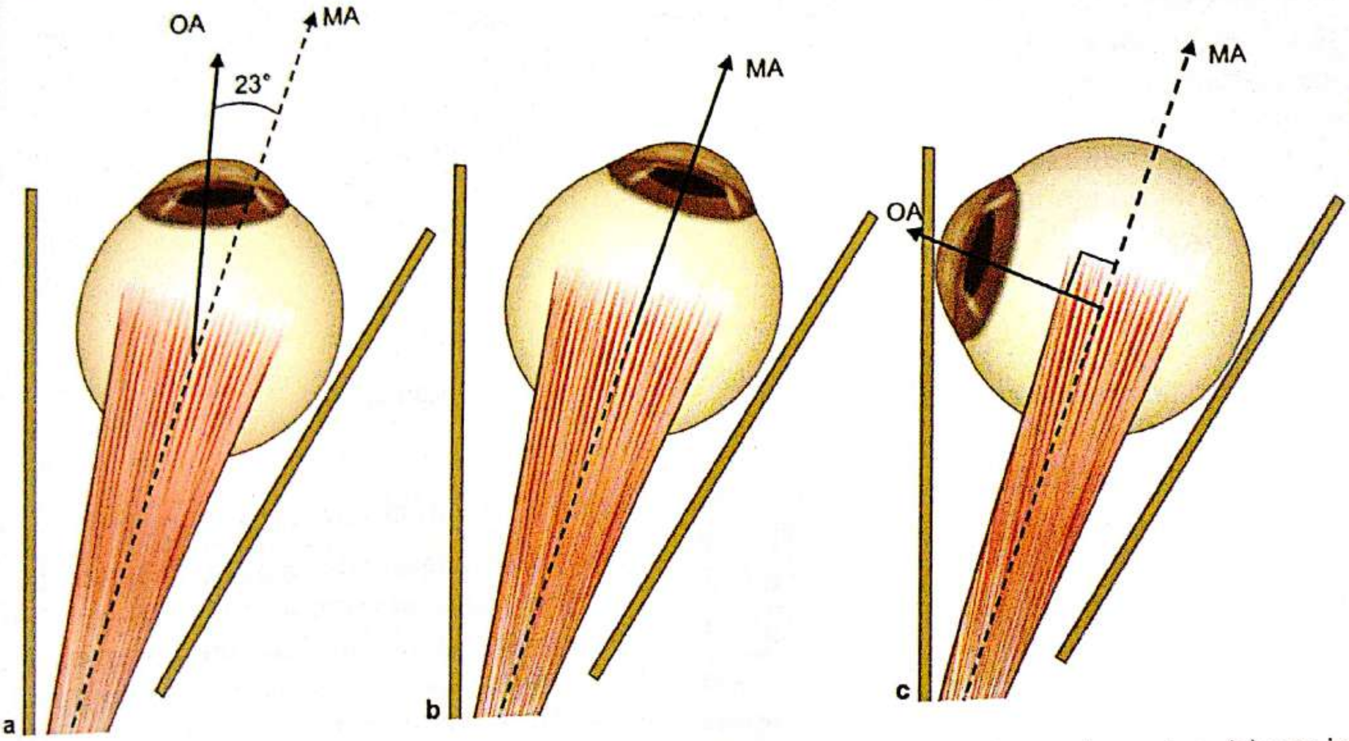

Fig. 2.11: Three positions of eyeball (axis OA) in relation to muscle axis (MA) of superior rectus. (a) eye in primary position (23° nasal). SR main elevator, (b) eye in 23° abduction (aligned with MA) SR 100% effective as elevator, (c) eye in 67° adduction (OA 90° to MA) SR pure intorter, no elevation.

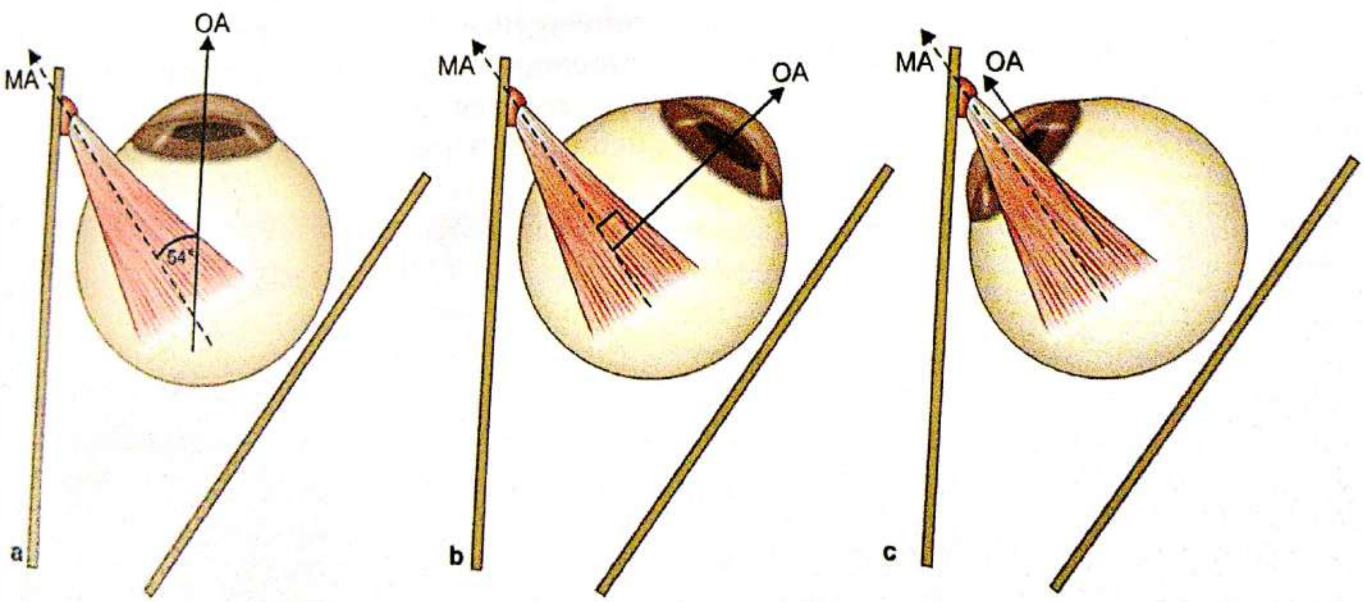

Fig. 2.12: Three positions of eyeball (axis OA) in relation to the muscle axis (MA) of superior oblique; (a) eye in primary position (OA 23° temporal to MA) so acts as an intorter mainly, also has depression, (b) eye in 36° abduction (OA 90° to MA) so acts as a pure intorter, no depressor effect, (c) eye in 54° adduction (OA parallel to MA) so acts as a pure depressor, no intorsion.