

STRABISMUS

INDEX

Introduction	3
Applied Aspects	6
Examination	10
Evaluation	11
Amblyopia	13
Esotropias	22
Exotropias	33
DVD	40
IOOA	43
SOOA.....	46
DRS.....	48
Brown's Syndrome.....	53
Tests	55
PRISMS.....	65
Strabismus Surgery	73
Misc	86

Introduction	3	IOOA	43
Classification.....	4	SOOA	46
Consequences.....	5	DRS	48
Applied Aspects	6	Brown's Syndrome	53
Anatomy	6	Tests	55
Muscle Pulleys	7	The simultaneous prism cover test ..	55
Accommodation and Convergence	7	Prism alternate cover test	55
Types of Eye movements.....	9	Krimsky test	56
Pathways	9	Modified Krimsky Test	56
Examination	10	Four prism dioptre test	56
Evaluation	11	The vertical prism test.....	56
Sensory Evaluation	11	The prism adaptation test.....	57
Sensory System	11	Prism under cover test.....	57
Sensory Anomalies.....	12	Hess Chart	58
Tests.....	12	Squint may result in	59
Muscle Function Evaluation.....	12	Various methods are devised for	
Ocular Torsion	13	measuring AC/A ratio	60
Motor Evaluation	13	Orthoptic Treatment.....	60
Amblyopia	13	convergence insufficiency	60
CHARACTERISTICS OF AMBLYOPIC		Definitions	61
VISION	14	Reading from Books	62
Classification.....	15	Nystagmus Examination	65
Clinical features.....	17	PRISMS	65
Clinical evaluation	17	Fresnel principle	67
Management	20	Prisms in	68
Prognosis	21	Pitfalls in measurement: 8P.....	68
Esotropias	22	Occlusion Therapy in AMBLYOPIA	69
Classification.....	22	Strabismus Surgery	73
Etiology	23	Preoperative evaluation.....	73
Accommodative Esotropias	23	History of Surgery	75
Partially Accommodative Esotropia .	26	Weakening Procedures	75
Essential Infantile Esotropias.....	27	Strengthening Procedures.....	76
Etiopathology	28	Conjunctival Incisions.....	78
Functional Deficits in Infantile		Glue Surgery.....	78
Esotropia.....	28	Adjustable Sutures	78
EPIDEMIOLOGY AND RISK FACTORS ..	28	Special Cases	80
CF	29	Vertical shift of horizontal muscle...	80
Management.....	30	Slanting Recession-resections	80
DD.....	30	Transposition of Muscles.....	80
Monofixation Syndrome	31	Vertical Recti.....	81
Acute Comitant Esotropia	32	Inferior Oblique	82
Exotropias	33	Superior Oblique	84
Classification.....	33	COMPLICATIONS	85
Etiology	35	Intraoperative Surgical	85
CF.....	35	Intraoperative Anesthesia related ...	86
Examination.....	36	Misc	86
Management	37	Q- Fixation Pattern	86
DVD	40		

Introduction

- The term *strabismus* is derived from the Greek word *strabismos*, 'to squint, to look obliquely'
- Overall prevalence of infantile strabismus is closer to 2%.
- **Listing's Planes:** 3 planes of eye movement
- **Fick's Axis:** 3 respective axis perpendicular to three planes
 - Horizontal plane: movement around Z axis
 - Vertical plane: movement around X axis
 - Torsional: movement around Y axis which is antero-posterior
- **Ductions:** uniocular eye movements
 - Thus a paresis missed on duction is picked up in a version.
- **Versions:** binocular eye movements in same direction
- **Vergence:** binocular eye movements in opposite direction: disjugate
 - Convergence and Divergence
- Muscles can be
 - Agonists = contralateral synergists= Yoke muscle
 - Antagonists
 - **Hering's law of equal innervation:** which states that for any movement the synergists receive **equal and simultaneous** innervation
 - *Clinical application: Secondary deviation, Inhibition palsy of contralateral antagonist*
 - **Sherrington's law of reciprocal inhibition:** In addition the respective antagonists receives **equal and simultaneous** inhibition
 - **Exception: Duane's retraction syndrome, Retraction nystagmus**
 - **Clinical application** - Occurrence of strabismus following paralysis of extra ocular muscle.

- Two laws govern the movements of the eyes into the *tertiary position*.:
 - **Donder's Law:** To each position of the line of sight belong a definite orientation of the horizontal and vertical retinal meridian related to coordinate of space.
 - **Listing's Law:** Each movement of the eye from primary position to any other position involve rotation around a single axis lying in the equatorial plane (Listing plane).
-
- **Correspondence:** Each fovea has a primary visual direction (the direction of its straight-ahead gaze), and the two fovea share a common visual direction.
 - The two foveas are said to have a normal retinal correspondence (bifoveal correspondence).
 - 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 **pannum's area of fusion**
 - This fusion produces **STEREOPSIS**
 - all the other points outside this area are called **DISPARATE POINTS** and here image produces **DIPLOPIA**.
- **Orthophoria** is an ideal condition. It means eyes are straight without any fusion. Small amount of heterophoria is always there and so **orthotropia or orthoposition** is more appropriate term.

Classification

- Concomitant/ comitant
 - Horizontal -tropia, phoria, intermittent
 - Esotropia
 - Accommodative
 - Non-accomodatice
 - Partially accomodative

- Exotropia
- Vertical
 - Hypertropia
 - Hypotropia
- Torsional
 - Incycotropia
 - excyclotropia
- Incomitant
 - Paralytic
 - Neurogenic: supra, infra, nuclear
 - Myogenic: nerve paralysis
 - Restrictive
 - Spastic

Consequences

- **Confusion**: generally cortex **suppresses** this foveal rivalry so actually this confusion produces no confusion
- **Diplopia**: more troublesome
- **Motor adaptations**
 - **Head posture**
 - **Blind spot mechanism**
- **Sensory adaptations (possible up to 6-7 years)**
 - **Suppression**: Suppression is generally possible easily when the other image is weak, that is imaged in the retinal periphery.
 - Facultative: under binocular condition
 - Obligatory: results in **AMBLYOPIA**
 - **ARC**: when image cant be suppressed

- Retinal correspondence is abnormal when the fovea of one eye has a common visual direction with an extrafoveal area in the other eye.
- When the amount of shift in the visual directions fully compensates for the deviation, adaptation is called as **harmonious ARC**
- When the amount of shift in the visual directions does not fully compensate for the deviation, adaptation is called as **unharmonious ARC**

Applied Aspects

Anatomy

- Spiral of Tillaux
- LR makes angle of 40-45 with sagittal
- SR/IR makes 23
- SO makes 54
- SO: posterior fibres of fan are for depression and anterior are for intorsion
- IO make 51
- *For actions of SR IR SO IO, one tip you can remember is that in abduction, their primary action increase/ purely primary action whereas in adduction their secondary action increases*
- This **pulse-step innervation** is responsible for a fast eye movement saccade, first a pulse and then step to maintain the in the net position.
- The torsional eye movements occur around the anteroposterior or Fick's Y axis. This does not pass through the centre of cornea but at a point on the lateral limbus as shown by Linwong.
- Orbital and Global differentiation of EOM
 - all fibre types participate in all activities though to a different extent, based on the amount of work and are recruited in a sequential order.
- Anatomical equator: on maximum diameter of globe

- Functional equator: depending on arc of contact of muscles
 - 2 mm posterior for LR and 2 mm anterior for MR
 -

Muscle Pulleys

- the observation of URRETS-ZAVALLIA who called attention to the relationship of palpebral fissure configuration and vertical incomitance in Mongoloid and antimongoloid in A and V patterns
- Improved M.R.I resolution now permits direct visualisation of E.O.M pulleys and paths of E.O.M are determined using high resolution MRI.
- The pulley zone located approximately at the junction between middle and posterior third of the globe corroborating with LISTING'S LAW which forms the functional origin of E.O.M the ligament of Lockwood forms pulley of inferior oblique and trochlea (ossified) forms pulley for superior oblique.
- The orbital half of E.O.M inserts into pulley complex next to orbital walls while the bulbar half moves anteriorly to insert into sclera.
- Pulley sleeves are continuous with the tough peripheral portion of posterior tenons fascia becoming slings to the sleeves, these sleeves are stabilised by fibro muscular septa.
- Extending from pulleys to orbital wall and to adjacent pulleys by tenons fascia centred at around equator.
- They are composed of collagen, elastin, smooth muscle. Possible function of smooth muscle in pulleys and tenons fascia is a possible maintenance of stiffness and possible dynamic role in fine tuning their position and a role in vergence mechanisms.
- ORBITTM 1.5 extraocular biosimulation program

Accommodation and Convergence

- Meter Angle: the vergence of two eyes for an object at 1 meter distance is called one meter angle. This is **Large Meter Angle: Ma**

- The angle formed between visual axis of one eye and median line is called **nagel's meter angle or small meter angle: ma**
- **NPA:** by a ruler, RAF, Nearest point that get blurred, $100/8 = 12.5$ D
- **Amplitude of accommodation:**
 - $4 \times 4 - (\text{Age}/4)$
- **NPC:** nearest point that get doubled
 - $100 - 8 = 12.5$ Ma
- **Convergence:**
 - Voluntary
 - Involuntary
 - Proximal
 - Fusional
 - Accommodative
 - Tonic
- **AC/A:** convergence amplitude per unit accommodation: normal 4-5
 - **Measured in prism diopter per diopter of accommodation**
 - **Stimulus AC/A:** as change in vergence is related to change in stimulus
 - **Response AC/A:** 8% higher than stimulus AC/A, in this refractive status is also taken into account
 - **Estimation of AC/A**
 - **Heterophoria method**
 - Changing distance of fixation from 6m to 33cm
 - $AC/A = IPD + (N-D)/3$
 - **Gradient method**
 - Done at fixed distance

- 6m with concave lens: -3D
- 33cm with convex lens: +3D
- $AC/A = (N-D)/3$
- Graphic method
- Fixation disparity method

Types of Eye movements

- Saccadic
- Pursuit
- Vergence
- Vestibular or tonic neck reflex
- Optokinetic eye movements
- Position maintenance system (fixation)

Pathways

Supranuclear

- voluntary saccades: contralateral frontomotor cortex
- pursuit eye movements: ipsilateral parieto-occipital
- vergence: temporoparietal cortex
- Horizontal eye movement: PPRF
- Vertical eye movement: riMLF and PC
- Convergence centre: central nucleus of perlia

Infranuclear

-

Examination

- Chief Complaint
 - DIPLOPIA
 - VISUAL CONFUSION
 - ASTHENOPIA
 - ABNORMAL EYE MOVEMENTS: wobbly eyes/ nystagmus

- History
 - Past History
 - History of patching
 - History of spectacle wear
 - Type of strabismus
 - History of trauma
 - Previous surgery
 - Birth History
 - Developmental Milestones
 - Family History
 - Review of Systems

- Physical Examination
 - Vision
 - Sensory Testing
 - Near Stereoacuity

- Distant Stereoacuity
- Retinal Correspondence
- Motor Testing
 - Bruckner
 - Krimsky
 - Hirschberg
 - Cover uncover
 - Cover
 - SPCT
 - PUCT
 - APCT
- Other Tests
 - Red Glass Test
 - Maddox Rod
 - Three Step Test
- Cycloplegic Refraction

Evaluation

Sensory Evaluation

Sensory System

- Visual Acuity
- Normal Retinal Correspondence
- Fusion: Central
- Fusion: Peripheral

Sensory Anomalies

- Amblyopia and Eccentric Fixation
- Suppression
- Anomalous Retinal Correspondence
- Horror Fusionis
- Diplopia and Visual Confusion
- Central Fusion Disruption

Tests

- Refraction
- Visuscope
- Prism Adaptation Test
 - Jampolsky" first described -lc prism adaptation test (PAT) developed by his OrhOptist Woodward. PAT was used to preoperatively predict which patients will develop residual c-tropia after surgery.
- W4DT
-

Muscle Function Evaluation

- Passive Forced Duction Testing
 - Office
 - Intraoperative
 - RESULTS
 - Qualitative
 - Absolute Restriction

- Uniform Restriction
- Leash Phenomenon
 - Quantitative
- PITFALLS
 - Patient Apprehension
 - Pharmacologic Effects
 - Errors in Techniques
 - Posterior Restriction
 - False Negative Tests
 - Coexisting Paresis and Restrictions
 - Co-contraction syndromes and Aberrant Regeneration
- Force Generation Testing
-

Ocular Torsion

Motor Evaluation

Amblyopia

- Amblyopia is defined as binocular or monocular decrease in best corrected visual acuity (BCVA) due to pattern visual deprivation and/or abnormal binocular interaction during visual immaturity for which there is no obvious ocular pathology or visual pathway defect and which in appropriate cases is reversible.
- Incidence - 2- 5%
- Prevalence- 1 - 4%
- More common unilaterally than bilaterally
- Commoner in rural than urban school children
- Visual acuity less than 6/12 bilaterally or a difference of 2 or more than 2 lines between the normal and the amblyopic eye in unilateral amblyopia when measured with the help of Snellen's Charts and 3 or more than 3 lines when measured with the logMAR charts
- **NEURAL BASIS OF AMBLYOPIA**
 - concept of cortical competition: All cortical cells are potentially connected to both the eyes equally.
 - critical period: neural plasticity makes the visual system vulnerable to any abnormal experience, 7 to 8 years in humans
 - It is postulated that strabismic amblyopia is initiated as a maladaptive differentiation in the ocular dominance columns, whereas the non-strabismic amblyopia may be initiated from the malfunctioning of the ganglion cell population of the amblyopic eye.
 - Traditionally, it has been postulated that there are 2 mechanisms
 - Deprivation of form vision
 - Abnormal binocular interaction
 - **Lateral Geniculate layers subserving the affected eye have been found to be atrophic in amblyopia.** The cortical ocular dominance columns representing the amblyopic eye are less responsive to stimulus and show changes microscopically.
 - There are two kinds of retinal ganglion cells - the magno cells and the parvo cells. **Dissociation between the parvo and magnocellular systems occurs in amblyopia.**

CHARACTERISTICS OF AMBLYOPIC VISION

- Single letter acuity is better than linear acuity.

- There is a decrease in contrast sensitivity for high spatial frequencies. In strabismic amblyopia, it improves on decrease illuminance whereas in anisometropic amblyopia, it does not.
- The amblyopic eye performs better in mesopic conditions. (Neutral Density Filters)
- Vernier acuity and spatial resolution is disproportionately affected to a lesser degree than the visual acuity in strabismic amblyopia.
- Naso-temporal optokinetic nystagmus (OKN) asymmetry for the resolution of vertical gratings is seen in strabismic amblyopia.
- Abnormalities in pattern visually evoked potential (VEP) are seen in both strabismic and anisometropic amblyopia. However in sensory deprivation amblyopia changes are seen in both flash and pattern VEP.
-

Classification

- Strabismic
 - Most common type of U/L amblyopia
 - Seen in constant tropia with strong fixation preference
 - Commoner in esodeviations
 - Rare in hypertropia
 - Grating acuity is less reduced a/c/to Snellen's acuity
 - Decrease in illumination - drop in visual acuity lesser in amblyopic eye a/c/to better eye
 -
- Anisometropic
 - Second MC cause
 - Significant difference in refractive errors between both eyes
 - Commoner in hyperopes
 - May be associated with strabismus

- Form vision deprivation and unequal foveal images causing abnormal binocular interactions
-
- Stimulus deprivation (amblyopia ex anopsia)
 - Congenital / traumatic total cataract
 - Complete ptosis, significant corneal scarring, therapeutic patching
 - U/L lesions worse than B/L
 -
- Isoametropic
 - B/L uncorrected high refractive errors
 - Hyperopia > +5.0DS
 - Myopia > - 8-10 DS
 - Astigmatism > +2.5 DC
 - Pure form vision deprivation
 - More amenable to treatment
 -
- Meridional
 - Uncorrected astigmatic refractive error
 - Selective visual deprivation of stimuli along particular spatial orientation
 - Astigmatism >2.5 DC in preschool children, >3-4DC in infants
- Organic Amblyopia
 - subclinical Macular Damage
 - Malorientation of cones
 - Cone deficiency syndrome
- For treatment and prognosis, amblyopia can be classified as
 - *Severe amblyopia* : when the best corrected visual acuity is less than 20/100.

- *Moderate amblyopia* : best corrected visual acuity 20/40 -
- *Mild amblyopia* : best corrected visual acuity 20/40 or more

Clinical features

- Typically described as “shimmer effect of hot air over a highway”
- Continuous wavy motion with parts of the image fading in and out of focus
- **Crowding Phenomena** - the isolated letter visual acuity is better than line acuity in amblyopia. Visual acuity testing should include both line and letter acuity.
- **Neutral Density Filters:** Profoundly reduce vision in eyes with central retinal lesions and glaucoma but vision in amblyopic eyes is not reduced. This is believed to be due to a relative increase in mesopic visual acuity in amblyopic eyes.
-

Clinical evaluation

- Visual acuity
 - Decrease in best corrected visual acuity (>2 Snellen lines between both eyes)
 - Recognition acuity is more impaired than resolution or detection acuity
 - Grating acuity is less affected than Snellen acuity in strabismic amblyopia a/c/to anisometropic
 - Visual acuity is more impaired in good eye than amblyopic with neutral density filter
 - Crowding phenomenon- visual acuity is more with isolated optotypes in amblyopia (decreased lateral inhibition)
 - Optokinetic nystagmus
 - VEP
 - Preferential looking test
 -
- Neutral density test and crowding test

- Thorough ocular and fundus examination
- Refraction
 - Objective, under full cycloplegia
 - Proper fixation ensured
 - Proper head positioning avoiding posturing or tilts
 - Refraction with loose lens with the examiner's hand occluding the other eye in young children
 -
- Evaluation of fixation
 - Angle Kappa method
 - hand light method
 - arc perimeter method
 - synaptophore method
 - Visusopic / ophthalmoscopic method
 - Types of eccentric fixation:
 - parafoveolar
 - parafoveal
 - paramacular
 - peripheral
 - Wandering fixation - can be central or eccentric type, occurs on covering sound eye
 - Paradoxical eccentric fixation-surgical overcorrection or spontaneous reversal of deviation, prolonged occlusion of sound eye
 - Localisation of objects - normal in central and eccentric fixation, faulty in eccentric viewing
 - Abnormal colour vision in <math><6/36</math> (peripheral eccentric fixation)
 -

-
- Other sensory abnormalities
 - **Afterimage test**
 - Each fovea individually marked during monocular viewing with linear strobe light that bleaches retina, causes linear afterimage shadow for 10sec
 - Center of light masked to spare fovea ∴ line has break in middle
 - NRC with any type of tropia- see a cross
 - ARC- each fovea has monocular afterimage but binocularly afterimage perceived as coming from peripheral visual field
 - **Four PD base out test**
 - Normally 4 PD base out test induces fusional convergence
 - 2 movements seen normally
 - 1st- version movement of BE in direction of apex of prism
 - 2nd- fusional vergence of eye without prism towards the nose
 - Motor fusion and large regional suppression- no movement when prism over nondominant eye, version in direction of apex when prism over fixing eye
 - Monofixation- no movement when prism over nondominant eye, version and fusional convergence in some when prism over fixing eye
 - **Amblyoscope**
 - Mirrors placed in front of each eye angled so that RE sees right temporal side and LE sees left temporal side
 - Transparent picture slides placed in front of each eye
 - Can measure fusional vergence amplitude, angle of deviation, area of suppression, retinal correspondence and torsion
 - Subjective angle (SA)- amount in degrees examiner must move amblyoscope to allow patient to see 2 pictures superimposed, measured under binocular viewing
 - Objective angle (OA)- measured by alternating target presentation till there is no refixation, measured during monocular viewing

- Strabismus with NRC and diplopia- SA=OA
- NRC and large regional suppression- no SA
- Harmonious ARC- significant OA but SA zero, \therefore OA = angle of anomaly
- Unharmonious ARC- pseudofovea does not compensate for objective deviation
-

Management

- Refractive correction
 - Amblyopia improved with optical correction by 2 or more lines in 77% of the patients and resolved in 27%.
- Occlusion therapy
 - Different types
 - PEDIG study says full time versus 6 hours has no difference
 - Problems
 - When to stop?
- Penalization
 - Its main role is as maintenance therapy and also in patients of moderate amblyopia, in children uncooperative for occlusion, occlusion failure and possibly n Manifest-Latent nystagmus (Fusion Maldevelopment syndrome).
- Combined therapy
 - Combined optical and atropine penalization (COAT) is an effective treatment when occlusion therapy fails initially, and it might have a more rapid effect than single modality penalization therapy, but there is an increased risk of reverse amblyopia. Its effect may be particularly useful in anisometric amblyopia.
- Drug therapy
 - Levodopa:

- Citicholine (Cytidin-5-diphosphocholine):
- Pleoptics
 - Active stimulation of the macula is done using Pleoptophore (Modified Gullstrand's ophthalmoscope), till fixation becomes central.
- CAM stimulator
- Home vision therapy
- Surgery to treat the underlying cause of amblyopia
- Other modes
 - **Liquid crystal glasses** -Liquid crystal glasses have recently been developed as a new treatment for amblyopia. They provide an electronic, controlled, intermittent occlusion of the sound eye allowing for visual stimuli input to the amblyopic fellow eye.
 - **Opaque (occluder) contact lenses**- Occlusive contact lenses can be used in treating amblyopia in children who are patch-intolerant and resistant to conventional treatment.
 - **Red Filter Treatment** - Red filter which excludes wavelengths <640 nm is used to stimulate cones at the fovea. Red light is ineffective in stimulating the eccentric point as compared to fovea, due to the lack of cones.

Prognosis

It has been shown that after one year of occlusion therapy, 73% cases show success but this decreases to 53% after 3 years. Risk factors for failure of occlusion therapy include.

1. Type of amblyopia

- Strabismic amblyopia has the best outcome,
- High anisometropia and organic pathology the worst

2. Age at which therapy began

- Younger age does better

3. Depth of amblyopia

- The better the vision at the start of therapy, the better the prognosis

Esotropias

Classification

A. Depending on Whether the Deviation is Manifest or Not as

- Esophoria: Which is a latent inward deviation of the eye
- Esotropia: Which is a manifest inward deviation of the eye

B. Depending on Whether the Deviation is Concomitant or Not

1. Concomitant

a. Primary

- Accommodative
 1. Refractive
 2. *Non-refractive*: Hyperaccommodative (High AC/ A ratio)
 3. Hypoaccommodative
 4. Mixed or partially accommodative
- Non-accommodative
 1. Essential infantile
 2. Essential late onset (Basic, Convergence excess, Divergence insufficiency)
 3. Acute concomitant
 4. Microtropia
 5. Cyclic esotropia
 6. Stress induced esotropia
 7. Esotropia due to spasm of the near reflex
 8. Esotropia in myopia
 9. Nystagmus blockade syndrome

b. Secondary

- Secondary
- Consecutive

2. Incomitant

- a. Paralytic: Lateral rectus palsy
- b. Restrictive: Duane's Tumour, thyroid, post-operative
- c. Spastic

Etiology

- Uncorrected hypermetropia → Blurred Retinal Image
 - Some do not accommodate → Orthotropic but amblyopic
 - Some accommodate
 - Low AC/A: Orthotropia
 - Sufficient fusional divergence: Esophoria
 - Insufficient Fusional divergence: Esotropia

Accommodative Esotropias

Classification

Von Noorden classified Accommodative Esotropia on the basis of underlying etiology as

1. Refractive Accommodative Esotropia
2. Non-refractive Accommodative Esotropia
3. Hypo Accommodative Esotropia
4. Partially Accommodative Esotropia

Classification of Eye Movement Abnormalities and Strabismus (CEMAS) group classified and defined this entity as-

1. Accommodative Esotropia
 - a. Pure Refractive: esotropia eliminated by hyperopic spectacles
 - b. Non-Refractive: esotropia at near only and eliminated with plus lenses at near, e.g. bifocal
 - c. Mixed: esotropia at distance and greater at near associated with hyperopia and responds to hyperopic correction at distance with bifocal for near
2. Mixed (Partially Accommodative) Esotropia
 - a. Hyperopia with incomplete response to spectacles and bifocals.

Clinical Features

Refractive

Normoaccommodative

- Here, the AC/ A ratio is normal, i.e., 3-4 PD/D
- The patient is unable to see for distance, so the patient accommodates more
- The deviation for distance and near is more or less the same (within 15 PD)
- Generally, they have mild to moderate hyperopia (2-6 D)
- They respond well to full hyperopic correction as derived by cycloplegics refraction

Hyperaccommodative

- Here, the AC/ A ratio is high, i.e., 7-8 PD/D
- The patient is unable to see for distance, so the patient accommodates more
- The deviation for near is 15 PD more than the deviation for the distance
- Generally, they have high hyperopia (> 6 D)
- They respond partially to full hyperopic correction as derived by cycloplegic refraction. Some deviation at near still persists

Non-refractive

Hyperaccommodative

- The accommodative mechanism is normal
- Here, the AC/ A ratio is high i.e. 7-8 PD/D
- The patient is able to see for distance
- The deviation for near is 15 PD more than the deviation for the distance
- Generally, they have mild (1-2 D) hyperopia
- They have a normal near point of accommodation
- They respond well to bifocal glasses.

Hypoaccommodative

- The accommodative mechanism is weak, so the patient has to over accommodate
- Here, the AC/ A ratio is normal, i.e., 3-5 PD /D, there is convergence excess
- The patient is able to see for distance
- The deviation for near is 15 PD more than the deviation for the distance
- Generally, they have mild (1-2 D) hyperopia
- They have a remote near point of accommodation
- They respond well to bifocal glasses.

Treatment

Optical correction

- The child should undergo full cycloplegic refraction.
- If the child is > 6 years, then the child is corrected such that mild esodeviation is present, so that the patient will use his fusional divergence to become orthophoric.
- The frame given to the child has to be light. Harness frames can be given to infants.
- The child should be examined frequently to check for esodeviations both at distance and near.

If residual esodeviation

- Near and distant: power of glasses increased
- For near: bifocals
- If residual esotropia still persists, then it is of the partially accommodative type and surgery will be required to correct the remaining deviation.

Role of miotics

- Miotics are given only if the patient is extremely uncooperative.
- Patient is started with 0.03% Echothiophate Iodide OD increased to BD or with 0.125% till desirable effect is achieved.
- The other miotic commonly used is Disopropyl Fluorophosphate.
- Miotics have side effects like brow ache, abdominal cramps and nausea.
- Other side effects also include iris cysts, lens opacities, angle closure glaucoma and retinal detachment.

Orthoptic treatment

Generally, orthoptic treatment has minimal role in management of accommodative esotropias. Once, the occlusion therapy has improved the visual acuity to the maximum, anti-suppression exercises are used to overcome the suppression and improve the fusional convergence.

Surgery

- Only, if there is esotropia at the end of full correction with glasses, surgery can be contemplated.
- Surgery is done more often if there is associated A-V pattern
- Surgery, if planned, should be done only after full adaptation with prisms. Generally, the residual esodeviation is first corrected with a Fresnel Add on prism worn for 1-2 weeks. If the esodeviation increases, the power of the add on prism is increased to neutralise the esodeviation.

This increase in the esodeviation after the prism is added is called 'eating up the prism'. Surgery should be planned for the full prism adapted deviation.

Partially Accommodative Esotropia

An esotropia is partially accommodative when accommodative factors contribute to but not account for entire deviation.¹ This entity is also described as decompensated accommodative esotropia. It is believed to be an evolution of a purely accommodative deviation into one that has both an accommodative component and a portion that is not corrected by suspending the accommodative effort. Various risk factors have been implicated in precipitating the decompensation of a fully controlled accommodative esotropia including an age of onset less than 2 years, untreated hyperopia, poor compliance with glasses, prolonged ill health, aggressive patching therapy for amblyopia and a high AC/A ratio.

Clinical characteristics

A residual esotropia(>10PD) for distance and near exists despite full correction of the hypermetropic refractive error or prescription of the bifocal lenses⁶. It is important to repeat the cycloplegic refraction to ensure that no residual, uncorrected hypermetropia is present.

Management

Prescribing the full cycloplegic refraction initially will provide the best opportunity for restoring ocular alignment and maintaining good visual acuity and stereopsis. Amblyopia may be treated with patching and/or atropine penalization, and amblyopia treatment in accommodative esotropia is usually successful.

Surgical Management

Surgery is indicated in partially accommodative and deteriorated accommodative esotropia. Strabismus surgery is generally performed with the goal of only correcting the non-accommodative component of the esotropia, with the understanding that the child will still need to wear spectacles postoperatively to correct the accommodative component of the esotropia. Bilateral medial rectus recession is the procedure of choice for partially accommodative esotropia. Unilateral recession/resection may also be performed on an amblyopic eye. There is however controversy regarding how to determine the target angle.

Prism Adaptation

Preoperative prism adaptation[15] is used to predict the patient's fusional capability and determine the augmented target angle for surgery. Fresnel prisms, split equally over the two eyes, are prescribed over the full hypermetropic spectacle correction. Patients are followed at 1 to 2 week intervals and the prism is adjusted until the deviation stabilizes at an esotropia of 8 prism diopters or less. Surgery is done for this amount of esotropia that has been determined by prolonged prism adaptation. Operating on the larger adapted angle reduces the rate of undercorrection, with the predictability of a successful surgical outcome at 90%. The disadvantage of prism adaptation is the time and cost involved in prescribing and adjusting the prisms until the deviation stabilizes.

Standard surgery

Standard surgical approach is based on the deviation measured with full hypermetropic correction. The target angle is an average of the near and distance deviation with correction. However, the standard surgery has a high undercorrection rate of approximately 25%.

Augmented Surgery

In augmented surgery the target angle is determined by averaging the near deviation with correction and near deviation without correction. Results comparing the standard surgery to this augmented surgery formula showed 26% undercorrection for standard surgery, while augmented surgery resulted in 93% success rate with 7% overcorrection

Essential Infantile Esotropias

Etiopathology

The aetiology of Essential Infantile Esotropia is multifactorial.

- Heritable:
- Innervational: Imbalance in the innervation of the medial and the lateral rectus.
- Developmental: Sometimes, the development of the abducens nucleus which supplies the lateral rectus lags behind the oculomotor nucleus.
- Refractive

Functional Deficits in Infantile Esotropia

- Fusion Deficits
 - Absence of disparity vergence (motor fusion)
 - Lack of two-dimensional fusion and stereopsis
 - Alternating monocular suppression
 - Subnormal binocular visual evoked potential response
- Motion/Pursuit Deficits
 - Asymmetric monocular tracking
 - Asymmetric monocular motion visual evoked potential
 - Asymmetric motion perception

EPIDEMIOLOGY AND RISK FACTORS

- 20% to 30% of children born to a strabismic parent will themselves develop strabismus
- Higher in LBW babies
- Risk increases roughly 4% for each 100 g decrease in birth weight under 5 pounds

-

CF

- Essential infantile esotropia presents within 6 months after birth
- It is characterised by large deviations (30 Degrees).
- There is alternate fixation or cross fixation. The patient sees the left field with the right eye and the right field with the left eye.
- There is no significant refractive error.
- There is no neurological defect.
- Essential infantile esotropia is associated with inferior oblique overactions (68%), dissociated vertical deviations (50%) and nystagmus (33%).

There is presence of asymmetric optokinetic nystagmus. Tracking of objects from temporal to nasal field is smooth while tracking of objects from nasal to temporal field is cogwheel.

With more physiological tests like the polaroid scotometer, there is presence of two-point scotoma, one at the fovea and the other at the diplopia point. While with more dissociating tests, a single scotoma is seen.

Variants

- **Ciancia syndrome**: Here, there is **manifest latent jerk nystagmus** (Fast phase in the direction of the fixing eye). The frequency of the **nystagmus increases in abduction** and decreases in adduction. The patient thus prefers **keeping his eye in the adducted position** with the head turned towards the side.
- **Lang syndrome**: Here, there is early onset esotropia with nystagmus, **DVD** and **excyclodeviation** of the non-fixing eye. This is associated with Torticollis.

Management

Correction of underlying refractive error

If hypermetropia is present up to 1.5 D, there is no need for correction with glasses.

If hypermetropia is greater than 1.5 D, correct with glasses.

Treatment of amblyopia

Surgical correction

Pre-requisites

- a. Deviation should be constant and stable.
- b. Eyes should be fixating alternately.
- c. Refractive error and amblyopia should have been treated.
- d. Any associated deviation should have been picked up.

Goals

Esotropia should be corrected within 10 PD of esotropia.

There should be peripheral fusion to combat diplopia and central suppression to combat confusion.

Principles

- a. In the absence of amblyopia, bilateral medial rectus recessions of 6.5 mm or more are generally required.
- b. In the presence of amblyopia, recess and resection can be tried.
- c. Inferior oblique overaction should be corrected by inferior oblique weakening procedure.
- d. Dissociated vertical deviation, if present, can be corrected at a later date.

DD

- **6th nerve palsy:** Due to the cross-fixation phenomenon in Essential Infantile Esotropia, the eye remains adducted mimicking a Lateral Rectus Palsy. To differentiate between Essential Infantile Esotropia and 6th Nerve Palsy, one can use the Doll's eye movements. The patient's

head is rotated to the side the eye is adducted to. If there is 6th Nerve Palsy, the eye will not abduct but if Essential Infantile Esotropia is the cause, then the eye will abduct. Sometimes, though the patient might be having Essential Infantile Esotropia, the eye will still not abduct. In this case, patch the other eye for few hours and then repeat the test. If the eye still does not abduct, then it is a 6th Nerve Palsy.

- **Duane's Syndrome:** It can be differentiated from Essential Infantile Esotropia by the retraction of the globe, changes in the palpebral aperture and associated upshoots and downshoots.

- **Down's syndrome**
- **Mobius syndrome**
- **Nystagmus blockade syndrome**
- **Accommodative esotropias**

Monofixation Syndrome

Small angle deviations which can be missed by ordinary methods of examination and have amblyopia of one eye with variable levels of binocularity are called Microtropias.

Clinical Features

1. Amblyopia of one eye.
2. Anomalous retinal correspondence.
3. Relative scotoma at the fixation spot. This can be tested by placing a 4D Prism diopter in front of the eye. Though, the image moves from the fovea to a parafoveal point, there is no refixation movement of the eye as the image lies within the scotoma.
4. Normal or near normal fusional amplitudes.
5. Normal stereoacuity.

Variable Clinical Features

1. Small angle deviation measuring 8 PD or less.
2. Presence of anisometropia. Commonly, these patients have hypermetropic astigmatism.

Management

1. Spectacles for refractive error.
2. Management of amblyopia.

Acute Comitant Esotropia

- acquired nature with sudden-onset with diplopia and minimal refractive error, usually in the first or second decade of life
- CF
 - Age of onset- 1st or 2nd decade.
 - Large-angle comitant esotropia usually >25-30 pd
 - Sudden onset esotropia: if the parents are observant enough, they will be able to tell the clinician the precise hour at which the squinting episode started.
 - Diplopia is an inconsistent symptom and its absence does not rule out acute comitant esotropia
 - Good binocular potential
 - Refractive error may be present, though its correction does not correct the esotropia
- DD
 - Accommodative esotropia
 - Basic esotropia
- 3 types
 1. Swan type

- a. associated with monocular occlusion for various reasons
 - b. due to artificial interruption of fusion after a period of monocular occlusion or visual loss
2. Burian-Franceschetti type.
- a. Most common
 - b. Normal Ocular motility in order to rule out sixth nerve palsy which is more common.
 - c. Normal Neuroimaging (MRI) to rule out an associated neurological problem
 - d. MX: prisms, botox, surgery
3. Bielchowsky
- a. sudden onset esotropia in patients with high myopia ($>-5.00D$).
 - b. Bielchowsky postulated the presence of esotropia due to increased tonus of both the medial recti
 - c. Meyer suggests the presence of esotropia due to direct damage of the lateral recti in patients with high myopia

Exotropias

Classification

Depending on whether the Deviation is Manifest or Not As

- Exophoria: Which is a latent outward deviation of the eye.

- Exotropia: Which is a manifest outward deviation of the eye.

Depending on whether the Deviation is Concomitant or Not

1. Concomitant

a. Primary

- Infantile exotropia
- Intermittent exotropia

b. Secondary

- Secondary
- Consecutive

2. Incomitant

- a. Paralytic: Medial rectus palsy
- b. Restrictive
- c. Duane's syndrome Type 2
- d. Dissociated horizontal deviation

Calhounz Classification depending on the State of Fusion

- a. Exophoria
- b. Intermittent exotropia
- c. Constant exotropia

Duane's Classification

- a. **Divergence excess pattern**: Distance deviation is 15 PD more than the near deviation.
- b. **Convergence insufficiency pattern**: Near deviation is 15 PD more than the distance deviation.

c. **Basic**: Distance and near exodeviations are equal.

d. **Simulated divergence excess**: Basic deviation presenting as divergence excess due to compensation of near divergence by fusional or accommodative convergence.

Etiology

Mechanical

Shape and axes of the orbit, interpupillary distance, size of the eyeball play a role in the development of exodeviations.

Innervational

Innervational imbalance between the convergence and divergence mechanisms are also supposed to play a role.

CF

- Onset of intermittent exotropia is in childhood. 50% develop intermittent exotropia within 6 months of birth and 70% develop intermittent exotropia within 2 yrs of birth.
- Exodeviations are more common in Females (70%).
- The exodeviations generally pass through the phases of exophoria, intermittent exotropia to constant exotropia.
- **Diplopia-phobia**: On exposure to strong light, the exophoria may decompensate into exotropia resulting in diplopia. To avoid this, the patient squeezes his eye. This is called as diplopia phobia.
- **Micropsia**: The patient tries to control his exodeviation by using his accommodative convergence. This leads to micropsia where the objects are seen smaller.
- **Asthenopia**: Patient develops eyestrain, blurring, headache.
- **Abnormal stereopsis**: This starts happening when an intermittent exotropia is becoming constant and is one of the indications of surgery.
- **Magician Forceps Phenomenon**: On passive adduction of the dominant eye, the other eye's exodeviation gets corrected. This reflex is present even in the dark. This reflex is abolished by deep retrobulbar anaesthesia.

- Generally, amblyopia never occurs unless the exotropia is unilateral, constant and present during the period of development of the eye. Sometimes, alternate suppression is present. The pattern of the suppression depends on the kind of test used to map it. With more dissociating tests like Prisms and Synaptophore, single large scotoma is produced from the fovea to the diplopia point. With less dissociating tests like polaroid scotometer and phase difference haploscope, two different scotoma are seen, one at the fovea and the other at the diplopia point.
- Anomalous retinal correspondence is also known to develop.
- **Associations**
 - A-V pattern strabismus
 - Comitant vertical deviation
 - Dissociated vertical deviation
 - Incomitant vertical deviation

Examination

- History
- Visual acuity
- Cycloplegic refraction
- Cover test: At near and distance
- Measurement of deviation: Should be done with Prism Bar Cover Test in all the cardinal positions of gaze and both for near and distance. There is **Lateral Gaze Comitance** in these patients, i.e. 20% reduction in the angle of squint in lateral gaze
- Measurement of Stereopsis
- Occlusion test:
 - First, do alternate cover uncover test and establish the presence of exotropia.
 - Now, if the exodeviation is found to be more for distance than near, then the eyes are patched for an hour. Sometimes, deviation more for distance than for near is simulated as the accommodative and fusional convergence compensates for the near exodeviation.
 - So, by patching for an hour, this accommodative convergence is broken.

- After an hour is over, an occluder is placed before the unpatched eye and then the patch is removed. It is very important to prevent the simultaneous use of both the eyes as even a brief binocular exposure may decrease the deviation for near by stimulating the accommodative and fusional convergence.
- Measurement of fusional amplitudes

Management

Optical Treatment

The patient is made slightly myopic by over-correcting with concave lens. This stimulates accommodative convergence and corrects exodeviation

Prismotherapy

Base in prisms are sometimes used to correct the exodeviation. Half of the exodeviation should be corrected with prisms, so that the remaining exodeviation can stimulate the fusional convergence. Normally, up to 8 PD can be used in front of each eye and with Fresnel's prisms upto 15 PD can be used in front of each eye.

Orthoptic Treatment

Anti-suppression exercises

The suppression scotoma should be first treated with flashes of light. Once, the suppression scotoma decreases, binocular single vision is maintained by anti-suppression exercises like Bar reading, Synoptophore or Cheiroscope.

Convergence exercises

The convergence exercises cannot affect the basic deviation but can improve the fusional control thus decreasing the occurrence of exodeviation.

First step is teaching the appreciation of Physiological Diplopia.

Second step, convergence exercises to increase both the tonic and phasic convergence.

Exercises

- Pencil push ups: The pencil is drawn closer to the patient
- SHOT: Simple Home Orthoptic trainer can be used. It consists of dark circles drawn on either side of a folded paper such that they overlap. The circle on one side has a cross on the top and the circle on the other side has a cross at the bottom. This paper is slid on the ruler. The patient has to overlap the two circles such that it appears as if there is only one circle with a cross both at the top and the bottom. The patient is to overlap the circles and hold it like that for 40 sees. He does this for 2-3 minutes 21 day. The paper is slid closer and closer to the eye as the convergence starts improving. It is important to note that convergence exercises should not be done by those patients who have Intermittent Exotropia at distance only as this may lead to post-operative over-convergence.

Occlusion Therapy

The occlusion of the preferred eye for 3-5 hours a day is useful in decreasing the angle of deviation. Exotropic patients become exophoric.

Surgery

Indications

- If constant exotropia is present.
- If intermittent exotropia is present for more than 50% of the waking hours.
- If exodeviation exceeds 20 PD
- If asthenopic symptoms/ diplopia are present
- If diplopia is present
- If the exotropia is progressing from intermittent to constant
- If suppression scotoma is developing
- If there is abnormal stereopsis.

Timing of the surgery

Early surgery

Early surgery is advocated by **Knapp**. The surgery can be done once the child is 6 months old. The advantage of doing it early is that sensory adaptations have not taken place.

The disadvantage is that if the patient is overcorrected, patient may develop Monofixation syndrome or consecutive esotropia.

Late surgery

Late surgery is advocated by **jampolsky**. The surgery can be done once the child is 2 yrs old.

The advantage of doing it late is the diagnosis will be more accurate, child will be more co-operative for any orthoptic treatment and the chances of consecutive esotropia and monofixation syndrome would be less.

The disadvantage is that sensory adaptations like suppression may have developed.

Choice of surgery

The choice of surgery depends on

- The type of exodeviation whether it is a true divergence excess, basic, simulated divergence excess or convergence insufficiency type
- The presence of lateral gaze inhibition
- The age of the patient
- The presence of A or V pattern
- The presence of Inferior Oblique over-action

General Guidelines

- In true divergence excess, bilateral recession of the lateral recti should be done.
- In convergence insufficiency, bilateral medial rectus resection should be done.
- In basic exotropia and simulated divergence excess, unilateral lateral rectus recession and medial rectus resection should be done.
- If operating on a child between 6 months 2 yrs old: Slightly undercorrect to avoid monofixation syndrome and consecutive esotropia.
- If eye is amblyopic, overcorrect by 20 PD to compensate for the slight post-surgical drift following the surgery.
- If lateral gaze inhibition is present, bilateral lateral rectus recession should be avoided and there should be slight under correction in the non-preferred eye

- Prior to surgery, the patient's refractive error should be corrected and amblyopia, if present, should be treated.
- The amount of recession and resection to be done varies from doctor to doctor. Generally, every 1 mm of medial rectus resection gives around 2.5 PD of correction and every 1 mm of lateral rectus recession gives around 2 PD of correction.
- In very large squints above 60 PD, sometimes 3 muscles need to be operated

Possible results following surgery

- **Orthoposition:** Generally, there is a post-operative drift after the surgery. So, if orthoposition is achieved immediately after the surgery, orthoptic exercises have to be prescribed to the patient to increase the positive fusional convergence.

- **Consecutive esotropia**

In children: Rerefraction, prisms, occlusion therapy

If esotropia > 15 PD persists, to be taken up for surgery as a fresh case.

In adult: Rerefraction, prisms, occlusion therapy

If esotropia > 20 PD persists for > 6 weeks

Surgery is required if esotropia persists for > 6 months in spite of the above non-surgical measures.

Residual exotropia

If residual exotropia is < 15 PD, then just re refraction, cycloplegics and prisms can be used.

If above exotropia persists at end of 6 months, surgery will be required. If residual exotropia > 15 PD, then surgery has to be planned within 6- 8 weeks.

DVD

- It is a condition wherein, the non-fixing eye moves up and out either on occlusion or during periods of visual inattention.
- When the occluder is removed or the patient regains visual attention, this eye which had drifted up and out starts coming down and sometimes even becomes hypo trophic. This re-fixation movement is not associated with a downward movement of the previously fixing other eye.
- **As, it does not obey the Herring's law**, this phenomenon is called dissociated vertical deviation. In addition, to an upward movement of the eye, there is an extorsion and abduction of the eyeball. It is generally bilateral and asymmetrical.
- **Types**
 - **Manifest DVD:** Wherein during periods of fatigue or inattention, one eye deviates up.
 - **Latent DVD:** Wherein when an occluder is placed in front of the eye, the eye deviates up.
- **Associations:** Seen in 75% cases of infantile esotropia, commonly after the age of 2 yrs. Other less common associations include infantile exotropia, heterotropia of sensory origin, A pattern exotropia with superior oblique overaction.
- **Theories**
 - Bielschowsky proposed alternate excitation and suppression of the vertical convergence centres
 - Spielman proposed imbalance of the binocular vision
 - Paralysis of the depressors
 - Defective mid-brain stimuli
- **Diagnosis**
 - **Cover-Uncover Test**

In a patient with manifest DVD, one eye is already fixating and the other eye is up and out. Now, when the fixating eye is covered, the non-fixating eye moves down and sometimes even overshoots. There is no movement of the eye under cover In a patient with latent DVD, when the eye is covered, the eye moves up and out. When the cover is removed, the eye which had moved up comes down back to the original position or sometimes overshoots downwards. There is no movement of the other eye.

- **Prism base down test**

If the patient has manifest DVD, one eye is already deviated up and out. Put an occluder in front of this eye. Tell the patient to fixate at a distance object with the other eye. Place a base down prism under the occluder. Then, shift the occluder to the other eye, there will be some downward movement of the deviated eye. Keep on increasing the power of the prism till there is no movement.

- **Modified Krimsky test**

This test can be used in those patients who cannot fix with the deviating eye

- **Red Glass test**

In this test, red glass is held alternately in front of the two eyes. If the eye has a DVD, then irrespective of in front of which eye, the red glass is held, there red image will always appear below the white image. If the eye has cyclodeviation, then red image is seen up or down depending on which eye fixates.

- **Bielschowsky phenomenon test**

In this test, the eye under the occluder is deviated upwards while the other eye is fixating. A neutral density filter is slowly introduced in front of the fixating eye and the density of the filter is gradually increased till the eye under the occluder assumes central position.

- **Management**

Non-surgical treatment

- If the patient has asymmetrical DVD, then patching of the eye with lesser deviation or occlusion of that eye with +3D will change the fixation to the other eye. So, the DVD will no longer be a cosmetic problem.

Surgical treatment

Surgical treatment is indicated when the deviation is significant and causing cosmetic problems.

No surgical treatment is able to correct the deviation completely; it is more of a palliative measure:

- **Faden Operation with superior rectus recession:** In this operation, the superior rectus is recessed by 3-5 mm and a posterior fixation suture is taken 10-12 mm behind the insertion of the muscle. This operation is successful but can lead to recurrences later
- **Large recession of the superior rectus muscle:** Large recession of the superior rectus of one or both the eyes can be done
- **Resection of the inferior rectus:** If, recurrences occur, resection of the inferior rectus can be done
- **Recess-resect procedure:** If the patient has a monocular deviation, 4 mm recession of the superior Rectus along with 6 mm resection of the inferior rectus can be done.
- **Recession of the inferior oblique and anteriorization of its insertion** to a point temporal to the inferior rectus has also been tried.

IOOA

- **Classification**
- **Primary**
 - Mechanical
 - Innervational
 - Secondary: Paralysis of ipsilateral superior oblique or contralateral superior rectus
- **Epidemiology**
- **Primary inferior oblique overaction occurs in:**
 - 72% Congenital esotropes
 - 34% Accommodative esotropes
 - 32% Intermittent exotropes
- **Age:** P100 presents around 2-3 yrs of age
- **Laterality:** Unilateral to start with, it soon becomes bilateral
-

Associations

Association with horizontal deviations in primary position: As shown above, P₁OO occurs in patients with congenital esotropia, intermittent exotropia and accommodative esotropia.

Association with vertical deviation in primary position: Generally less than 5 degrees. Quite often a V-pattern strabismus is present which has greater exodeviation in upgaze than downgaze.

Association with upshoots/downshoots: With the eyes in lateral gaze with the abducted eye fixing, the adducted eye is elevated. With the adducted eye fixing, the abducted eye is depressed. There is no head tilt and the Parks Bielschowsky test is negative. Though, objective sign like tilting of the disc may be present, subjective tests like the Double Maddox rod test, Bagolini test, Hess Screen test and Major Amblyoscope are absent. This happens because in patients with P₁OO, sensory adaptations take place.

Grading of Inferior Oblique Overaction

- *Depending upon the vertical deviation*

1. Mild overaction: When vertical deviation is present only on sursum adduction.
2. Moderate overaction: When vertical deviation is present on adduction also.
3. Severe overaction: When vertical deviation is present in primary position.

- *Depending on the angle the adducting eye makes with the horizontal line as it elevates and abducts on lateral version*

Grade 1: Angle between the line drawn from the medial canthus to the lateral border of the eye and from there to the centre of the pupil is up to 15 degrees

Grade 2: Angle is 16-30 degree

Grade 3: Angle is 31-60 degree

Grade 4: Angle is 61-90 degree

- **DD**

- • Dissociated vertical deviation
- • Aberrant regeneration of the 3rd cranial nerve

- • Rectus rotation in patients who have craniosynostosis
- • Tether effect in patients who have Duane's syndrome
- • Tight lateral rectus muscle syndrome

Treatment

There are various surgeries that can be done for inferior oblique overaction. These surgeries are called inferior oblique weakening procedures.

1. Disinsertion: Here, the muscle is cut from the globe near its insertion and left like that.

Advantage

- Simple and easy procedure
- No suturing of the muscle to the globe required, therefore, no chances of globe perforation, damage to the macular area.
- Bleeding is minimal.

Disadvantage

The muscle tends to reattach to the globe leading to high recurrence rates. Therefore, this procedure is not very popular.

2. Myectomy: A 8 mm segment of the inferior oblique is excised either nasal to the inferior rectus or temporal to the inferior rectus. The temporal approach is preferred. But, due to the high recurrence rates, unpredictable results and occurrence of post-operative adherence syndrome, this technique is not preferred.
3. Extirpation: The excision of the entire muscle with the Tenon's capsule is the most effective technique but leads to a lot of complications.
4. Recession: Being preferred for Grades 2 and 3 and in cases of secondary inferior oblique overaction.

Finks operation

Here, the muscle is reattached to a point which is 6 mm posterior and 6 mm inferior to the inferior border of the lateral rectus. 8 mm correction is achieved by the above procedure. If the point of attachment is 2 mm above or below this point, then 6 mm and 10 mm correction can be achieved.

Parks operation

Here, the muscle is reattached to the globe at a point 2 mm lateral and 3 mm posterior to aspect of insertion of the inferior rectus muscle. 10 mm correction is achieved by this procedure. A 10mm Park's operation gives better correction than a 10mm Fink's operation.

Elliot and Nankin's operation

It is the anteriorisation of the inferior oblique. Here, the muscle is disinserted and attached just lateral to the lateral border of the inferior rectus.

Advantages

- Predictable and sustainable results
- Post-operatively, if the desired correction is not achieved, a second surgery is possible.

Disadvantages

- Violation of the Tenon's capsule may lead to fibrofatty proliferation of the orbital fat on the sclera or contracture of the radial fibrous septa leading to 'adherence syndrome'. In this syndrome, there is progressive Hypo tropia, Exocycloptropia and elevation limitation.
- The vortex vein can be damaged leading to severe bleeding.
- Excessive traction on the inferior oblique may damage the Parasympathetic fibres to the ciliary ganglion leading to transient pupillary dilatation and decreased accommodative tone.

SOOA

- Classification

Primary

Mechanical

Innervational

Secondary: Paralysis of ipsilateral inferior oblique or contralateral inferior rectus

- Epidemiology

Age: PSOO presents around 2-3 yrs of age

Laterality: Unilateral to start with, it soon becomes bilateral

- Associations:
 - Association with horizontal deviations in primary position: Associated with exotropia and esotropia both.
 - Association with vertical deviation in primary position: Generally less than 5 degrees. Quite often an A pattern strabismus is present which has greater exodeviation in downgaze than upgaze.
 - Association with downshoots/upshoots: With the eyes in lateral gaze with the abducted eye fixing, the adducted eye is depressed. With the adducted eye fixing, the abducted eye is elevated.

There is no head tilt and the Parks Bielschowsky test is negative. Though, objective signs like tilting of the disc may be present, subjective tests like the Double Maddox rod test, Bagolini test, Hess Screen test and Major amblyoscope are absent. This happens because in patients with PSOO, sensory adaptations take place
- Grading is just like IOOA.
- Differential Diagnosis:
 - Secondary superior oblique overaction: **It is rare as the Inferior Oblique rarely gets paralysed alone**
- Treatment

Superior oblique weakening procedures are required when there is 'A' pattern strabismus or the deviation is significant

- **Superior oblique weakening procedures**

The superior oblique weakening procedures can be done either through the nasal or the temporal approach
- Nasal approach

When a surgery is done through the nasal approach, the intermuscular septum attachment to the tendon is undisturbed. This reduces the chance of post-operative torsional diplopia. Therefore, this approach is preferred when operating on a patient with Brown's syndrome.
- Temporal approach

This approach is preferred over the nasal approach in all other indications as

- Approach is easier
- The distance at which the tenotomy is to be done can be accurately measured
- Incidence of post-operative ptosis and superior rectus palsy is lesser
- **Tenotomy:** Here, the muscle is transected at a particular point.
- **Recession:** Here, the muscle is disinserted and reattached to a point at the medial border of the superior rectus 4 mm posterior to its insertion
- **Anteriorisation:** Here, the superior oblique is attached further anteriorly
- **Translational recession:** Here, the anterior point of the superior oblique reinsertion is 4 mm nasal from the superior rectus and 12 mm posterior from the limbus. The advantage of this is that it prevents the depression of elevation in adduction that occurs with the other two procedures
- **Posterior tenotomy of the superior oblique:** Here, selective transection is done of the posterior fibres. It is believed that these fibres are responsible for depression. Thus, by transecting these fibres a vertical deviation will be corrected
- **Superior oblique expander:** Here, a 2-2.5 mm silicon band/ silastic band is inserted between the cut ends of the superior oblique, 3 mm nasal to the superior rectus.

DRS

- It was first described by Stilling and then Turk, so, it is also called as Stilling-Turk-Duane syndrome.
- Duane syndrome is a type of incomitant strabismus (misalignment of the eyes which varies with gaze directions).
- It also belongs to the group of extraocular muscle fibrosis syndromes (conditions associated with restriction of both active and passive movement of the eyeball). But evidence suggests that DS (and other Congenital Cranial Dysinnervation Disorders-CCDD's) may actually be primary disorders of nerve innervation.

- Duane's syndrome (DS) is an eye movement disorder characterised by
 - Limited adduction, abduction or both.
 - In addition, when the affected eye(s) adducts, the eyeball retracts (pulls in) and the eye opening (palpebral fissure) narrows.
 - In some cases, there is also upshoot or downshoot of the eye
- Etiology
 - Genetics

Majority of cases are sporadic in origin 2-5% of patients showing a familial pattern. Both dominant and recessive forms of DS have been documented. In some families with dominant DS, it has skipped a generation (shown reduced penetrance) and ranged in severity within the same family (shown variable expressivity). Most familial cases are not associated with other anomalies.
 - SALLY Gene: Deletions of Chromosome 4 and 8
 - Theory of Innervational Anomaly

Duane syndrome results from an absence of cranial nerve VI (abducens nerve) or its nucleus and its corresponding alpha motor neurons in the pons and aberrant innervation of the lateral rectus muscle by a branch of cranial nerve III. When individuals with DS attempt to adduct, both of these muscles contract at the same time, resulting in the eyeball retracting inward (pulling in) and the eye opening (palpebral fissure) narrowing.
 - Theory of Structural Anomalies: Some studies suggest that there is fibrosis of lateral rectus and to some extent of the medial rectus. There is a fibrotic band running from the orbital apex to the site of insertion of both the lateral and the medial rectus.
- Epidemiology
 - Incidence: The frequency of Duane's syndrome in the general population of squint patients is 1-4%.
 - Gender Distribution: Females more commonly affected than the males.
 - Laterality: Left eye is more commonly (75%) affected. Both the eyes are affected in 20% cases.
- Clinical Features
 - Limitation of abduction/ adduction or both

- Narrowing of the palpebral fissure on adduction and widening on abduction
- Retraction of the globe on adduction
- Eye may be esotropic, orthotropic or exotropic
- Presence of upshoots and downshoots. Mechanical upshoots tend to be sudden whereas innervational upshoots are progressive
- Abnormal head posture may be present
- 71% of patients have hypermetropia >1.5 D.
- 15% of patients have amblyopia.
- Associated Ocular Anomalies
 - Congenital ptosis
 - Microphthalmos
 - Congenital distichiasis
 - Nystagmoid movements
 - Epibulbar dermoids
 - Keratoconus
 - Heterochromia iridis
 - Congenital cataract
 - Persistent hyaloid artery
 - Medullated nerve fibres
 - Optic nerve hypoplasia
 - Morning glory syndrome
- Associated Non-ocular Findings
 - Goldenhar's syndrome
 - Klippel-Feil anomaly: Non-formation of the cervical vertebrae along with torticollis and facial asymmetry
 - Wildervanck syndrome :Above with sensorineural deafness

- Variants of Duane's Syndrome
 - Vertical retraction syndrome
 - Congenital adduction deficit with synergistic divergence
- **Huber's Classification of DRS**
 - Type1
 - Most common(78%)
 - Limitation of abduction with normal or near normal abduction
 - Narrowing of the palpebral fissure and retraction of the globe on adduction
 - Type2
 - 7%
 - Limitation of adduction with normal or near normal abduction
 - Narrowing of the palpebral fissure and retraction of the globe on adduction
 - Type3
 - 15%
 - Limitation of both abduction and adduction
 - Narrowing of the palpebral fissure and retraction of the globe on both adduction and abduction
- **Khurana's Modification of Huber's Classification**
 - The three types are further classified as A, Band C depending on the position of the eye in the primary position
 - **A: Esotropic(53%)**
 - **B: Exotropic(16%)**
 - **C: Orthotropic(31 %)**
- **Differential Diagnosis**
 - 6th nerve palsy: Definite onset of new large angle esotropia associated with diplopia. Also, globe retraction and upshoots/ downshoots are not present.

- Moebius syndrome: Complete paralysis of both the 6th nerves along with loss of olfactory and gustatory senses.
- Congenital esotropia: Child may cross-fixate.
- Management
- Indications for Treatment
 - The commonest indication is a face turn.
 - Other indications include Narrowing of the palpebral fissure, retraction of the globe, torticollis and limited abduction.
- Contra indications
 - Less than 5 yrs of age.
 - In DRS, late surgery is advised as surgery may disrupt the development of binocular vision.
- Surgical Procedures
 - Never resect in Duane's syndrome as it can worsen the narrowing of the palpebral apertures.
 - If esotropia: Medial rectus recession It is the mainstay of treatment of DRS.
 - If the esotropia in primary positions $< 20\Delta$, then ipsilateral MR recession is sufficient.
 - If the esotropia $> 20\Delta$, then bilateral MR recession is required
 - If exotropia: Lateral rectus recession
 - Upshoots/Downshoots: If upshoots/ downshoots are present Y splitting of the lateral rectus muscle or Faden's operation (posterior fixation suture over the IR belly). This decreases the slippage of the lateral rectus muscle on the globe during adduction which is the main cause of the upshoot and downshoot.
 - Enophthalmos: If enophthalmos is the main complaint, simultaneous recession of both the lateral and the medial rectus muscle

Brown's Syndrome

- Brown's syndrome is an ocular motility disorder which simulates Inferior Oblique palsy. It is caused by the restriction of the action of inferior oblique due to overly taut tendon of the superior oblique.
- Causes
 - Congenital: Short SO tendon, tight trochlea, nodule on SO tendon
 - Acquired:
 - Tenosynovitis of the superior oblique tendon
 - Trauma
 - Rheumatoid nodule on the tendon
 - Extraocular surgery: Scleral buckling
 - Damage to trochlea while giving injection
 - Acromegaly
 - Marfan's syndrome
- Clinical Features
 - Failure of elevation in adduction
 - Less severe failure of elevation in midline
 - Elevation in abduction is present
 - No superior oblique overaction which should be present in a c/o true inferior oblique palsy
 - FDT positive in adduction but negative in abduction
 - Presence of 'V' pattern exotropia
- Variable Features
 - Downshoot in adduction
 - Widening of the palpebral fissure on adduction
 - Abnormal head posture if hypo tropia is present

- Eustis Grading of Brown's Syndrome
 - Mild: Restriction of elevation in adduction
 - Moderate: downshoot in adduction
 - Severe: hypotropia in primary position
- DD
 - Inferior oblique palsy
 - Double elevator palsy
 - Fracture of the orbital floor
 - Fibrosis of the inferior rectus muscle
- Management
- Treatment of Amblyopia: If amblyopia is present, then treat that first.
- Treatment of the underlying cause, e.g., if Tenosynovitis is the cause of Brown's, then oral steroids or injection of steroid around trochlea.
- Surgical Correction
- Indications
 - Abnormal head posture
 - Hypotropia in primary position
 - Diplopia in downgaze
- Surgeries
 - Superior oblique tenotomy: 50% cases develop superior oblique paralysis which can be managed by either recession of the ipsilateral inferior oblique or the contralateral inferior rectus.
 - Superior oblique tenectomy: To avoid the complication of superior oblique paralysis associated with SO tenotomy, 6 mm SO tenectomy within the muscle sheath just nasal to the superior rectus is advocated.
 - Silicon band expander: Superior oblique weakening using a silicon band expander.

Tests

The simultaneous prism cover test

- Detects the manifest deviation only.
- Used in small angle esotropia- microtropia.
- Prism over the deviating eye and cover the normal eye at the same time.
- Equivalent prism test.
- It does not dissociate the eyes.
- Sufficient time should be given between changing prisms to allow fusion.

Prism alternate cover test

- Most reliable method in adult patients and co-operative children.
- Measures the total deviation.
- Should be done with prism on both eye.
- Eye with out the prism is the fixing eye.
- Watch the eye under prism for neutralization. cessation of movement is the end point. subtract 2 pd after reversal is appreciated.
- Cannot measure cyclodeviations.
- Performed in the 9 diagnostic positions.
- Performed at distance and near.
- Subjective prism alternate cover test.

Krimsky test

- Prism is placed before the normal fixating eye.
- More accurate than the Hirschberg test.
- Can be done in infants, patients with poor visual acuity and eccentric fixation.
- Can be done only for near.
- For distance u have to examine the eyes grossly.
- All gaze positions should be examined.
- Measures only the manifest deviation. - underestimates the true deviation.
- U should see in alignment with the deviated eye.
- Value may be affected as the eye is not in primary position.

Modified Krimsky Test

- Prism is placed over the deviated eye.
- Seen from midline.

Four prism dioptre test

- Can be used as base out or as base in.
- Placed first over the normal eye and then over the micro tropic eye.
- Less sensitive than worth 4 dot test.
- Should be done in every patient with anisometropic amblyopia and suspected microtropia.

The vertical prism test

- To find out the fixating eye .both eyes move if placed in front of the fixating eye.
- A patient should be able to maintain fixation with a 16 pd prism. to find out the dominance.

- To detect malingering. ask the patient , how many images does he see. if he sees 2/3/4.

The prism adaptation test

- First described by Dr Jampolsky.
- To judge which patients may develop residual esotropia postoperatively .
- Overcorrecting prisms are placed and reexamined after 1 hr in the clinic.
- Prism acceptance-stable exodeviation or a slight convergence movement to attain bifoveal fixation.
- Do a cover test.
- The target angle is the prism adapted angle.
- There was no over corrections.
- Better successful alignment.increased presurgical fusion.

Prism under cover test

- Base down prisms are placed in front of the dissociated eye.
- Point of neutralization is achieved when no down ward movement is seen.
- Spielmans occluder.
- To measure the dvd.

Hess Chart

- for incomitant strabismus
 - a. **neurogenic** such as 3rd, 4th and 6th cranial nerve palsy
 - b. **myogenic** causes such as myasthenia gravis, Duane's syndrome, Brown's syndrome, Thyroid eye disease
 - c. **mechanical** such as orbital floor fracture.

In **Hess screen**, the two eyes are dissociated using lenses of different colours. The fixating eye looks through the red lens (or filter); the non-fixing eyes through the green lens (or filter).

In **Lees screen**, the eyes are dissociated using two opalescent glass screens at right angles to each other bisected by a two-sided plane mirror.

- In mild incomitant strabismus, the central field may appear normal. By analysing the outer field, small underaction or overaction may become apparent.
- **stages in the development of muscle sequelae:**
 1. **Overaction** of the *contralateral synergist* according to Hering's law
 2. **Overaction** of the *ipsilateral antagonist* as its action is unopposed by the paralysed muscle
 3. Secondary **underaction** of the *contralateral antagonist*.

This occurs for two reasons:

a} as the ipsilateral antagonist action is unopposed, less impulse is needed to move it into its desired position and consequently according to Hering's law, its contralateral synergist receives less impulse and therefore underact.

b} overaction of the contralateral synergist means that its ipsilateral antagonist will receive equal impulse to relax according to the Sherrington's law.

The chart with the small field is the abnormal one.

If compressed, consider mechanical causes

The greatest negative or inward displacement represents the primary underaction

The muscle with positive or outward displacement indicates an overaction.

Squint may result in Diplopia or Confusion,

Pt. adapts himself to overcome diplopia or confusion by:-

1. Motor adaptation

- 1) Latent squint
- 2) Compensatory head posture/ Paralytic squint
- 3) Purposive squint (blind spot syndrome)

2. Sensory adaptation

- 1) Supprssion of image from squinting eye
- 2) Eccentric fixation
- 3) ARC

- Good visual acuity, normal physiological retinal correspondence, proper coordination and fixation with each eye, formed, are the essential requirements of binocular vision.

- The vision in significant anisometropia may be binocular, alternating or exclusively uniocular.

Various methods are devised for measuring AC/A ratio

- a. Heterophoric method
- b. Gradient method
- c. Fixation-desparity method
- d. Haloscopic method
- e. Graphic method.

Orthoptic Treatment

1. Antisuppression exercises:
2. Fusion exercises:
3. Ex. diploscope exercise
4. Exercise on Remy separator
5. Exercise with the help of stereogram cards
6. Occlusion to induce use of eye with marked suppression

convergence insufficiency

There are seven types of convergence insufficiency:

1. Primary idiopathic
2. Secondary to primary divergent strabismus (divergence excess type)
3. Secondary to a vertical muscle defect
4. Convergence insufficiency due to refractive error

5. Systemic convergence insufficiency (poor general health)
 6. Convergence insufficiency associated with presbyopia
 7. Surgically induced convergence insufficiency.
- Periodic squint is a special type as reported by Duke-Elder, which differs in degree depending on far or near fixation. If the squint is greater for near, it is called directly periodic; if greater for distance, inversely periodic.
 - Cyclic squint—Cyclic squint is another special type in which the squint appears and disappears in a rhythmic manner, most frequently at 48 hours intervals.
 -

Definitions

- Normally, any point of retinal receptors in one eye corresponds to another point in the other eye. Such points do not refer to individual retinal receptors but a group of receptors in a small area—**Pannum area**. Each eye contains many such areas and the sum of points in space the images will fall upon corresponding retinal areas is called horopter. In other words **horopter** can be considered as a sum total of points in the physical space that stimulate corresponding elements of two eyes.
- The response to a single optotype has been termed **angular vision**, while the response to a row of letter is known as **cortical vision**, the reading of a row of letter involves interpretation by the cortex, whereas angular vision, or recognizing simple optotypes, depends simply on the angular magnification of the letter.
- The angle subtended by the object at the nodal point of the eye is called the **visual angle**.

- The convergence response of an individual to a unit stimulus of accommodation may be expressed in a number termed accommodative convergence/accommodation ratio (**AC/A ratio**). This ratio which has the dimensions (D/D) is a measure of the responsiveness of person's convergence function to a unit of stimulation of accommodation.

In other way, it is how many prism diopters a person's eyes converge for each diopter that they accommodate. The normal AC:A ratio is approximately 3-5 prism diopters of convergence per diopter of accommodation. Values above 5 are considered to denote excessive accommodative convergence and values under 3 as in sufficiency.

- **TROPIA**: misalignment that is always there, even when both eyes are open and attempting to work together. Large angle deviations are obvious, if small angle, you can detect by cover-uncover test.

PHORIA: misalignment that only occurs some of the time, such as when the synchronization between the eyes is broken by covering one eye. You can break fusion by cross-cover test.

- **Horror fusionis**: is a rare clinical finding associated with congenital strabismus, commonly with harmonious ARC. This term literally means "fear or fusion". Patients are unable to simultaneously perceive images presented to the right and left eye in the same place in space.
- **Diplopia** is seeing seeing a single object simultaneously in two different visual directions so that a single object of regard is perceived as two. **Visual confusion** implies seeing two different objects in the same visual direction.
- **TNO: Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek** or **TNO (Netherlands Organization for Applied Scientific Research)**
-

Reading from Books

- The 10-PD test is specifically designed to assess fixation preference in preverbal children who are not strabismic or who have small deviations. It may be performed either in the base-down or base-up position.

- **Assessment of Vision in Nystagmus**

When assessing monocular vision in a patient with nystagmus, an occluder placed in front of one eye may cause nystagmus to worsen leading to a decline in recorded acuity.

Four methods are commonly used:

1. remote occlusion.
2. high plus lenses for fogging.
3. Neutral density filter
4. American Optic (AO) vectograph testing.

- Stereoacuity less than 40 seconds of arc suggests peripheral fusion.
- TNO Test is based on anaglyphic (red/green dissociation) method.
- Binocular lateral critical flicker fusion level is 30Hz.
- **Normal retinal correspondence** occurs in straight eyes (no tropia) under binocular condition or when the patient's objective and subjective angles of strabismus are the same. The objective angle is measured by the alternate prism cover test. The subjective angle is determined by measuring the amount of neutralizing prisms required for superimposition or fusion.
- ARC is binocular phenomenon. There are two types of **ARC**: harmonious and unharmonious.

Harmonious ARC occurs when the subjective angle is zero. For example, a patient who has 20 PD of esotropia on alternate cover testing but who reports a subjective fusion response with Bagolini lenses (without neutralizing prisms) has harmonious ARC.

Unharmonious ARC occurs when the subjective angle is greater than zero but less than the objective angle. This result from incomplete sensory adaptation, a test artifact or change in the original strabismic angle.

- Suppression, amblyopia and ARC occur in children who acquire strabismus before reaching age 7.
- Mean possible angle kappa ranges from 1.4 to 2.8 degrees with emmetropes and hyperopes tending to have slightly larger angle kappa than myopes.
- patient fixating first with one eye and then the other, are of fundamental diagnostic importance, since a difference between a **primary deviation** (nonparetic eye fixating) and a **secondary deviation** (paretic eye fixating) clearly distinguishes paralytic from nonparalytic strabismus; *the secondary deviation is always greater than the primary deviation.*
- **Antepodean Strabismus:** It is present when the patient has esotropia while fixing with one eye and exotropia when fixing with the other eye. This occurs with anisometropia and an improperly corrected refractive error. Some cases are believed to be due to unequal accommodation.
- **Park's Three Step Test:**
diagnostic scheme popularized by Parks by asking the following three questions:
 - (1) Does the patient have a right or left hypertropia in primary position?
 - (2) Does this deviation increase in dextroversion or levoversion?
 - (3) Does it increase with the head tilted to the right or left shoulder?Using this three-step method, one can distinguish a paretic oblique or vertical rectus muscle in most instances.
- For clinical purposes, stereopsis equal to or better than **40 seconds** of arc is considered normal.
- **Horror fusionis:** is a rare clinical finding associated with congenital strabismus, commonly with harmonious ARC. This term literally means "fear of fusion". Patients are unable to simultaneously perceive images presented to the right and left eye in the same place in space.
- **Diplopia** is seeing seeing a single object simultaneously in two different visual directions so that a single object of regard is perceived as two. **Visual confusion** implies seeing two different objects in the same visual direction.
- Testing for CFDS requires a haploscopic type instrument such as a major amblyoscope or synoptophore. (central fusion deficiency syndrome)
-

Nystagmus Examination

- Observe the eye for any abnormal head posture which may be used to dampen nystagmus (to achieve null point) especially in those with congenital nystagmus.
- Look for any nystagmus in the primary position. Observe for:

its plane: horizontal, vertical, rotatory or see-saw

its type: jerk (phases of unequal velocity) or pendular (phases with equal velocity)

its direction: direction of the fast phase in jerky nystagmus

its amplitude: fine, medium or coarse

- Perform the ocular motility by getting the patient to fixate on an object (such as your finger or a picture) placed about 1/2 metres away. Move the object from right to left, upwards and downwards. Place the object at least 5 seconds at each direction to elicit the nystagmus. Observe if the amplitude of the nystagmus is increased or decreased in each direction.

Tip 1: Avoid extreme of gaze in each direction as this may elicit physiological nystagmus

Tip 2: In jerky nystagmus, the amplitude is increased when the eyes turn in the direction of the quick phase.

- Ask the patient to fixate on a distant object (such as a Snellen's chart) and then on an accommodative target (such as a picture). Observe for any dampening of amplitude (null point) with convergence when the eyes accommodate.
 - Perform cover test on each eye in turn to elicit manifest latent nystagmus.
 - You may be asked to perform further examination based on your findings.

Tip 1: In the presence of jerky nystagmus or internuclear ophthalmoplegia, look for cerebellar signs such as pass-pointing or disdiadochokinesia

Tip 2 In pendular nystagmus, look for conditions such as ocular albinism, congenital cataract or optic nerve hypoplasia.

Tip 3: In see-saw nystagmus, test for bitemporal hemianopia.

PRISMS

- A portion of a refracting medium bounded by 2 plane surfaces which are inclined at a finite angle.
- Image is Erect/virtual/displaced towards the apex.
- Angle of Deviation depends on
 - Refractive index of the material
 - Refracting angle
 - Angle of incidence.
 - Not thickness dependent.
- Types of prisms
 - Loose prisms
 - Prism bar
 - Trial frame prisms
 - Fresnel prisms/press on prisms
 - Prism induced by decentration.
 - based on material - Glass , plastic , polyvinyl chloride
- Prism notations
 - 1 prism dioptre = apparent deviation of the image by 1 cm of an object placed at a distance of 1 m.
 - **Centrad- older unit, takes in to consideration the curvature of field.**
- Prism placement
 - Prentice position- parallel to the iris plane. Apex is closer to the eye in prentice position. glass prisms , trial frame prisms, Fresnel prisms, prisms incorporated in spectacles.
 - Position of minimum deviation:
 - Frontal position: back surface of the prism is perpendicular to the fixation target. plastic prisms
- Stacking of prisms-guidelines
 - U can stack a horizontal and a vertical prism

- U should not stack two horizontal prisms.
- U can use two horizontal prisms on two eyes.
- U should not place two vertical prisms on same eye.
- U can stack a vertical loose prism on a horizontal prism bar.

Fresnel principle

- Augustin fresnel introduced the concept.
- Fresnel wafer prism
- Wafer prism -woodward and chester.

Fresnel membrane prism

- Composed of concentric annular rings.
- **Principle: the prism apex deviates light just as much as any other part of the lens.**
- Sheet of prism apices on a thin base sheet used to obtain a prismatic effect across the lens without creating additional lens thickness.
- Method of choice for temporary use. Upto 30° can be applied to either eye but high powered prisms may not be tolerated. Upto 20° can be worn comfortably
- The prism is normally fitted to the back surface of the spectacle lens.
- Molded optical grade polyvinylchloride.
- Wet - conforms and adheres.
- Flexible ,thinner.
- Press on prisms.
- Maximum thickness- < 2 mm.
- Magnification is minimal when compared to conventional prisms.

Prisms in neuroophthalmology & orbit

- Myasthenia gravis
- Internuclear ophthalmoplegia
- Treatment of field defects.
- Treatment of nystagmus
- Thyroid ophthalmopathy.
- CPEO

Glaucoma

- Tonometry-applanation tonometry
- Gonio- prism

retina

- Indirect ophthalmoscopy
- Contact lens
- Laenders prism for vitreo retinal surgery. 60 prisms.??

Instruments

- Slit lamp
- Operating microscope.
- Keratometer.
- Indirect ophthalmoscopy.

Pitfalls in measurement: 8P

1. Position of the head

2. Position of the eye.
3. Position of the prism.
4. Placing of the prism.
5. Presence of high power glasses.
6. Picking the wrong test.
7. Poor co-operation.
8. Prejudiced examiner.

Occlusion Therapy in AMBLYOPIA

- Aim of Treatment
 - Centralise the fixation
 - Achieve optimum V/A
 - Equalise vision of 2 eyes
- Principles of treatment
 - Removal of amblyogenic factor
 - Optical correction: To Provide best possible vision
 - Occlusion and Penalisation of good eye
- French scientist **Count de Baffon** (1743) introduced occlusion therapy

- Patching dates back to days of **Thabit Ibn Qurrah** AD 900 from Mesopotamia
- **Occlusion therapy depends on**
 - Age of patient
 - Depth of amblyopia
 - Compliance of patient
 - Type of amblyopia
 - Associated abnormalities
- **Classification**
 - **Type**
 - **Conventional**
 - Occlusion of sound eye
 - Decrease in neural signals from sound eye
 - Most effective, specially in younger children, below 5 years of age
 - **Inverse**
 - **Occlusion of Amblyopic eye (in eccentric fixation)**
 - Helps to break abnormal fixation
 - Used in initial phase of therapy below 5 years of age
 - Useful in making child accustomed to patch, before switching it to sound eye
 - Not used commonly, as studies show - conventional occlusion best irrespective of type of fixation below 5 years
 - **Time**
 - **Full time**
 - All waking hours - At no time both eyes open together during treatment
 - *Advised only when no BSV* due to constant squint/ Dense Amblyopia or difficult to follow schedule

- **RATIO** Normal: Amblyopic Eye = age in years: 1
- **Part time**
 - Poor compliance for total occlusion
 - Parents may stop t/t due to difficulty - Poor outcome
 - Social and psychological factors
 - For 2-6 hours patch to sound eye
 - Well accepted - Better Compliance
 - Along with one hour near activity / Active vision
 - therapy shows equal results as total occlusion
 - Results of ATS encouraging
- **Amount of Light Transmitted**
- **Total - Skin patch - No light, No form vision**
 1. Direct Skin Patch
 2. Spectacle Patch
 3. **Doyne's Occluder: Black rubber occluder - sticks by suction to glass**
 4. Pirate Patch
 5. Contact Lens - opaque
- **Partial - only form vision obscured**
 - by transparent tape / nail warnish
 - For mild cases
 - For maintenance patch
 - Advantage: Maintains binocularity
- **Occlusion Amblyopia**
 - **Incidence 4% in 6 hr patch & 10% in full day patch**

- Most dangerous complication
Prevented by proper regime & follow-up
- Careful V/A testing in follow-up
- Subclinical Δ :Pursuit abnormalities in ocular motility recording in sound eye before V/A ↓
- T/T : Recovers of its own after stopping occlusion after giving period of BSV
- **Liquid Crystal Glass:** Recently developed T/T, with appropriate correction → Provide electronic controlled, intermittent occlusion of sound eye - intermittent flickering shutter
- **Follow up**
 - 1 wk per year of child age
 - To examine improvement and To diagnose Occlusion Amblyopia at the earliest
 - Continued till V/A improves or No further improvement of 3 mths of occlusion
 - Look for Vision (not improving or stabilised)
- **Maintenance Occlusion**
 - V/A improved and stabilised
 - To prevent recurrence → Must be continued till 9 to 12 years of age
- **Decision of Surgery**
 - **Occlusion first then surgery**→ in **Strabismic Amblyopia**, at end point of occlusion therapy
 - Surgery first then occlusion → Only If Dense Amblyopia, Large Squint, Does not tolerate Occlusion
- **End point of occlusion therapy**
 - V/A stabilised
 - Equal vision in both eyes
 - Freely alternating
 - Less than 2 line diff. in 2 eyes
 - No improvement after 3 consecutive visits with good compliance.
-

Strabismus Surgery

GOAL:

- Cosmetic
- Functional

Preoperative evaluation

- Assessment of vision, refraction and amblyopia therapy
- Measurement of deviation
 - Surgery for static angle and not for dynamic angle
 - In incomitant paralytic squint, both primary and secondary deviation are noted and surgery is decided on the basis of fixating eye. If the paralytic eye is dominant, then secondary deviation needs to be operated.
- Important tests
 - FDT:
 - fixation forceps or pierce Hoskins forceps
 - both direct and reverse leash may be present
 - Exaggerated FDT for Obliques
 - David guyton

- Globe is retracted to exaggerate restriction to obliques
- For inferior oblique traction test: limbus is held at inferotemporal and superonasal quadrant positions, the globe is pushed back into the orbit, in full adduction position maintaining intorsion of the globe. It is then brought temporally while continuing to push it backwards. A normal or taut IO muscle would cause the globe to 'pop up' which can be felt and seen. A lax or weakened muscle would not show this response. After a weakening procedure positive test indicates insufficient weakening.
- For the superior oblique traction test: the limbus is held in the superotemporal and inferonasal quadrant positions. The eye is pushed back into orbit, in full adduction positions, maintaining extorsion of the globe. It is then brought temporally while continuing to push it back in the orbit. A normal or taut SO muscle would cause the globe to "pop up." A click is felt by the examiner. After a weakening procedure a positive test indicates an insufficient weakening done.
- **Spring-back Balance Test**
 - Jampolsky
 - whether surgical adjustment of the muscle has disturbed the balance of passive muscle forces.
 - The eye is passively rotated in chosen direction while holding globe at limbus by two forceps. After removing the forceps, globe should spring back into primary position or not is noted and necessary readjustments are done.
- Muscle stretch test
 - simple test for checking the elasticity of the recti muscles, intraoperatively. muscle to be operated upon after disinsertion and passing sutures, is pulled toward the opposite side. A normal muscle, can be advanced up to the centre of cornea with the in straight ahead position. If this is not permitted, it indicates a contracture or fibrosis the muscle.
- **Ocular deviation is altered in general anesthesia due to relaxation of convergence tone.**
- The lateral triangle of limbus merges more indistinctly with sclera.
- The sclera is thinnest at the insertion of recti. (0.3mm) so at least 0.5 mm muscle stump should be left for resection surgery.
- Nerves to recti are usually safe at 26 mm from insertion site but nerve to IO is at crossing of IR nasal border and oblique.

- In neonate, anterior segment is 80% size of adult and posterior segment is 70% size of adult.
- *Symmetric surgery: equal amount of surgery in both eyes.*
- *Symmetrizing surgery: try to establish symmetry where none exists and maintain it where it exists.*
-

History of Surgery

- The history of strabismus surgery starts from the end of the eighteenth century. The first surgical trials consisted of performing myotomies of the medial rectus.
- Although **Taylor** from Great Britain could be one of the first to be mentioned, it was **Dieffenbach** from Germany who accomplished the first official myotomy in 1839. He is followed by many authors as Roux, Velpeau in Paris, and Bonnet in Lyon, the latter performing tenotomy instead of myotomy.
- In 1849 **Guerin** performed muscular advancement.
- In 1883, **de Wecker** described the muscular pleating, and **Blasowicz** the muscular resection. Thus, by the end of the nineteenth century, the surgical treatment of esodeviations was supported by methods aimed to weaken the medial rectus (tenotomies, myotomies) and to strengthen the lateral rectus (advancement, pleating and resection).
- During twentieth century, progress achieved in anesthesiology and the quality of suture material led **Jameson** (1922) to substitute tenotomy by muscular recession. Since then, the surgery of squint has never been modified basically up to 1970 when **Cuppers** created the retro-equatorial myopexy. Thus, two kinds of surgical techniques are currently available to surgeons: classic surgery, recession, resection and their variants, dealing with the static component of the deviation angle, and the Faden Operation of Cuppers struggling against the dynamic or innervational component.

Weakening Procedures

M²R²F

Limbal incision = aka von noorden style incision

- **Recession**
 - **Conventional:** inserting muscle directly at desired point
 - **Hang Back or Hemi Hang Back:** inserting muscle with long ends of sutures hanging, intending supramaximal recession, in hemi-hang back, sutures are passed through scleral tunnel
 - **Adjustable**
 - **Vertical Transposition of Recti**
 - **Slanting Recession**
- **Retro Equatorial Myopexy**
 - FADEN = suture in german
 - Devised by copper
 - Muscle sutures posterior to its insertion farther than limit of its arc of contact (functional equator)
 - It shortens lever arm drastically and decreases muscle action
 - Most effective for medial rectus
- **Marginal Myotomy**
 - Transverse cuts in muscle atleast two thirds of width
 - Several cuts are made alternately at 2 borders
- **Myectomy**
 - Done for IO by some surgeons, otherwise its obsolete
- **Free Tenotomy or Disinsertion**
 - Historical, not done now, highly variable

Strengthening Procedures

1. Resection

- Shortens muscle length
- Makes muscle taut
- Raising it to higher length tension curve
- Maximum limit depends on fibrotendinous part of muscle
- Maximum for MR 6 mm, LR 9 mm
- Minimum for MR 3 mm, LR 4.5 mm

2. Advancement

- Makes muscle more taut and effective
- Reverse of recession
- Ideal in consecutive squint
-

3. Double breasting or Tucking

- Muscle is shortened without excision of muscle mass
- In cases of paralytic muscles with thin muscles

4. Cinching

- Modified double breasting in which passage of suture is such as to cause double breasting

5. Transposition of adjacent muscles

Conjunctival Incisions

1. Limbal incision of von Noorden
2. Over the muscle incision of Swan.
3. Paralimbal incision of Prem Prakash
4. Fornix incision of Parks.
5. MISS by Mojo

Glue Surgery

- Advantages
 - Avoid needle related complications
 - Perforations
 - VH/ RD/ Endo
 - Avoid suture → avoid sharing....
 - Cheaper → drops of glue are used.
 - Quicker
 - ? Antibiotic properties
 - Flexible bonding
- Glued muscle can hold upto 200 gms. Actual muscle forces are known to develop forces of upto 75 gms.

Adjustable Sutures

- **Jampolsky** introduced adjustable suture technique in 1974
- Most advantageous in:

- Large angle strabismus
- Restrictive strabismus
- Paralytic strabismus
- Multiple muscle surgery
- Repeat surgeries
- In small children (accurate assessment difficult)
- Various techniques introduced commonly
- **Site modifications**
 - ***Limbal***
 - Conjunctiva may be recessed till the level of original muscle insertion to allow access to adjustable sutures.
 - One corner of limbal incision is left deferring suture closure till the adjustment is made
 - ***Fornix based***
 - Retraction suture can be placed distal to incision at the edge of muscle insertion prior to end of the procedure
 - Adjustment can be made on conjunctival surface. Muscle sutures are tied together and needle of one end is removed. second needle is passed through conjunctiva
- Half bow-knot
- Full bow-knot
- Cinch Method
- Slip-knot Method (Wilmer Eye Inst.) (noose suture)
- **Ripcord technique**: indicated when large amount of adjustment is required and other methods of adjustment cannot be used
- Complications: Post-op
 - Infection
 - Slippage of muscle

- Suture granuloma
- Perforation
- Residual strabismus
- Persistent diplopia

Special Cases

Vertical shift of horizontal muscle

- to correct associated A-V patterns or to correct associated vertical deviations along with the horizontal deviations.
- MR shifted towards apex of A/V patterns

Slanting Recession-resections

- Same as above principle ..!! (think and understand)
- A eso/exo
- V eso/exo

Transposition of Muscles

- Indications
 1. Paralytic
 2. Slipped/ lost muscle
 3. DRS
- Essential pre-requisite: absence of any restriction in antagonists

- Knapp's procedure:
 - in elevator underaction
 - both horizontal recti are reinserted close to SR
- Hummelsheim's procedure:
 - LR palsy
 - lateral halves of superior and inferior rectus are **dissected up to 14 from their insertion and reinserted adjacent** to the lateral rectus insertion
- Jensen's procedure
 - LR palsy
 - lateral halves of both superior and inferior recti and the upper and lower halves of lateral rectus **dissected** free for about 14 mm from their insertion.
 - At equator, they are tied with 5-0 mersilene. (SR+LR, LR+IR)
- Callahan's procedure
 - Modification of same jansen's procedure
 - used for elevator palsy
- peter's procedure
 - for MR in 3rd nerve palsy
 - using SO
- O' Connor's lateral rectus cinch
- Helveston's procedure

Vertical Recti

- vertical recti are intricately connected the upper and lower lids. Any surgery more than 5-6 mm without dissecting these attachments can cause changes in the palpebral aperture, also causing:
 - Inferior rectus recession: lower lid retraction. Ptosis of the lowerlid.
 - Inferior rectus resection: elevation of the lower lid.

- Superior rectus recession: upper lid retraction.
- Superior rectus resection: ptosis upper lid.
- This is due to the fact that the ligaments for the vertical recti are linked to the Whitnall's ligament (for superior rectus) and Lockwood's ligament inferior rectus).
- inferior rectus should be done conservatively as down gaze is more critical to be compromised.

Inferior Oblique

Weakening Procedure

Indications

1. SO palsy
2. V pattern with IOOA
3. DEP
4. Upshoot in DRS
5. DVD
6. Torsional kestaunbaum

Initially **skin approach by bonnet**, now conjunctival approach preferred.

- **Generalized weakening**
 - **Recession**
 - FINK method: A point 6 mm inferior and 6 mm posterior from the inferior end of the lateral rectus insertion provides the anterior Point of insertion for 8 mm recession of IO. (8 mm recession)

- PARK method: A point 2 mm lateral and 3 mm posterior to the lateral end of the insertion of inferior rectus, gives a point of recession of about. (slight anteroposition also) (10 mm recession)
- *Myectomy*
- *Disinsertion*
- *Denervation*
- *Extirpation*
- **Selective weakening**
 - *Anteropositioning with recession*
 - PARK method
 - Elliot and Nankin's method: anterior end of muscle is positioned at the lateral end of the inferior rectus insertion with the posterior end being further down
 -
 - *Pure anteropositioning (without recession)*
 - Inferior oblique muscle is reinserted just adjacent to the inferior edge of the lateral rectus with the anterior end of the obliques, being at the inferior end of the lateral rectus insertion.
 - *Total anteropositioning*
 - The entire width of the inferior oblique is re-inserted anterior to the inferior rectus
 - *Recession of anterior fibres*
 - selectively weaken extorsion without affecting the elevator and abduction

Strengthening Procedure

- **Generalised strengthening**
 - *Advancement*
 - Advanced 8 mm from its innervation

- *Resection and/ or double breasting*
- **Selective strengthening**
 - *Advancement of anterior fibres*

Superior Oblique

Weakening Procedure

Indications

1. Pattern deviation with SOOA
 2. Brown's plus
 3. Torsional kestenbaum surgery
- **Safer to approach from temporal side**
 - **Generalised weakening**
 - *Tenotomy (temporal/nasal approach)*
 - Tendon disinserted from its insertion and left to retract, very unpredictable
 - *Tenectomy: PTSO*
 - anterior (1 or 2 mm width) fibres are spared and the posterior fibres are excised.
 - selectively weakens the and abduction in downgaze, correcting the pattern deviations, without significantly affecting intorsion.
 - *Recession*
 - *Translational recession*
 - *L-lengthening*
 - *Silicon expander lengthening*
 - **Selective weakening**

- *Posterior tenotomy*
- *Posterior tenectomy*
- *Recession of anterior fibres.*
- *Anteropositioning.*

Strengthening Procedure

- **Generalised strengthening**
 - *Tucking (tenoplication)*
 - Caution to prevent ianrogeic browns
 - 4+4 mm double folding give 8 mm tucj
- **Selective strengthening**
 - *Tenting of nasal fibres (Harada Ito and its modifications)*
 - Anterior fibres are selectively advanced towards LR (6-8 mm from SR)

COMPLICATIONS

Intraoperative Surgical

- Operating on wrong eye
- Operating on wrong muscle
- Wrong operation performed
- Hemorrhages
- Scleral perforations

- Splitting of muscle fibres
- Loose suture and partial thickness suture in muscle
- Central sag
- Lost muscle or slipped muscle
- Muscle sheath, tenon's rupture
- Fat prolapse

Intraoperative Anesthesia related

- Cardiac arrest
- Bradycardia
-

Misc

Q- Fixation Pattern

Fixation Pattern	Visual Acuity
No Fixation, Eccentric fixation	< 1/ 60
Unsteady fixation	2/60 – 5/60
Central, not steady	6/ 60 – 6 / 24
Central ,steady , not maintained on binocular checking	6 / 18 or 6 / 9
Central, steady, maintained on binocular checking	6/ 6

Alternate spontaneously	6/6 both eyes (equal both eyes)
Cross fixation	6/ 6 both eyes (equal both eyes)

