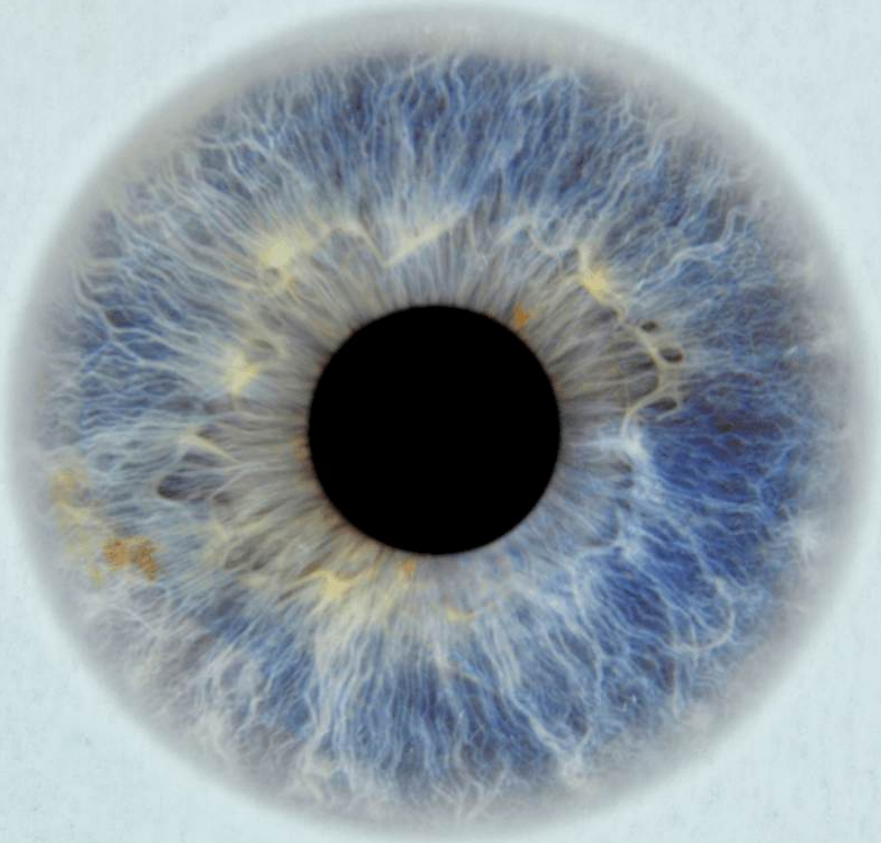
Rapid Revision Optometry



AASTHA BHANDARI

NOTES FOR LICENSING EXAMINATION

Author- Aastha Bhandari
Co-Author- Jenish Chaudhary

From Author

Preparing for exams with a different syllabus can be quite challenging. I faced similar difficulties when I had to compete in an exam with an entirely unfamiliar syllabus. Despite studying numerous books, I realized during the exam that there were still significant gaps in my preparation.

These notes became my most valuable resource during that time and played a crucial role in helping me secure a spot in the **Master of Optometry exam** conducted by MEC. Later, when preparing for my Master's license exam, I revisited these notes and found them just as helpful.

With that in mind, I am sharing my notes in the hope that they might assist you in your exam preparation journey.

I would like to express my gratitude to my co-author, **Jenish**, for helping me finalize this compilation, and to **Prashamsha Dhungana and Pabitra Chaudhary** for contributing to the writing process.

Wishing you all the best for your upcoming exams!

Aastha Bhandari

Table of contents

Ocular anatomy and physiology

Anatomical landmarks

Cornea

Dimensions

- Horizontal diameter - 11.75 mm
- Vertical diameter - 10.6 mm
- Posterior diameter - 11.5 mm
- Anterior radius of curvature - 7.8 mm
- Posterior radius of curvature - 6.7 mm

5 layers

1. Epithelium – guards the cornea
2. Bowman's membrane: Can't regenerate – scar formation
3. Stroma- thickest layer
4. Pre-Descemet's layer (PDL)/Dua's layer
5. Descemet's Membrane: Strongest membrane, only fungus can penetrate
6. Endothelium:
   - ☐ most important
   - ☐ Maintains transparency of cornea
   - ☐ Have endothelial pumps – Na K ATPase pumps
   - ☐ Endothelium irreparable: Cause irreversible corneal edema.

Endothelial cell count

At birth - 6000 cells/mm2

In young adults - 2400 cells/mm2

Corneal decompensation - 500 cells/mm2

Thickness of cornea

- Centre - 0.52 mm
- Periphery - 0.67 mm

Refractive index -1.37

Surgical limbus - 2 mm *preferred site of limbal incision

Sclera Thickness

- Posteriorly - thickest 1 mm
- Thinnest at insertion of rectus muscle - 0.3 mm
- Vortex vein - 4.7 mm posterior to equator

Uvea

- Average diameter of the iris - 12 mm
- Average thickness - 0.5 mm
- Thinnest part - root of iris
- Pupil diameter - 3-4 mm
- Pars plicata 2-2.5 mm
- Pars plana - 5 mm temporally, 3 mm nasally
- Cilliary process - 70-80 in number
- Short posterior cilliary artery - 10-20 branches from ophthalmic artery
- Long posterior cilliary artery - 2

Aqueous humor

- Originated from non -pigmented epithelium of pars plicata (production -2.5ul/min)
- Posterior chamber - 0.06 ml
- Anterior chamber -0.25 ml
- Depth of AC - 3 mm in the center

Lens

- Diameter of lens
- 6.5 mm at birth
- 9-10 mm in second decade
- Thickness of lens
- 3.5 mm at birth
- 5 mm at extreme
- Thinnest at - posterior capsule
- Refractive index - 1.39
- Weight - 135-255 mg

Orbit

- Volume -29 ul
- Superior wall
- Inferior wall - most common fractured in blow out fracture
- Medial wall - thinnest wall (infection enters through this wall)
- Lateral wall - thickest and strongest wall

Viterous humor

- Weight - 4 gm
- Volume - 4 cc

- Anterior hyloid membrane starts approx 1.5 mm from ora serreta

Retina

10 layers: 9 neurosensory layers(NSL) and 1 Retinal pigment Epithelium (RPE)

- Inner 2/3 blood supply: Central retinal artery (CRA)
- Outer 1/3 blood supply: Posterior ciliary artery (PCA) also choroidRetinal surface area -266 mm2
    - Macula leutea - 5.5 mm2
    - Fovea centralis - 1.85 mm in diameter (5 ° of visual field)
    - Foveola - 0.35 mm in diameter
    - Parafovea - 0.5mm in diameter
    - Perifovea - 1.5 mm in diameter
    - Orra serreta - 2.1 mm temporally, 0.7-0.8 mm nasally
    - No of rods- 120 million
    - No of cones - 60 million
    - Foveal avascular zone - 500 mm
    - Optic disc - 1.5 mm(after mylination -3.6 mm)

Optic Nerve

- Length of optic nerve - 47-50 mm
- Intraocular = 1 mm (shortest)
- Intraorbital - 30 mm (longest)
- Intracanalicular - 6.9 mm
- Intracranial - 10 mm

Extraocular muscle

Muscle	Approx muscle length	Origin	Insertion	Tendon length	
Medial retus	40	Annulus of Zinn	5.5	4	Shortest retus muscle (tendon)
Lateral rectus	40	Annulus of Zinn	7.0	8	
Superior rectus	40	Annulus of Zinn	8.0	6	

Inferior rectus	40	Annulus of Zinn	6.5	7	
Superior oblique	32	Orbital apex above Anuulus of Zinn		27	Thinnest and longest (tendon)
Inferior oblique	37	Lacrimal fossa	Macular area	1 mm	Shortest intraocular muscle (tendon)

Glands of eye

- Gland of Moll - sweat gland
- Krause and Wolfring - accessory lacrimal gland
- Zeiss and Mebomian - sebaceous gland

OPTICS OF EYE

Total power of the eye + 60 D (Diopters)

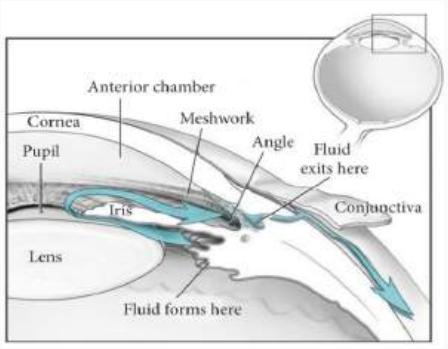
43 D cornea + 19 D (lens) = 60

(70%) (30%)

Anterior cornea: + 49D, Posterior cornea :-6D

Reflecting power: -253 D

Angle of anterior chamber (AC)



Produced from Pars Plicata

↓

Post chamber

through pupil

↓

Anterior chamber

Angle of eye (Junction between iris and cornea)

↓ → If iris shifts forward and blocks the angle –results in angle closure glaucoma(ACG)

Trabecular meshwork

System of collagen sheets piled over each other, perforated cseries of holes

↓ Commonest structure to get blocked in OAG

Schlemm's canal

↓

Episcleral veins

Vasculature of the Eye

1. Principal artery of eye- Ophthalmic artery -10 branches (OA is 1st branch of ICA)
2. Most critical- Central retinal Artery (CRA)
3. Principal Veins- Central Retinal vein / vortex vein

Nerve Supply of Eye

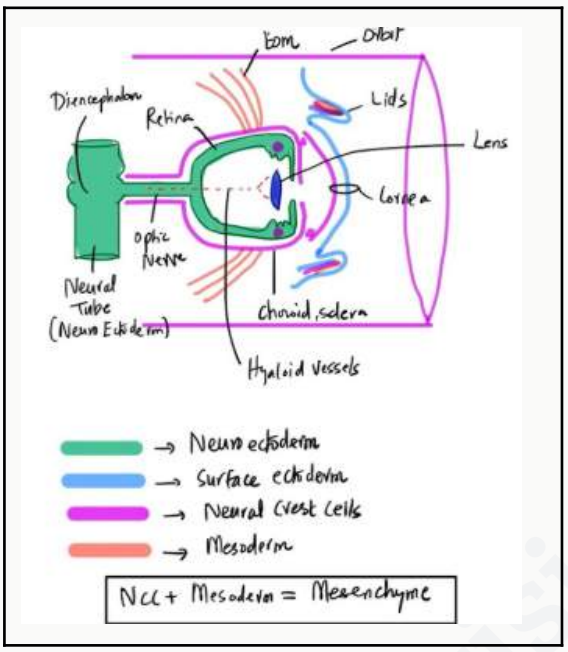
- 6 cranial nerves - II, III, IV, V, VI, VII
- Autonomic nervous system
    - Parasympathetic –through 3rd CN – miosis and ciliary muscle contraction - accommodation
    - Sympathetic –through 5th CN – Mydriasis , Muller's muscle ,Inferior tarsal muscle , sweat glands of eye , aqueous humor secretion

Near triad

- Accomodation
- Convergence
- Miosis

Ocular embryology

- Neuro ectoderm
- Mesoderm
- Surface ectoderm
- Neural crest cell



Neuro ectoderm (ROSES)

- Retina and retinal pigment epithelium
- Optic nerve
- Sphincter and dilator pupillae
- Epithelium of iris and cilliary body
- Secondary viterous

Mesoderm (MESO)

- Muscle (Extraocular muscle)
- Endothelium of all eye and orbital vessel
- Sclera (temporal part), scleral spur
- Ocular vitreous

Surface ectoderm (LEVL)

- Lens
- Epithelium of all eye except cilliary body and iris

- Viterous (primary and tertiary)
- Lacrimal apparatus

Neural crest cell

- Cilliary muscle
- Trabecular meshwork
- Corneal stroma and endothelium
- Melanocytes
- Sheath of optic nerve and tenon capsule
- Adipose tissue
- Cartilage and connective tissue

Embroyogenic structure	Adult structure
Primary viterous	Millendort dot Loqurt's canal Bergmaster papilla
Secondary viterous	Viterous body
Tertiary vitreous	Zonules/ vitreous base
Tunica vaculosa	Persistent pupilary membrane

Physiological and geometrical Optics

Purkinjee- Sanson image

- 1- erect and virtual, anterior cornea
- 2- erect and virtual, posterior cornea
- 3- erect and virtual , anterior lens
- 4- real and inverted, posterior lens
- 1,2 and 3 formed in convex reflecting surface while 4th in concave reflecting surface
- Purkenjee image seen in Keratometry, Hirschberg corneal reflex test is 1st Purknjee image.

Asphericity of cornea - 0.26 Q, prolate shape

Photometry

Deals with effect of radiation on visual system (not power produced= radiometry)

Luminous power: Total light powerproduced by a source, unit = Lumens

Luminous intensity: Light power producedin a solid angle by a point source, unit = Lumens/steradian or candela

Luminance: Luminous intensity per unit projected areaof an extended source, unit = Candelas/square meter or Foot-lamberts

Illuminance: Luminous powerfalling on a surface, unit = Lumens/square meter or Lumens/square foot

Note:
Threshold = 1/Sensitivity
- Low threshold indicates high senistivity

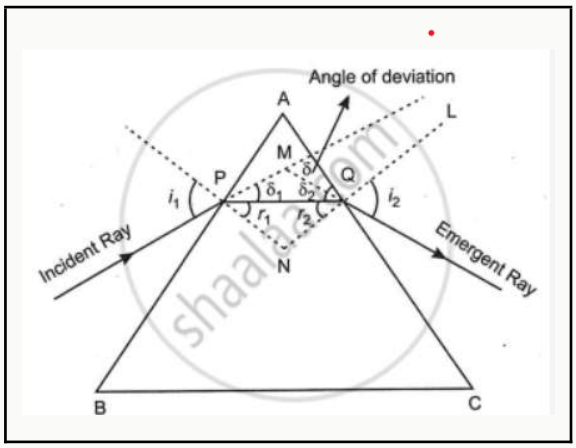
Webers law:

- Defines the relationship between just noticeable difference (JND) and the background on which they persented.
- Increment threshold = Webers constant x Backround illumination

* As backround intensity increases, contrast sensitivity remains constant

UVA- (320-400 nm)
UV B- (280-320nm)
UV C-(220-280 nm)

Prism



Ray of light deviated towards the prism, image towards the apex.

↑ Apical angle, stronger the deviation

Angle of deviation depends upon,

- Refractive index of prism
- Refractive angle of prism
- Angle of incidence of ray

Angle of minimum deviation when, angle of incidence= angle of emergence

1 PD→displacement of 1cm, at distance of 1 m

1 Δ = 0.57° of arc

Use in optical instrument

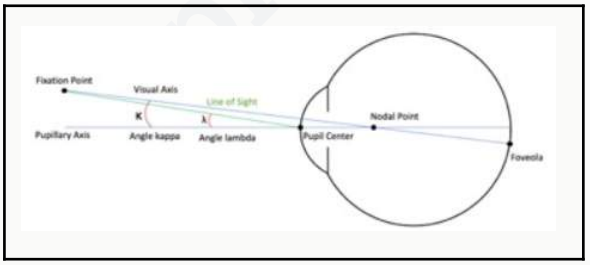
Slit lamp, Keratometer, GAT, Gonioscope

Prentice formula, P = d*D

Where, d= distance from optical center in cm

D= Diopter

Various axes in eye



Angle Kappa (K) at the pupillary axis

Angle Alpha (α) at nodal point

Angle Gamma (ɣ) at centre of rotation

Optical axis

An imaginary line that passes through the center of the pupil and is perpendicular to

the cornea. It's also the line that connects the center of the corneal curvature and the pupil center.

Visual axis
An imaginary line that connects the center of the fovea, the center of the entrance and exit pupil, and the object in space. It's also known as the foveal-fixation axis.

Pupillary axis
A line that's perpendicular to the cornea and passes through the center of the pupil. It's also the line that's found by aligning the first Purkinje image with the center of the pupil.

CPF 450	Reading, TV, glare
CPF 511	Developing cataracts Aphakia and pseudophakia Macular degeneration Corneal dystrophy Optic atrophy Sometimes glaucoma and DR
CPF 527	Same as CPF 511
CPF 550	Intense sensitivity to lighting Poor dark adaptation Retinitis pigmentosa
CPF 550XD	Extraordinary photophobia Aniridia Achromaptosia

X series for normal work
Types of glare

- Discomfort
- Disability

Dominant aberration - coma

Cosmic rays	4*10^25
Electronic rays	2.7*10^25
Gamma rays	6*10^25 - 0.14

X ray	0.14-13.6
UV rays	13.6-397
Visible rays	397-723
Infrared rays	723-1*10^5
Wireless rays	1*10^5- 3*10^13
Electromagnetic oscillation	>3*10^13

Light is dual nature

- Wave nature
    - Reflection of light
    - Refraction of light
    - Propagation of light through vacuum
    - Polarization
    - Interference
    - Diffraction
- Particle nature:
    - Photoelectric
    - Absorption
    - Emission
    - Scattering

Properties of light

- Propagated as electromagnetic wave, does not require medium
- Speed of light-3*10^8 m/s(186,000)miles/s in vaccum
- Transverse in nature, can be polarized
- When passed from a medium to another, velocity and wavelength change, amplitude doesnt, color and frequency doesnt
- (Color determined by frequency)
- Speed of light lesser in medium than in vacuum (denser the medium, lesser the speed of light)
    - Single wavelength- monochromatic
    - White light- heterochromatic

❖ Cornea absorbs ray shorter than 295 nm

❖ Lens blocks rays (350-400)nm

Visual Science

Signal Detection theory

Methods of threshold determination in visual field = Staircase method

JCC is method of force choice method of stimulus detection

Lax Criterion vs. Strict Criterion

1. **Lax**: Indicate a stimulus even with a great deal of uncertainty
    - High: Hits, False Positives
    - Low: Misses, Correct Rejects
2. **Strict**: Do not indicate a stimulus until they are certain one is present
    - High: Misses, Correct Rejects
    - Low: Hits, False Positive

Photoreceptors:

- Produce graded potential but not action potential
- Hyperpolarisation occurs when exposed to light(-70mv)
- Resting membrane potential(-50mv)

Bipolar cells:

- First retinal cell to display spatial antagonism donot produce action potential
- On center biploar cell- glutamate is inhibitatory- reduction in glutamate causes excitation (depolarization) viceversa for off center bipolar cells
- Midget bipolar cells- High spatial resolution(VA); Exhibits color opponency
- Diffuse bipolar cells are non color opponent

Amcarine cells: First neuron to display action potential; role in coding movement

Receptive field of Ganglion cells

- Center-surround organization
- Spatial or lateral antagonism- Light falling on center has opposite effect than light falling on surround
- May be On center or off surround (Light on center cause excitation & viceversa) or Off center and on surround
- Ganglion cells are selective for spatial contrast not diffuse illumination

Horizontal cells: Shows spatial summation

***90 %** of retinal ganglion cells project to dorsal lateral geniculate geniculate nucleus (dLGN) while **10%** to superior colliculus.

Structutral organization dLGN

Dorsal four layers- small neurons-p cells = parvocellular layer (midget cells)

Ventral two layers- large neurons- m cells = magno layer (parsol cells).

Between P and M cells = very small stratified cells- konio cells, manifest bule-yelow color opponency

Layer 2,3,5 receive input from ipsilateral eye and layer 1,4,6 from contralateral eye

Magno system:

- Where system
- Temporal pathway
- Dorsal cortical processing system,
- Represents 90% of foveal ganglion cells
- Small receptive field
- Higher spatial frequency
- Slow conduction velocity
- Sustained response to stimulus
- Represents 90% of foveal ganglion cells
- Alerts events has happened
- Role in motion perception and lacalization in visual space

Parvo system:

- What system
- Dorsal Pathway
- Vental cortical processing system
- Represents 10% of non-foveal ganglion cells
- Large receptive field
- Faster conduction velocity as larger diameter axon
- Detalis of events are analyzed
- Transient response to stimulus
- Role in object identification

Striate cortex

Line of Gennari: distinctive striae of the dense plexus of geniculate axons. Commonly referred to as:

- Primary Visual Cortex
- Visual Area I
- V1
- Broadmann's Area 17

Simple cells

- Most sensitive to an edge or bar of a specific orientation provided it oriented properly in cell's receptive field
- **Stimulus position within receptive field of a simple cell is critical**
- Receptive field-antagonistic, excitatory, inhibitory

Complex cells

- Response best to elongated stimulus of a specific orientation
- **Orientation: Stimulus can be positioned anywhere with in the receptive field**

Extrastriate cortex

- Not distinguished by Line of Gennari
- Extrastriate Cortex Areas Include:
  - Visual Area 2 (V2)
  - Visual Area 4 (V4)
  - Inferotemporal Cortex (IT)
  - Visual Area 5 (V5)
    - Middle Temporal Cortex (MT)

Visual area 4 (V4)

- Role in color perception and responds to complex forms including face
- Ventral processing stream

V5 (Middle temporal cortex)

- Encodes motion
- Dorsal processing stream

Lesion

- Striate Cortex

  - Simple blind spots (scotomas)

- Extrastriate Cortex
  - Ventral Processing Stream
    - Visual Agnosia-inability to recognize objects
    - Prosopagnosia- inability to recognize face (V4) which is accompained by achromatopsia
  - Dorsal Processing Stream
    - Visual Neglect-patient ignores area of visual field

Note :Disparity detectors are found in cortex

X cells linear cells and Y cells are nonlinear cells

Monocular depth cues

- Pictorial
  Size, linear perspective, texture, intrerposition, clarity, lighting and shadow
- Motion parallax
  Near objects move opposite of head movement & viceversa
- Accomodation
- Areial perspective

Binocular Depth cues

- Stereopsis (Corresponding retinal points and retinal disparity)
- Convergence

Three types of electrophysiological tests = EOG, ERG and VEP

In order of increasing voltage= VER/VEP, ERG, EOG

EOG:

- Measures resting or standing potential between cornea and retina
- Retina has negative charge
- Cornea has positive charge
- Depicts RPE function
- Performed in both light and dark adapted states
- EOG has amplitude close to 10mV
- Patient is instructed to move eyes from side to side
- Arden ratio = (Minimum height of light peak/minium height of dark trough) x 100

- An Arden ratio (test of normalcy) of 1.80 or greater is normal, 1.65 to 1.80 is subnormal, and < 1.65 is significantly subnormal
- EOG affected :RP and retinal dystrophies, Vit.A deficiency, RD, toxic neuropathies, Tapetoretinal degeneration, Ocular albinism, Bests disease, Fundus albipunctatus, Cholorquine toxicity

ERG

- Active electrode - Embedded in contact lens placed in patients cornea or gold foil on patients eyelid
  Refrence electrode - Outercanthus
  Ground electrode - patients forehead
- Elicited in light dapted (Photopic) and dark(scotopic) state and usually is biphasic
- **Components**
  -A wave arises from photoreceptors (-ve wave)
  -B wave arises from off bipolar cells and interaction with mullers cells(+ve wave).
  Note: Stimulus should be 555nm wavelength to maximimize size of b wave
  -C wave arises from Metabolic activity of pigment epithelium
  -D wave is rare positive wave arises from on bipolar cells

- **Types**
  - Flash (full field)
  -Focal
  -Multifocal
  -Pattern (represent ganglion cell activity or retinal function & differentiates optic nerve disorders from macular disorder)

VEP/VER

- Small cortical potential generated by visual stimuli on order of 5mv mostly by striate cortex(V2 or geniculate nucleus)
- Depends on the integrity of the visual pathway including eye, optic nerve, optic chiasm, optic tract, optic radiation and cerebral cortex (@cortical function)
- If the VEP is normal, the visual pathways are intact up through at least primary visual cortex
- Electrodes

Occipital lobe (active/positive)
Forehead (reference/negative)
Earlobe/vertex/mastoid (ground/neutral)

Pattern-reversal VEPs

- Best for clinical purpose
- Standard reversal is 2 reversal per second
- The pattern-reversal VEP waveform - 2 negative and one positive wave (N75, P100 and N135 peaks). Amplitude of P100 = peak of N75 to peak of P100.

Pattern onset/offset VEPs

- Best for malingering and nystagmus
- Checkerboard on for 200ms and off for 400ms
- Consists of three main peaks in adults;
- C1(positive,approximately 75 ms), C2 (negative, approximately 125 ms), and C3 (positive, approximately 150 ms)

Flash VEP

- a brief luminance increment, a flash, which subtends a visual field of at least 20 degree.
- Best for poor optics(opaque media), poor cooperation or poor vision
- Assess integrity of macula and visual pathway in infants,aphasic and mentally retarted patients
- Distinguish organic vs psychological blindness

*Amblyopia affects the cortex, not the retina.Consequently, the VEP is abnormal, and the PERG is normal

Diagnostic interpretation

	VEP	EOG	Standard ERG	PERG
RP	Abnormal	Abnormal	Abnormal	Abnormal
Amblyopia	Abnormal	Normal	Normal	Normal
Malingering	Normal	Normal	Normal	Normal
Macular disease	Abnormal	Normal	Normal	Reduced
Optic nerve disease	Abnormal	Normal	Normal	Abnormal
Generalized tapetoretinal degeneration	Abnormal	Abnormal	Abnormal	Abnormal

.

Key Visual milestones

- Pupillary reaction - 29 weeks of gestation
- Blinks to light- Birth
- VOR and OKN *seen*- 1 week
- Small saccades develop- 2 weeks
- Accomodation *occur*- 1 months
- Fixation *well develop* and bifoveal fixation;smiles at parents - 2 months

- Sensory fusion and accomodation *begins* to develop;search for objects - 4 months
- Meance reflex- 5months
- Fusional vergence and accomodation well develop, stereopsis begins to develop; *Peak CSF* in adult location- 6 months
- Ability to match colors- 2 years
- Stereopsis well develop- 5 years

Critical period is cosidered over with in 7 to 9 years of age

Color vision

- ☐ Red (protan)- 549-570 nm
- ☐ Green (deutrian)- 522-539 nm
- ☐ Blue (tritan)- 414-424 nm

Classification of colour vision deficiency:

Trichromatism – all 3 types of cones present

Anomalous trichromatism – one colour reduced sensitivity

- ❖ Protanomaly - red color weakness
- ❖ Deuteranomaly - green colour weakness
- ❖ Tritanomaly -blue color weakness

Dichromatism - 2 cones present

Anopia- absent

- Protanopia – Red cones absent-Red col blindness
- Deuteranopia - Green cones absent-Green color blindness
- Tritanopia - Blue cones absent-Blue color blindness

Monochromatism: complete color blindness in which all colors appear as shades of gray.

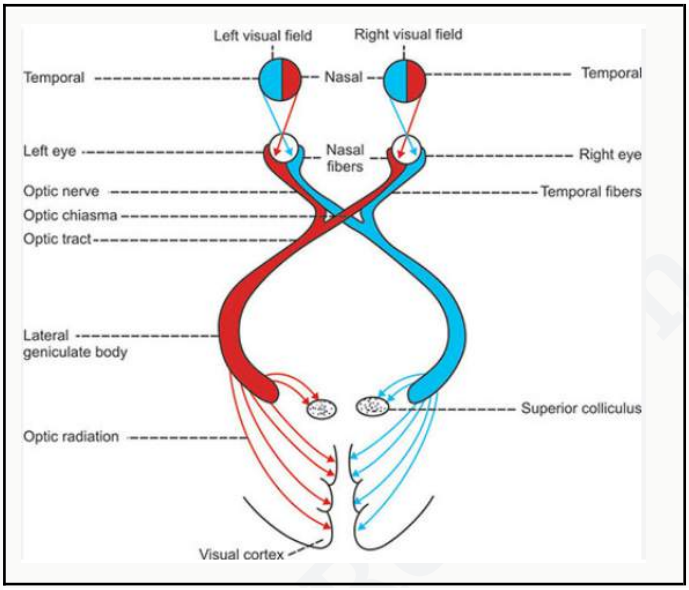
Normal Monochromats

Tests for color blindness:

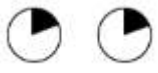
- Ishihara Chart
- FM 100 Hue Test
- NAGEL'S ANOMALOSCOPE

Visual Pathway

- Optic disc – beginning of optic nerve, called the optic nerve head(ONH)
- Optic nerve – axons of retinal ganglion cells form optic nerve
- Optic Chiasma - X shaped structure where the optic nerves cross over
- Optic Tract - continuation of the optic nerve, carrying information from chiasma to LGB
- Lateral Geniculate Body – pyramidal structure, great relay center of the retinal ganglion cells where 90% of visual bers end
- Optic radiations -fbers carry information from the LGB to the visual cortex, pass through internal capsule- two components –
    - Meyer's loop – passing through temporal lobe
    - Baum's loop – passing through parietal lobe
- Occipital lobe - Primary visual cortex, around the calcarine sulcus, V1



Summary of visual field defect

Site of lesion	Visual field defect	
Optic Nerve:	Same sided, monocular blindness	
Optic Chiasma:	Bitemporal hemianopia	
Optic tract:	Opposite sided Homonymous hemianopia	
LGB:	Rarely seen	
Optic Radiations: Meyer's loop:	Pie in the Sky	

Occipital lobe:	Macular Sparing	

Temporal vision

- Time related vision; changes in luminance over time
- Closely realted to motion perception
- Visibility of a temporally modulated stimulus is related to its depth of modulation,
  % modulation= (Amplitude of modulation/ Time averaged luminance) x 100
- Light modulated at greater modulation apperas flickering and viceversa

Critical Flicker Fusion Frequency (CFF)

- Highest or lowest temporal frequency that <u>can not be resolved</u> at given % resolution (if not specified, typically refers to high frequency CFF)
- <u><4Hz and > 10Hz are not resolved</u>

Ferry-Porter law

High frequency CFF increases approximately lineraly with log of retinal illumionation.

Granit Harper law

CFF increases with log of stimulus area

<u>Broca-Sulzer Effect</u>:

Suprathreshold flashes of light with a duration on the order of 50 to 100 ms appear brighter than stimuli of either shorter or longer durations.

<u>Brücke–Bartley Effect</u>

A flickering light of approximately 10 Hz appears brighter than a steady light of the same average luminance.

Talbot–Plateau Law

- A temporally modulated stimulus that is fused, is equal to brightness of a steady light with same time-averaged luminance.

- temporally modulated stimulus must be presented at a rate beyond CFF

Bloch's Law

There is total temporal summation within critical duration as long as the threshold number of quanta arenot delivered with in this period

Spatial vision

Ability to detect variations in luminance (brightness) across space, allowing to perceive border, edge and lines of object

Sine Wave Gratings
Bright to dark bars, with gradual (sinusoidal) transition, not an abrupt transition

Square Wave
- Abrut changes in luminance
- Primary Sine-wave + infinte odd harmonics (low contast sine waves)

Spatial Modulation Transfer Function

- Tells how well an optical lens tranfers information
- At low and moderate saptial frequency, good optical image transfer
- At high frequency, image more degraded

High frequency cut off: 60 cycles/degree

Nyquist theorem: Each photoreceptors sums the light that falls on it. Higher denisty will resolve more detail

Low frequency Drop off: Due to lateral inhibition or spatial antagonism

Contrast Sensitivity Function: Peaks at 4 cycles/degree

Contrast = Lmax- Lmin/ Lmax + Lmin, where L= luminance
***** Threshold contrast under photopic conditions is close to 0.010

Light and Dark Adaptation

Rhodopsin
- A molecule absorb one quanat of light (bleached=cannot capture quanta)
- In 5 minutes 50 % become unbleached spontaenously
- Most readily absorb 507 nm

Cones

- In 1.5 minutes 50 % of cone unbleach (more rapid than rods)
- Ratio of L-M-S cones= 16/8/1

Scotopic System: Stimuli of 507 nm are pereived brighter

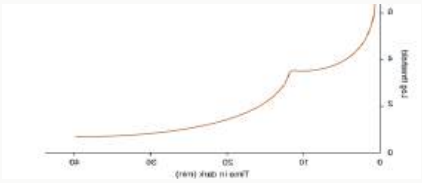
Photopic System: Stimuli of 555 nm are pereived brighter

Purkinge Shift : Difference in peak senisitivites of photopic and scoptopic system

Photochromatic interval: The difference in sensitivity between scotopic and photopic systems,for a given wavelength

Dark adaptation Curve

- For 420 nm, Section 1 Cone threshold (5 min) followed cone rod break (10 min) and then section 2 Rod threshold (upto 35 minutes)
  **650 nm only one curve*

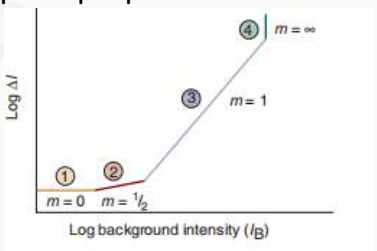


- Factors affecting- intensity and duration of preadaptaion light, size and poistion of retina used, wavelenght distribution and rhodopsin regeneration

*Bleaching rhodopsin by 1% raises threshold by 10 or decreases sensitivity by 10.

Light adapation curve

- 5 section;section 1-4 represent scotopic portion while section 5 represents photopic portion



Entoptic Phenomenon

Causes

1. Refractive Effects

- Tear film
- Corneal corrugation

2. Diffraction Effects

- Corneal haloes
- Corneal corona
- Ciliary corona (spread of light around isolated source)
- Asterism

3. Shadows

- Ocular opacities
- Purkinje tree
- Blue field Entoptoscope

* If opacity is same size as pupil and close to retina, then only a shadow will be casted.
*Opacity behid exit pupil against motion and viceversa (Parallax)

4.Xanthophyll Effects

- Maxwell's spot (use to tag where patient is fixatinf in vision therapy)
- Haidinger's brush (due to birefrignce induced by xanthophyll)
  *Haidingers brush is absent or less in macular edema

5.Pressure Phosphenes (only viewed in dark as weak stimuli)

- Digital Pressure
- Eye Movement
- Moore's Lightning
- Streaks

6.Electrical Phosphenes

- Battery stimulation
- Blue arcs of the retina

Emsley-Fincham test

- Move stenopaeic slit across pupil
- Lenticular haloes changes in shape and brightness
- Corneal haloes reduce in brightness

Note: Primary circadian clock in mammal is located in suprachiasmatic nucleus located in thalamus

Diagnostic and investigative Optometry

Visual field

AVF

Principle DLS (Differential light Sensitivity)

Higher db = lower intensity = high retinal sensitivity

Lower db= higher intensity = lower retinal sensitivity

0 db =	10,000 asb
10 db=	1000 asb
20 db=	100 db
40 db=	1 asb
50 db=	0.1 asb

- 10-2 :
  - Measures 10° temporally and nasally
  - Test 68 points
  - point density 2 degree, bare area 1 degree
  - Used for macula, retina and neuro ophthalmic conditions and advanced glaucoma
- 24-2
  - 24° temporally and 30° nasally
  - Test 54 points
  - point density(resolution) 6 degree; bare area 3 degree
  - Neuro ophthalmic, general screening and early detection of glaucoma
- 30-2
  - 30° temporally and nasally
  - 76 points
  - point density 6 degree; bare area 3 degree

Standard size- Goldmann size III (however, range I-V)

Background illumination 31.5 asb(Humphrey 700) vs 31.4 asb (Octopus 300)

Test strategy- 4-2-1 db bracketing (Octopus 300) vs 4-2 db bracketing (Humphrey 700)

Constricted pupil (<2mm) can give diffuse visual field defects and edge scotomas

Fixation loss >20% are considered unreliable test (tested by Heijl Krakau method)

* During test 5% of stimuli is presented on blind spot

False positive up to 15 % is acceptable

False negative up to 20 % is acceptable

Total deviation plot

The numeric value of threshold (raw data) is compared with the age matched normative data and the difference in value at each points

Generalized defect is more prominent

Pattern deviation

Gives the total deviation plot after correcting it for the generalized field defect

Localized defect is more porminent

Mean deviation between +/- 2 db is normal (in global indices)

PSD less than 6 is normal

5 results of glaucoma hemifeild test: outside, borderline, with in normal limits, general reduction in sensitivity and abnormally high sensitivity

Andreson and patellas Criteria diagnostic of glaucoma feild

1. Cluster of 3 or more points on pattern deviation plot abnormal at P < 5% level, at least one at the P < 1% level in an expected area of the visual field

2. Pattern standard deviation abnormal at P < 5% level.

3. GHT outside normal limits.

Progression

Deepening of an existing scotoma = reproducible depression of a point in an existing scotoma by >or=7 db (Reproducible)

Enlargement of an existing scotoma = depression of a point adjacent to an existing scotoma by > or =9 db (Reproducible)

Development of a new scotoma = depression of a previously normal point in the visual field by > or=11 db, or of 2 adjacent, previously normal points by > or =5db (Reproducible)

Short wave length perimetry (SWAP)

Selectively tests the B-Y ganglion cells that project to the koniocellular layers of the LGN.

SWAP is mostly being used currently to test patients who have suspicious optic discs but normal V.F

'**Clover leaf pattern**' is due to fatigue effect

Amsler grid

It measures 20° of visual field centred on fixation

Charts

There are seven charts, each consisting of a 10-cm outer square

- Chart 1:
    - White on black background
    - 400 smaller 5 mm square
    - Viewed at ⅓ meter, substends 1°
- Chart 2:
    - Similar to chart 1 with a diagonal line for patient with central scotoma.
- Chart 3:
    - Is identical to chart 1 but has red squares.
    - Used to detect subtle colour scotomas and desaturation in toxic maculopathy, optic neuropathy and chiasmal lesions.
- Chart 4:
    - Consists only of random dots
    - Used mainly to distinguish scotomas from metamorphopsia,
- Chart 5:
    - Consists of horizontal lines and is designed to detect metamorphopsia along specific meridians.
    - Especially for patient complaining of difficulty in reading.
- Chart 6:
    - Similar to chart 5 but has a white background and the central lines are closer together, enabling more detailed evaluation.
- Chart 7:
    - Fine central grid
    - Each square subtending an angle of a half °
    - Is more sensitive.

Light brightness comparison test

- This is a test of optic nerve function.
- A light from an indirect ophthalmoscope is shone first into the normal eye and then the eye with suspected disease.
- The patient is asked whether the light is symmetrically bright in both eyes.

- In optic neuropathy the patient will report that the light is less bright in the affected eye.
- It takes about 5 min to adapt from darkness to bright sunlight and 20-30 min from bright sunlight to darkness

Goldmann tonometry

It is based on Imbert Flick principle. It states that

- the pressure inside the sphere (P) equals the force necessary to flatten its surface (F) divided by the area of flattening (A) (i.e. P = F/A).
- IOP∝ pressure applied to the globe (i.e. cornea) and thickness of wall (i.e. thickness of the cornea) which is variable
- However, cornea is rigid and resists flattening and capillary meniscus of tear film attracts cornea towards tonometer.
- Corneal rigidity and capillary attraction cancel each other out when the flattened area has a diameter of 3.06 mm, as in Goldmann tonometry

❖ Mire thickness is around 10% of the diameter of it's arc.
❖ Inner margin of semi circle aligns when circular area of diameter is 3.06 mm flattened.
❖ Goldmann applanation tonometer assumes that CCT is 520 um with minimal normal variation
  ➢ Thinner CCT- underestimation
  ➢ Thicker CCT- over estimation
  ➢ Corneal edema - decreased IOP, boogy softening
  ➢ Astigmatism- over 3D , prism rotated 90°

Gonioscope

Evaluating the angle of the anterior chamber

Principle:

- Angle of the anterior chamber is not visible because light from the angle undergoes total internal reflection.
- <u>The critical angle for the tear film-air interface is 46°.</u>
- <u>Because the refractive index of a goniolens is similar to that of the cornea, it eliminates total internal reflection</u> by replacing the tear film–air interface with a tear film–goniolens interface.

Indirect goniolens

- Non indentation
  - Goldmann 3 mirror
- Indentation

- Zeiss, Posner, Seissman

Direct goniolens

- Koepee
- Barkan
- Swan Jacob

Ultrasonography

Ultrasound waves are acoustic waves with, frequencies greater than 26 kHz.
Acoustic wave- generated by vibration of piezoelectric crystal in the probe

Relationship between frequency and wavelength

1. Higher the frequency - shorter wavelength- less depth penetration (useful for ophthalmic ultrasound)
2. Lower frequency- greater wavelength- greater depth penetration (useful for abdominal ultrasound)

Probe orientation

- Axial scan - directly centre of the cornea.
- Transverse scan- parallel to the limbus
- Longitudinal scan- perpendicular to the limbus

Quantitative B scan

- Reflectivity
- Internal structure
- Attenuation

- ❖ Reflectivity: This is evaluated by observing the spike height on the A-scan vector overlay and signal brightness on the B scan. The normal ocular structure causing the highest reflectivity is the sclera.
- ❖ The probe should be placed on the globe opposite to the area to be examined.
- ❖ To evaluate superior and inferior fundus, the marker is directed towards the nose.
- ❖ To evaluate nasal and temporal fundus, the marker is directed in 12 o clock meridian.

Topography

Classification

- Topography(anterior cornea)
  - Placido disc

- Tomography(anterior and posterior cornea)
    - Slit scanning system
    - Scheimflug imaging(Pentacam, Sirius)

Topography maps

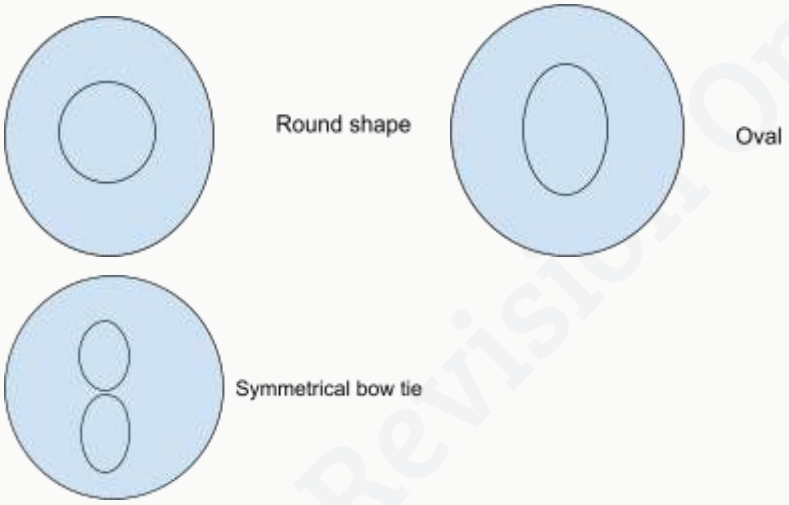
- Axial map/saggital map
- Elevation map (anterior)
- Elevation map (posterior)
- Pachymetry map

❖ Axial map/ anterior sagittal map- depicts the curvature of the anterior corneal surface in dioptric value for each point.

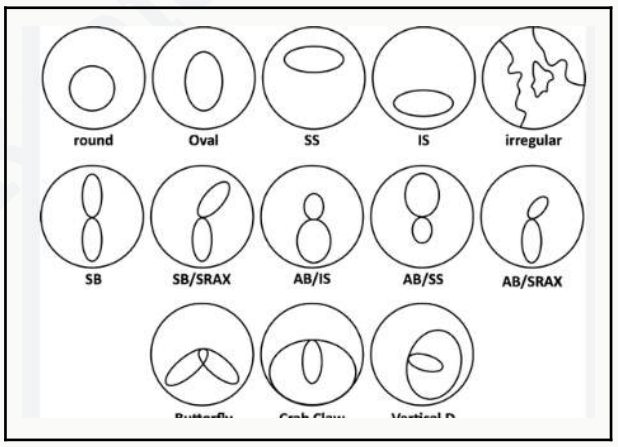
Type of shape of axial map

➔ Symmetrical shape

- ◆ If K max > 50D- high risk
- ◆ IF kmax>47 D - moderate risk



2. Asymmetrical shapes



<u>Superior- Inferior difference >1.50 → high risk of ectasia</u>

Skewed SRAS >22°→ high risk of ectasia

Biometry

A constants

Acording to IOL position

1. Capsular bag (A = 118.0): IOL
2. Scleral fixated IOL (A= 118.50); IOL+ 0.50D
3. PCIOL in Sulcus (A= 117.0): IOL- 1.00D
4. ACIOL (A=115.0): IOL= -3.00D
5. Silicone Oil : Normal mode Axl *0.74
6. High myopia : IOL +2.50D
7. Child upto 2 years: Undercorrected by 20% (0.8* measured IOL)
8. Child 2-8 years : Undercorrected 10*(0.9* measured IOL)

Range of axial length and preferred formula

Axial length	Formula
<20 mm	Holladay II
20-22 mm	Hoffer Q
22-24.5 mm	SRK/T; Hoffer Q; Holladay
>24.5-26 mm	Holladay I
>26 mm	SRK/T
Myopic LASIK	Hagis L
Piggy back	Holladay's Refractive formula

Opthalmoscope

- Direct opthalmoscope- virtual,erect,magnified, magnification- 15X, FOC- 5
- Indirect opthalmoscope- real, inverted, magnified, magnification- 3-5X,FOV- 30-45

Field of vision

- ∝ size of pupil of observed eye
- ∝ axial length of observed ye
- 1/∝ distance between observer and observed eye
- Smaller the sight hole of the opthalmoscope better the view

OCT

Based on prinicipal of low coherence interferometry

Outer retinal layers appear hyper-reflective

- ELM, Elliopsoid zone, Interdigitation zone, RPE/Bruchs membrane complex

Inner retinal layers appear as hyper (ILM, NFL,plexiform layers) and hypo(cellular or nuclear layer)

High reflective structures – Hard exudates, Cotton wool spots, neovascularization, Microaneursm

Low reflective strucures: Cysts, Diffuse intra retinal edema, Exudative detachment, intraretinal cavities

OCT at 1310nm wavelength is better for anterior segment

Oct evaluation of retina- use IR of 800 nm wavelength

Swept source oct better resolution than time domain

Specular microscopy

Diagnostic modality for imaging corneal endothelium

endothelial cells refractive index greater than 1.336 value for the aqueous humor, and hence can be imaged

aqueous interface reflects 0.022% of the projected light

Co-efficient of variation (CV) : Measure of polymegathism; less than 33 % is considered normal.

CV= SD cells area/Mean cell area

HEX or 6A : Measure of Pleomorphism; greater than 50 % is considered abnormal

* The minimum donor ECD is established for keratoplasty, for most eye banks is at 2000 cells/mm^2

GVF

Target size diameter and area

GOLDMANN STIMULUS SIZE	DIAMETER (in mm)	AREA (in mm²)
0	0.28	1/16
I	0.56	¼
II	1.13	1
III	2.26	4
IV	4.51	16
V	9.03	64

*Rule of thumb: 2 fold increase in diameter and 4 fold in area in each step

1, 2, 3, 4 settings represent 0.5 log unit changes

a, b, c, d and e settings represent 0.1 log unit changes

Background luminance of the bowl is **31.5 asb**

Move at a rate of 5 degrees per second inside

Present kinetically every 15 degrees interval

Target equivalence

Targets sharing the same letter designation are supposed to be equally visible if the sum of their Roman and Arabic numerals is the same.

Eg.IV2e(4+2=6) and III3e(3+3=6)

I2e (or I4e) is used for blind spot plotting

Color coding of isopters

- I-2e Blue
- I-3e Orange
- I-4e Red
- II-4e Green
- III-4e Purple
- IV-4e Brown
- V-4e Black

***Subjective refraction in astigmatism**

- *Testing without Fog: JCC*
- Testing under Fog: Clock dial, Sunburst, Rotatorary T, Astigmatic fan and Block, Stenopaeic Slit

Lensometer

Measures both back and front vetrex power as well as amount of prism (usually back)

When applied to lensmeters, Knapp's law is calledè the **Badal principle** "size of the retinal image does not change when the **center of the correcting lens** coincides with anterior focal point of eye"

Green light is used to eliminate chromatic aberration in lensometer

Keplerian telescope in lensometer

Amount of target movement

$$x_s = f_s^2 F_V$$

x_s = amount of target movement

f_s = primary focal length of the standard lens

F_V = power of the lens measured

Autorefractometer :Double pinhole apertures (Scheiner disc)

: Uses IR light

: refraction 0.75 to 1.5 D more hypermetropic as IR

Keratometry

Principle dobling principle

Types of keratometer: One position (Fixed object size and variable image e.g B&L) vs two positions (viceversa e.g Javel Schiotz)

Extended Keratometry

Normal range of keratometer is 36 to 52 D

K reading very high +1.25D lens is placed over eye piece, increases K reading by 9D or multiply by 1.185

K reading small -1.00D trail lens is placed over eye piece, decrease power by 6D or multiply K reading by 0.840 D

Types of keratometer: One position (Fixed object size and variable image e.g B&L) vs two postion (viceversa e.g Javel Schiotz)

Dynamic retinoscopy

Performed at near

accommodative response > stimulus [accommodative lead]

accommodative response < stimulus [accommodative lag]

Accommodative lag = accommodative demand (+2.50D at 40cm) – accommodative response

Normal lag : + 0.50 or + 0.75 diopters

High Lag : + 1.00 diopters or higher

Lead : + 0. 25 diopters or less

Types

1. Cross Method
2. Sheard's Method
3. Tait 's Method
4. Nott's Method
5. Low neutral and high neutral methods
6. Bell Retinoscopy
7. MEM Retinoscopy

* Just look retinoscope is new method

FFA

Principle: Absorbs light energy from a lower wavelength and emits at a higher wavelength with fluorescence properties

Excitation peak = 490nm (blue part of spectrum)

Emission peak = 530nm (green-yellow part of spectrum)

Five angiographic phases:

- Pre arterial (choroidal 9-15 seconds)
- Arterial
- Arteriovenous(capillary)
- Venous

- Recirculation

Dye injected in the forearm or anticubital vein

Abnormal Findings

⚫ **Hypofluorescence:**

Filling defect

Blocking defect

⚫ **Hyperfluorescence :**

window defect

Leakage

Pooling

Staining

Causes of hypofluorecene: Vascular occulusion (Capillary non-perfusion) and Loss of Vasculature (Choroideremia or high myopia)

Causes of hyperfluorecene: Leakage of dye(CME,CNVM) and Prolong dye rententation(associated with drusen)

Peadiatric Optometry and Binocular vision

Visual acuity assessment

Infants

1. Fixation (CSM)
2. Menace reflex
    1. Brukner's reflex
    2. OKN
    3. Catford drum(OKN)
    4. PLT
    5. Teller's acuity
    6. Lea Grating
    7. VEP

1-2 1. Worth's Ivory Ball test
2. Boek candy test

2-3 1. Cardiff acuity test
2.Minature toy test
3. Coin test
4. Lea symbol

3-5 1. Allen picture test
2. Sheridan letter
3. HOTV
4. Tumbling E
5. Sjogren's hand test
6.Landlot broken ring
7. Snellen chart

Visual Development Milestone

Age	Visual milestone
0-2 months	Pupillary response Sporadic fix and follow Jerky saccadic eye movement Alignment - Exo common, eso -rare

2-6 months	Central fix and follow Accurate binocular smooth pursuit Smooth pursuit asymmetry Temporal to nasal better than nasal to temporal Alignment- orthotropia with few exo, eso rare
6 months- 2 years	Central fixation and follow Accurate and smooth pursuit Alignment- orthophoria
3-5	Visual acuity - 20/40 and not more than 2 line diffrence
>5 years	Visual Acuity 20/30 and not more than 2 line difference

Reduced contrasensitivity while normal visual acuity

- Amblyopia
- Optic neuropathy
- Some cataract
- Higher order abberation

Strabismus

Angle kappa : temporally displaced fovea

Positive angle kappa (exotropic appearance)

ROP, Toxocara canthi

Negative angle kappa: nasally displaced fovea (fovea)

Vertically rectus muscle functions :

Superior Rectus:

- At 23 ° only elevator
- At 67 ° only depressor

Inferior Rectus :

- At 23 ° abduction- only depressor
- At 67 ° adduction - only extrusion

Oblique muscle

Superior oblique :

- 51 ° adduction - only depression
- 39 ° abduction - only intorsion

Inferior oblique -

- 51 ° adduction - only elevation
- 39 ° abduction - only extorsion

Convergence

1. Tonic convergence- innervational tone to medial recti
2. Proximal convergence- induced by psychological awareness of near awareness
3. Fusional convergence - optomotor reflex that maintains BSV initiated by bitemporal retinal image disparity.
4. Accomodative convergence - AC/ A ratio

   Sykinetic near reflex

   1 diopter accommodation= 3-5 diopter convergence

Synergist - muscle of same eye that act to move the eye in same direction

__Synergist= same eye

Yoke muscle- paired agonist muscle from each eye.

Sherington law:

Increased innervation to an EOM is accompanied by reciprocal decreased innervationnto it's antagonist. (Duane's retraction doesn't follow it)

Hering's law:
equal innervation to the yoke muscle
Primary vs secondary deviation

- In paretic deviation, secondary deviation > primary deviation

Muscle sequele

1. Primary underaction
2. Secondary overaction of Yoke muscle
3. Secondary overaction of ipsilateral antagonist
4. Secondary inhibition of contralateral (anti- Yoke muscle) antagonist

Retinomotor values - 0 at fovea, increased progressively towards periphery.
Panum's fusional area- 6 seconds of arc at fixation, 30-40 seconds of arc at 15 ° from fovea

Steropsis
1 ° = 60 min of arc
1 min= 60 sec of arc

Titmus fly test : 3000 sec of arc
Animal: 400-100 sec of arc
Circles: 800-40 sec of arc

TNO : (480-15) sec of arc at 40 cm
Frisby: disparity created by thickness of the plate (600-15 sec of arc)
Lang test : 1200-200 sec of arc

#Diplopia testing
Most dissociating
Maddox rod
Dark red filter
WFDT- room lights out
WFDT - room lights on
Bagolini - (least disociating)

Red light

- Straight eyes/NRC- one pink light
- ARC with strabismus - one pink light
- Strabismus with suppression- one light red/green

- Esotropia - uncrossed diplipia
- Exotropia - crossed diplopia

Vertical Red prism

- In ARC , red light over white light
- In NRC, two red lights horizontally and vertically displaced.

WFDT

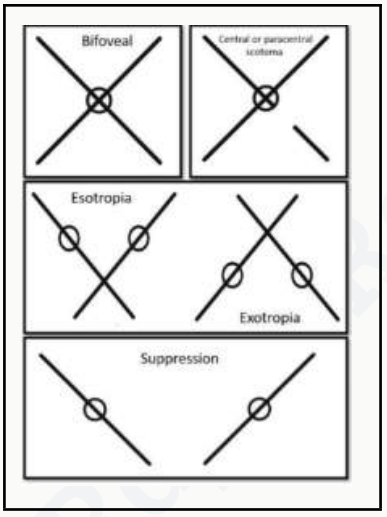
- Similar to red light
- Distance WFDT-1.25 ° (monofixator cannot appreciate because of central supression)
- Near WFDT : 6 ° (monofixator appreciate because of peripheral fusion)

(monofixation- central scotoma (<5 °) and peripheral fusion

Bagolini test:

The **Bagolini test** is a clinical test used to assess **binocular vision** and detect subtle forms of **strabismus** or suppression.

It employs **Bagolini striated glasses**, which have fine parallel lines etched onto their lenses



Cycloplegia :

	Strength	Mydriasis maximum (min)	Mydraisis Recovery (min)	Cycloplegia max	Cycloplegia (recovery)
Phenylephrine	2.5%	20	2-3 hrs	none	none

Tropicamide	0.5%, 1%	20-30	2-6 hrs	30	2-6 hrs
Cyclopentolate	0.5,1%	30-60	6-12 hrs	52-75	6-12
Homatropine	2.5%	40-90	1-3 days	30-60	1-3 day
Atropine	0.5%,1%	30-60	7-14	60-180	3-12

Prescribing guidelines

- Hypermetropia -
    - Upto 4D - shouldnot be corrected in child without squint unless they are experiencing near vision problem
    - More than 4D - 2/3rd correction is given
    - In esotropia - full cycloplegic correction even under the age of two years
- Myopia-
    - Under 2 years of age- -5.00D or more should be corrected
    - Between 2-4 years of age- -3.00D or more should be corrected
    - Older children- even low myopia should be corrected
- Anisometropia-
    - After 3 years full difference between refraction should be prescribed if it is more than 1 D

Smooth pursuit :

- Generated in occipito parietal temporal cortex
- Ipsilateral control
- First occurring ar 4-6 week
- Velocity upto 30 °/s

Saccade:

- Present at 1 week of birth
- Frontal lobe, contralateral control
- Velocity upto 200-700 °/s (1000°/s)
- Only rectus can generate saccade

Red reflex test

- Cataract - may block red reflex and appear white
- Vitreous hemmorhage - blocks red reflex (dark or dull reflex)
- Retinoblastoma - yellow or white (leukocoria)
- Anisometropia- unequal red reflex
- Strabismus- brighter reflex in deviated eye

Screening eye examination

- I - Inspection
- A- Acuity
- R- Red reflex
- M- Motility

Deviation

	Corneal light reflex	cover/ uncover	Alternate cover	Fusion
Orthotropia	Straight	No shift	No shift	Yes
Phoria	Straight	No shift	Shift	Yes
Tropia	Deviation	Shift	Shift	yes
Monofixation	Small deviation	Small shift	Large shift	Yes

*AC/A ratio:

Heterophoria: AC/A= IPD+ (N-D)/DA

Lens Gradient: AC/A = (Deviation with out lens- Deviation with lens)/ lens in diopter

*Paresis vs Restriction

Paresis

- No saccade generation
- Slow eye movement compared to fellow eye
- Active force generation- relative weakness
- Lid fissure widening and proptosis

Restriction

- Forced duction test- dog on leash eye movement
- Normal saccadic movement, until reachesrestriction and stops abruptly
- eye ball retraction and lid fissure narrowing
- Increased IOP on attempted movement towards restriction

After image test

- ARC eso- crossed (opposite side)
- ARC exo - uncrossed (same side)

Esodeviation

*Congenital Infantile esotropia : #need correction

Associated abnormalities

- IO overaction
- Latent nystagmus
- DVD
- Smooth pursuit asymmetry

*Ciancia syndrome

- Large angle deviation(>60PD)
- Bilateral limited abduction with intact adduction
- Fixing eye in adduction
- Nystagmus in attempted abduction
- Face turn to the side of fixing eye

*Accomodative esotropia

That resolves on giving cycloplegic hypermetropic correction

High AC/A ratio esotropia:

- Larger esotropia at near (<10PD) from distance
- Near add to correct near deviation and promote fusion
- Exucutive bifocal preferred

Partially accomodative esotropia:

- With full hypermetropic correction, a reisual esotropia(>10PD) for distance and near exist.

*Acquire non accomodative esotropia

- Rule out possibility of intracranial tumor, AR malfunction and myasthenia gravis
- A divergence paralysis with a larger esotropia in distance than near - red flag for 6th nerve paresis and neurological disorder

*Manifest Latent Nystagmus

*Congenital nystagmus with constant esotropia

*Nystagmus compensation syndrome

- Use accomodative convergence to damp nystagmus producing esotropia (only at near) with pupillary miosis

#Exotropia

*Intermittent exotropia

- Excellent bifoveal fusion
- Steroacuity 40-50 sec of arc perfectly aligned in phoric phase

Classification

1. Basic - distance deviation is within 10 PD of near deviation

2. Pseudo divergence excess
   -larger distance deviation than near deviation
   - masked by tonic fusional convergence
   -dissiciapates slowly after monocular occlusion

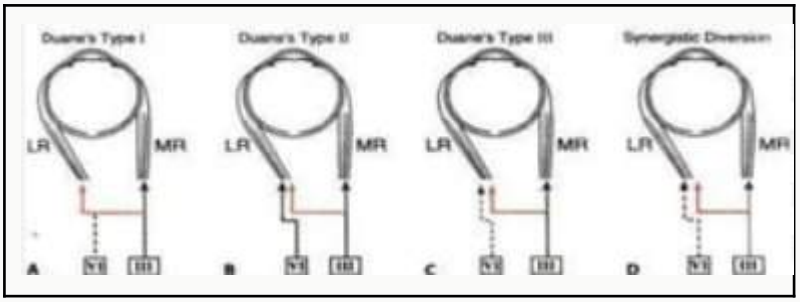
3. True divergence excess-
   - Distance deviation greater than near deviation by more than 10PD after patching also
   - High AC/A ratio

Alphabet pattern
V pattern
- IO overaction with exotropia
- SO palsy with esotropia
- Brown syndrome
- SR underaction

A pattern
- IO palsy with esotropia
- SO overaction with exotropia
- IR underaction

DVD
- Tendency for an eye to elevate , abduct and extort when binocularly is suspended by occlusion or patient spontaneously dissociates.
- Isolates Hering's law of Yoke muscle
- Increased with head tilt, Right head tilt increases right DVD and left head tilt increases left DVD
- Have some ° of binocularity , sometimes high grade steroacuity

Duane's retention syndrome:
Agenesis of 6th nerve nucleus with inferior division of oculomotor nerve splitting to innervate both MR and LR
Fire and contract simultaneously on attempted adduction



Huber classification of DRS

Type 1

- Poor abduction, good adduction , sometimes eso in primary gaze.
- Limited abduction
- Reteraction of globe on attempted adduction.
- Compensatory head posture towards Duane's eye

Type 2

- Limitation or absence of adduction
- Exotropia

Type 3

- Poor adduction and abduction
- Exo appearence on primary position sometimes

*Blowout fracture:

- Diplopia secondary to restricted vertical eye movement
- Enopthalmos and numbness of the face below the traumatized orbit along with upper teeth

*Mobius syndrome:

- Esotropia
- Limited abduction'Lack of facial expression
- Difficulty feeding because of pooe sucking
- Combination of facial nerve plasy and 3rd nerve palsy, distal limb abnormalities
- Cause: prenatal exposure to misoprotol>

*Congenital fibrosis of EOM:

- Bilateral ptosis and restrictive external ophthalmoplegiea.
- Hypoplastic superior division of ophthalmic nerve.
- Inability to elevate the eye above the horizontal plane.

*Myopic strabismus fixus:

- Large angle esotropia with limited abduction and hypotropia in myopia
- Restrictive adduction and limited elevation due to inferior displacement if LR and mild nasal displacement of SR

*Monocular elevation deficit:

- Inability of one ye to elevate across horizontal plane from abduction to adduction

#Causes of uniocular diplopia:

- Subluxated clear lens
- Subluxated IOL
- Keratoconus
- Double pupil
- Incipient cataract

Morgan's Table of Expected findings

Test	Expected Finding	Standard Deviation
Distance lateral phoria	1 exophoria	±2 Δ
Near lateral phoria	3 exophoria	±3 Δ
AC/A ratio	4:1	±2 Δ
Base-out (distance)	Blur:9 Break: 19 Recovery: 10	±4 Δ ±8 Δ ±4 Δ
Base-in (distance)	Break: 7 Recovery: 4	±3 Δ ±2 Δ
Base-out (near)	Blur: 17 Break: 21 Recovery: 11	±5 Δ ±6 Δ ±7 Δ
Base-in (near)	Blur: 13 Break: 21 Recovery: 13	±4 Δ ±4 Δ ±5 Δ
Amplitude of accommodation Push-up	18 – 1/3 age	±2.00 D
Fused cross-cylinder	+0.50	±0.50 D
Negative relative accommodation	+2.00	±0.50 D
Positive relative accommodation	−2.37	±1.00 D

TESTS EVALUATING POSITIVE FUSIONAL VERGENCE

- Positive fusional vergence (PFV)—smooth vergence testing
- PFV—step vergence testing
- PFV—vergence facility testing
- NRA
- Binocular accommodative facility with plus lenses
- Near point of convergence
- MEM retinoscopy and fused cross-cylinder

TESTS EVALUATING NEGATIVE FUSIONAL VERGENCE

- Negative fusional vergence (NFV)—smooth vergence testing
- NFV—step vergence testing
- NFV—vergence facility testing
- PRA· Binocular accommodative facility with minus lenses
- MEM retinoscopy and fused cross-cylinder

TESTS EVALUATING THE ACCOMMODATIVE SYSTEM

- Monocular accommodative amplitude
- Monocular accommodative facility with plus and minus lenses
- MEM retinoscopy
- Fused cross-cylinder
- NRA/PRA
- Binocular accommodative facility testing
- Binocular accommodative amplitude

TESTS EVALUATING VERTICAL FUSIONAL VERGENCE

- Supravergence and infravergence
- Fixation disparity

TESTS EVALUATING THE OCULAR MOTOR SYSTEM

- Fixation status
- Subjective assessment of saccades using grading scales
- Developmental eye movement (DEM) test
- Visagraph
- Subjective assessment of pursuits using grading scales

MOTOR ALIGNMENT AND INTERACTION TESTS (MAIT)

- Cover test at distance
- Cover test at near

- Phoria at distance
- Phoria at near
- Fixation disparity
- AC/A ratio
- CA/C ratio

Classification of Binocular Vision Disorders

1. **Heterophoria with low AC/A ratio:**(insufficiency have low AC/A ratio)

- Ortho at distance; Exo at near: Convergence insufficiency
- Exo at distance; greater exo at near: Convergence insufficiency
- Eso at distance; ortho at near: Divergence insufficiency

2. **Heterophoria with normal AC/A ratio:** (Basic have normal AC/A ratio)

- Ortho at distance; ortho at near: Fusional vergence dysfunction
- Eso at distance; same degree of eso at near: Basic esophoria
- Exo at distance; same degree of exo at near: Basic Exophoria

3. **Heterophoria with high AC/A ratio:** (Excess have high AC/A ratio)

- Ortho at distance; eso at near: Convergence excess
- Eso at distance; greater eso at near: Convergence excess
- Exo at distance, less exo at near: Divergence excess

4. **Vertical heterophoria:**

- Right or left hyperphoria

5. **Accommodative anomalies:**

- Accommodative insufficiency
- Ill Sustained accommodation
- Accommodative excess
- Accommodative infacility

6. **Ocular motor problems:**

- Ocular motor dysfunction

Modified Duane classification system

Convergence insufficiency:

Exophoria greater at near than at distance
Low AC/A ratio
Receded NPC
Reduced fusional convergence (PFV)

Divergence excess:

Exophoria greater at distance than at near
High AC/A ratio
High tonic exophoria
Large exophoria/ tropia at distance

Basic Exophoria:

Exophoria equals at distance and at near
Normal AC/A ratio

Convergence excess:

Esophoria greater at near than at distance
High AC/A ratio

Divergence insufficiency:

Esophoria greater at distance than at near
Low AC/A ratio
High tonic esophoria
Cpmplains of diplopia

Basic Esophoria:

Esophoria equals at distance and at near
Normal AC/A ratio

Vergence insufficiency:

Normal AC/A ratio
Restricted fusional vergence amplitudes

Vertical phoria:

Comitant deviations
Non comitant deviations
4th nerve palsies

Shread's criteria:

Prism needed(P): $\frac{2}{3}$ phoria- $\frac{1}{3}$ compensating fusional vergence

Percival's criteria:

P= ⅓ G- ⅔ L where,G = Greater vergence reserve

Lesser vergence reserve

Conditions requiring added lens

Added +	Added -
Convergence excess	High exophoria
Basic esophoria	Divergence excess
Accomodation insufficiency	
Ill sustained accomodation	

Contact lens and Ocular Prosthesis

Contact Lens

Oxygen permeability (dk)
D- Diffusion coefficient
K - solubility coefficient
Unit- 1 Fatt/Barrer= 1*10-11 (cm2/sec)(mlO2)(mlmmhg)

Oxygen transmissbility (dk/l)
Unit= Barrer/cm =1*10-9(cm/sec)(mlO2)(mlmmHg)

Cornel edema upto 5% is safe
Daily wear dk/l =24.1 Fatt unit
Extended wear dk/l = 87 Fatt unit

PMMA

- Acrylic lens(CH2=CH-COOH)
- 1948 by Kevin Tuchy
- 0 dk/l
- Tear pump only source of oxygen

Rigid Gas Permeable lens(RGP)

CAB(Cellulose Acetate Butyrate)

- Dk (4-8)
- Tendency to wrap
- Easily scratched

Siloxane methyacrylate

- Dk value - (12-60)

Fluro polymer

- Extended wear
- Dk value up to 150

Soft contact lens

- DK value

FDA classification

Group 1	Group 2	Group 3	Group 4
Low water content	High water content	Low water content	High water content
Non ionic	Non ionic	Ionic	Ionic

Contact lens manufacturing

- Lathe cutting- RGP/SCL
- Spin casting - SCL
- Cast moulding - SCL
- Cast moulding modified - RGP

Optics of Contact lens

Correction of vertex distance

Fcl= Fs/(1-dFs)

Contact lens is placed in vertex plane while spectacle are placed 12-13 mm in front of vertex plane

- Minus lens require less power than spectacle in contact lens
- Plus lens require more power in spectacle than contact lens.

Magnification

Spectacle = 1/(1-af) aphakic eye 22%

Contact lens = 1-af aphakic eye 7%

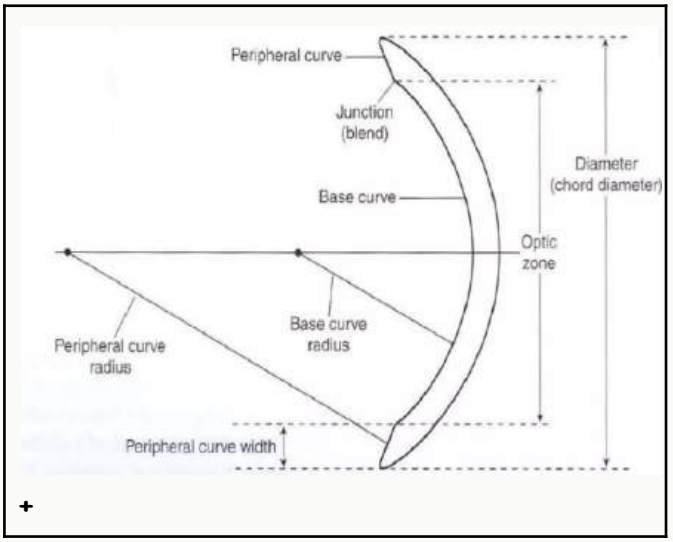
Accommodation and convergence

- Accomodation and convergence demand increases in myopic eye with contact lens
- Accomodation and convergence demand decreases in myopic eye with contact lens

Fluid lens

- No power/plano in soft contact lens
- In RGP
    - Plano power if BC= K reading
    - Plus power if BC is steeper than K reading
    - Minus lens if BC flatter than K reading
    - 0.05 mm difference = 0.25 D
    - SAM FAP (Steeper Added Minus)(Flat Added Plus)

Contact lens nomenclature



- Diameter of lens
    - PMMA - 7.5-8.8 mm
    - RGP - 9.0-9.8 mm
    - SCL - 13-15 mm
- Increasing Base curve reduces sag
- Increasing diameter increases sag
- BC inversely proportional to sag
- Diameter directly proportional to sag

Tear Evaluation

- Normal blink rate= 15 blinks per minute
- Normal scirmer = more than 10 mm
- TBUT > 10 sec is suspicious of dry eye
- Tear prism height = 0.1-0.3 mm
- Tear film dimension
    - Lipid layer - 0.1 um
    - Aqueous layer -8 um
    - Mucin layer - 0.8 um

RGP lens fitting

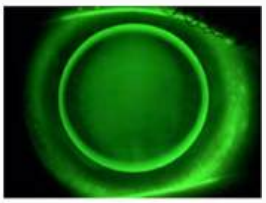
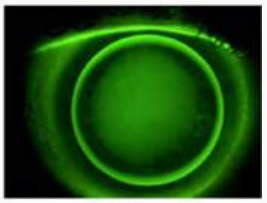
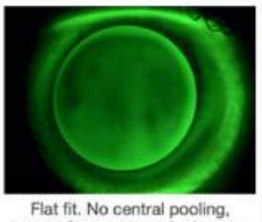
- Base curve

K and astigmatism	BC selection	Example	Final Base curve
0-0.75 D	Fit on K	41.0(8.23) 41.50 (8.13)	8.23 mm

0.50-1.0 D	Fit on 0.05 steeper than K	41.0(8.23) 42.0 (8.04)	8.23-0.05=8.18 mm
1.0D-2.50D	Fit on 0.10 mm steeper than K	41.0(8.23) 43.0 (7.85)	8.23-0.10=8.13 mm
>2.50 D	Mean K	41.0 (8.23) 44.0 (7.67)	Mean K =7.94 mm

- Overall Diameter
    - HVID -(1.2-1.4)mm
    - Base curve : A flatter base curve requires a larger diameter, and a steeper base curve requires a smaller diameter.
    - Astigmatism - smaller lens improves comfort for high astigmatism (>2.50D)

- For power 0.15 mm = -3.00D
- Modify 0.01 mm per diopter
- **Fluorescein evaluation**

	Ideal	Steep	Flat
Central fit	Alignment (uniform thin film of fluorescein)	Pooling (bubbles if excessive)	Touch
Mid peripheral	Minimal or no contact	Touch or bearing	Pooling
Peripheral	Optimal bandwidth (0.2-0.3) Moderate edge clearence	Narrowband (<0.2 mm)	Bright fluorescein at edge wide band(>0.36)
	 Optimum fit. Faint central pooling, stable movement 1-2mm.	 Steep fit. Central pooling, flatten BOZR 0.1mm	 Flat fit. No central pooling, excessive movement, steepen BOZR 0.1mm

- **Fluorescein evaluation on astigmatic cornea**

	Optimal	Steep	Flat

Central	Light touch	Pooling	Touch
Horizontal meridian	Mild touch	Touch on vertical	Touch on horizontal
Edge width	0.2-0.3	Narrow	Wide

Soft contact lens

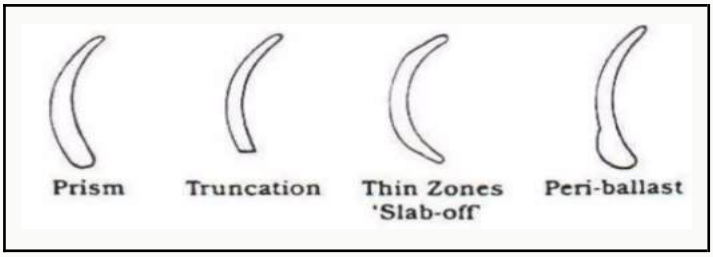
- Thin lenses are more flexible and will move less
- High water content are more flexible and will move less
- Cylinder less than 0.75 D or well within 4:1 ratio is corrected with spherical soft contact lens.
- In-cylinder form Add +1.00 to mean K for base curve
- Evaluation
    - HVID + (1.0-1.5 mm)
    - Movement of (0.2-0.4) mm for thin lens.
    - Lens lag of (1-1.5) mm
    - Vision before and after blink is equal.
    - Keratometry mires and retinoscopy steaks before and after are clear
    - 0.3 mm change in base curve = 0.5 mm change in diameter

Therapeutic contact lens

- Hydrogel
    - High water content - epithelial defect, descematocoeles, Aphakic Bullous Keratopathy, Pseudophakic Bullous Keratopathy (>80%), post Penetrating Keratoplasty
    - Mid water content - small perforation or leaking wounds(45-60%)
    - Low water content: Trichiasis, dry eye, etc(<45%)
    - The ideal is Plano therapeutic contact lens
- Cosmetic lenses should not be cleaned with hydrogen peroxide or a chlorine-releasing agent but can withstand chemical disinfection and enzyme cleaning.

Toric soft contact lens

- Prism ballast- 1- 1.5D base down is added in the inferior contact lens, based on the watermelon seed technique, most stable.
- Truncation: The lower part of the contact lens is truncated/ cut off to increase stability.
- Double slab off: Thin zones are created at the edge. It is most comfortable.
- Peri ballast: Minus carrier design at the edge.
- Reverse Prism Design: Two prism, one base up and other base down



- Types of toric lens:
    - Front surface toric
    - Back surface toric
    - Bitoric
- LARS= Rotation to left, addition, Rotation to right subtraction.

Toric RGP Lens

- Front surface toric: prism ballast
- Back surface toric:
    - Full alignment model: parallel (alignment) fitting in each meridian provides stability, creates tight fitting lens, inadequate tear exhange
    - Low toric simulation model: flat meridian fitting near alignment, improved test exchange
- Bitoric : both front and back surface toric
- Peripheral toric

Keratoconus

- Spectacles
- Soft contact lens
- RGP - 3 point touch
- Scleral lens
- Rose K lens

Scleral RGP lenses

It is a lens fitted to vault over the entire cornea, including the limbus, and to land on conjunctiva overlying the sclera. Forms a tear fluid vault over the cornea.

Classification:

- **Corneal-** Lens entirely rests on cornea.
- **Corneo- scleral-** Lens rests partly on cornea and partly on sclera
- **Full (scleral)-** Lens rests entirely on sclera
    - **Miniscleral-** Upto 6 mm of HVID
    - **Large scleral-** 6 mm larger than HVID

Classification based on diameter:

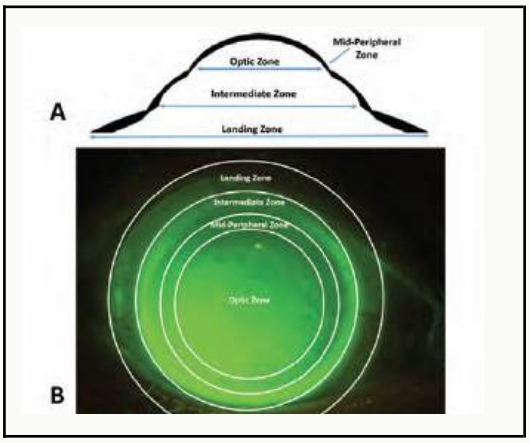
- **Corneoscleral lenses**: 12.9-13.5 mm
- **Semi scleral lenses:** 13.6-14.9 mm
- **Miniscleral lenses:** 15-18 mm
- **Scleral lenses:** >18 mm

Indication of scleral lens

- ❖ Vision
- ❖ Ocular surface protection
- ❖ Cosmetics

Spherical design

- ➔ Optical zone- creates desired optical effect using lens power and radius
- ➔ Transitional zone- creates sag of the lens
- ➔ Landing zone- area that the lens rests on



Scleral lens material-hexafocon B

With full scleral 100-300 um is desired.

#Ortho K

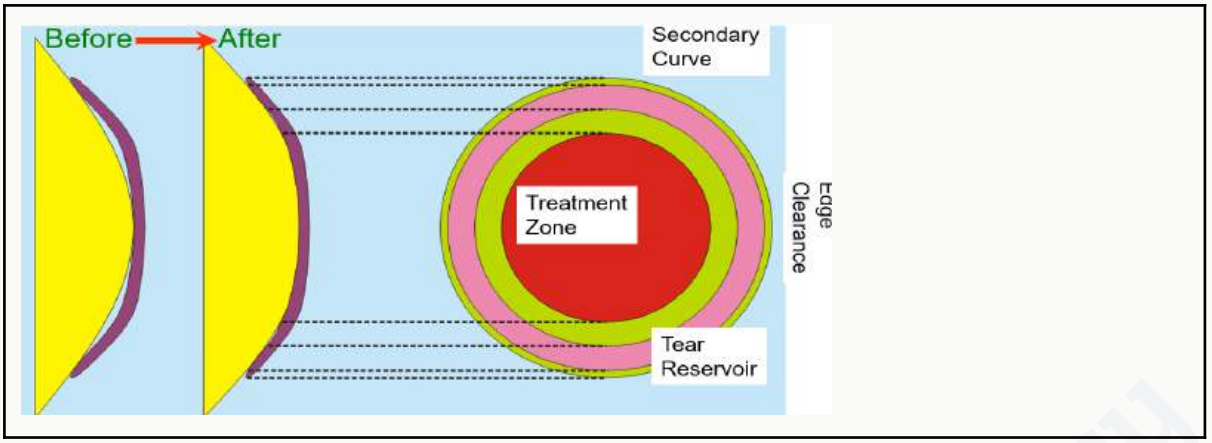
Orthokeratology, or Orthok, involves use of specially designed rigid gas-permeable (RGP) contact lenses to alter the shape of the cornea in order to reduce or correct myopia.

Challenging candidates for Ortho K

- Patient with very high refractive error, very flat corneal curvature
- Manifest cylinder greater than spherical
- Lenticular cylinder

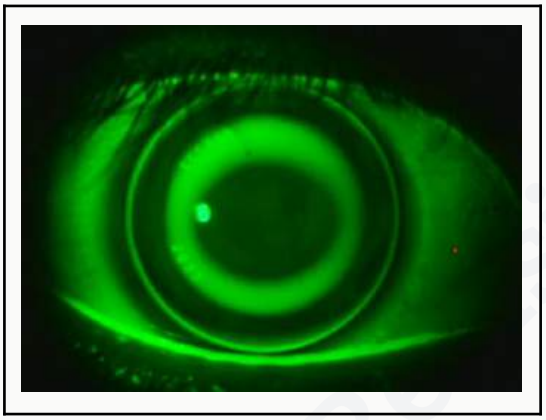
Nomenclature for ortho K

- Base curve
- Return zone depth (RZD)
- Landing zone angle



Proper Contact lens fit

- Centration
- A 3-4mm Base Curve/Treatment Zone
- Uniform landing in the Landing Zone
- Appropriate edge lift of 0.5 -1.0mm



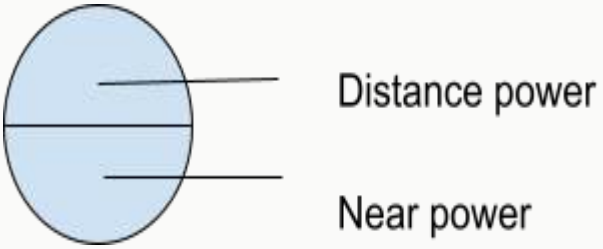
Paediatric

<u>Best contact lens for aphakic children is silicone elastomer</u>

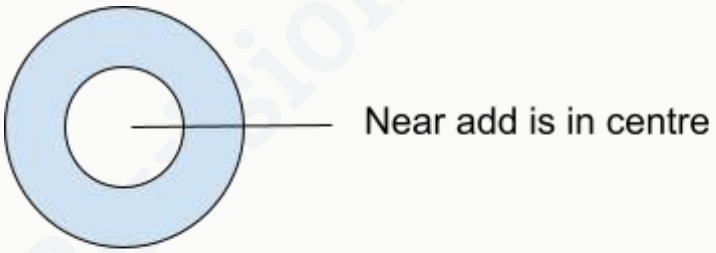
- Cornea dimension:
  - At birth -10 mm(47-49 D)
  - At 4 years -11.5 mm(43.5 D)
  - Microcornea - 14-15 mm
  - Megalocornea- 14-15 mm
- Have less lipid deposit.
- Have increased aqueous.

Presbyopic

1. Monovision: One eye is corrected for distance while another eye is corrected for near. Usually dominant eye is corrected for distance and the non-dominant eye for near.
2. Bifocal- It is similar to executive bifocal. While viewing at near, the lower lid pushes the near portion of the contact lens in front of the pupil, therefore allowing clear near vision.



3. Simultaneous :
    a. Concentric-
        i. Centre near: Central power is for near , while peripheral power for distance.
        ii. Centre distance: Centre power is for distance while peripheral power near.



4. Diffractive- Based on the principle of diffraction, concentric rings are present.
5. Aspheric
    a. Aspheric back surface lens- increasing plus power peripherally.
    b. Aspheric front surface lens- increasing plus power centrally.

Verification of contact lens parameters

- Base curve - Radioscope
- Diameter- V slought gauge
- Power- Lensometer
- Central thickness- Dial gauge
- Peripheral curve/ width/band- projection analyzer/ magnification loop
- Material-specific gravity test

Contact lens care system

1. Cleaning
2. Rinsing
3. Disinfection
4. Enzymatic cleaning
5. Lubricating

- Tonicity- 0.9%Nacl
- Ph of tear- 7.0-7.4
- Ph comfort range- 6.6-7.8
- [Heat disinfection not suited for>45% water content]
- #H2O2(0.005-0.006)
- as preservative and 3% as disinfectant
- Not suitable for group 4 lens

Efficacy against bacteria

1. Heat
2. H2O2
3. Thiomersal 0.002% (4 hrs)
4. Dymed 0.005% (4hrs)
5. Polyquad 0.001% (4 hrs)

Efficacy against acanthamoeba

1. Heat
2. H2O2
3. Thiomersal 0.002% (4 hrs)

RGP modification

- Polishing induces minus lens

Ocular prosthesis

- **Enucleation** - Removal of the entire eyeball, including the cornea and sclera, but leaving the optic nerve and extraocular muscles.
- **Evisceration** - Removal of the contents of the eye, including the lens, retina, and vitreous humour, but leaving the sclera and extraocular muscles.
- **Exenteration** - Removal of the eye and the orbital contents, including the eyelids, fat, and eye muscles. Orbital bone may also be removed.

Enucleation, evisceration or secondary implantation surgery → Conformer is placed in the conjunctival fornices to maintain the conjunctival space → Conformer is replaced with a custom-made ocular prosthesis typically fashioned 4–6 weeks

Classification of implants:

Porous	**Non-porous**
Permits the fibrovascular ingrowth	Does not permit fibrovascular ingrowth
Hydroxyapatite, Aluminum oxide, Porous polyethylene)	Polymethylmethacrylate, Silicone

Integrated implant	**Non integrated implants**
There is a small break in the overlying conjunctiva through which the peg protrudes	There is a small break in the overlying conjunctiva through which the peg protrudes
Coupled with overlying prosthesis	No connection with overlying prosthesis

Implant selection in adults

- **Ages of 15 and 65 years old**
  - Porous implant
  - Quasi-integrated implant
  - Non porous implant wrapped centered with muscle cone, attached with inferior oblique and rectus muscle
- **Age above 70 years**
  - Non porous implant without wrap or connection with muscle.
- **Age up to 15 years**

- Wrapped non porous implant, may be replaced with age.

Types of ocular prosthesis

1. Ocular

•Prosthetic contact lens

•Scleral shell

•Full thickness prosthesis or prosthetic eye or reform eye

2. Orbital

•Partial orbital prosthesis

•Complete orbital prosthesis

- Spectacle mounted prosthesis
- Adhesive retained prosthesis (Stick on skin type)
- Magnetic retained prosthesis

Low vision and visual rehabilitaion

Low vision definition-

A person with low vision is one who has impairment of visual functioning even after treatment and/or standard refractive correction, and has a visual acuity of **less than 6/18** to light perception, or **a visual field less than 10 °s** from the point of fixation, but who uses, or is potentially able to use, vision for the planning and/or execution of a task.

Categories of Visual impairements

Categories	**BCVA**	**WHO standard defination**	**WHO working defination**
0	6/6-6/18	Normal	**Normal**
1	<6/18-6/60	Moderate VI	Low vision
2	<6/60-3/60	Severe VI	Low vision
3	<3/60-1/60	Blind	Low vision
4	<1/60-PL	Blind	Low vision
5	NPL	Blind	Total blindness
9			Unspecified or Undetermined

ICD classification

ICD Code	**Grade**	**Defination**
H 54.0	Blindness, binocular	VI category 5
H 54.1	Severe VI, binocular	VI category 2
H 54.2	Moderate VI, binocular	VI category 1
H 54.3	Mild or no VI, binocular	VI category 0
H 54.4	Blindness, monocular	VI categories 3,4,5 in one eye and categories 0,1,2,9 in other eye
H 54.5	Severe VI, monocular	VI category 2 in one eye ,categories 0,1,9 in other eye
H54.6	Moderate VI , monocular	VI category 1 in one eye and categories 0 or 9 in other

		eye
H 54.9	Unspecified	VI category 9

Ref. error commonly associated with LV disorders

- Albinism- moderate to high hyperopic or myopic astigmatism
- Cerebral palsy- Mod to high hyperopia
- Corneal scars- Astigmatism
- Microphthalmos- Mod. to high hyperopia
- Pendular nystagmus - with the rule astigmatism
- ROP- High myopia
- Down's syndrome - Mod. to high myopia
- ROP – myopia & keratoconus
- Coloboma & microcornea- hyperopia
- Lenticular subluxation – aphakia & myopia

Spectacle trial lens clips (Halberg, Janelli)

Blur sensitivity-

Snellen's acuity	**Blur sensitivity**
6/12	±0.25 D
6/18	± 0.50 D
6/60	± 1.00 D
3/60	± 1.50 D

Just Noticable Difference

Minum power difference for which patient will percieve difference in visual acuity.

Calculation of JND

1.JND = Denominator of VA / 30 (Metric Notation eg, VA of 6/60 , JND = 60/30 = 2D)

2.JND = Denominator / 100 , for feet notation.

(2D means a range of + 1 to -1D)

Telescope

- Objective lens- positive, convergent, larger diameter to collect larger quality of light
- Ocular lens- convergent / divergent, greater power

- Ocular lens is so positioned , it's primary focal point is coincident with image formed by objective lens ;Parallel rays of light is incident and emerges
  Mag = D oc/ D obj
- Produce only angular magnification
- Equivalent power of telescope= zero

Gallilean telescope

- Tubelength shorter
- Image is virtual and erect
- Oculr lens is negative
- Exit pupil inside the telescope and shows with movement
- For uncorercted myope, decrease magnification
- For uncorrected hyperope, increased magnification

Keplerian telescope

- Tubelength longer
- Ocular lens, positive; image real and virtual
- Exit pupil-Outside and shows against movement (ocular lens)
- For uncorrected myope, increased magnification
- For uncorrected hyperope, decreased magnification

Astronomical telescope : image is inverted
Terestrial telescope : image is erect with added prism (porroro prism)

➔ For uncorrected myope to focus, shorten the telescope
➔ For uncorrected hyperope to focus, lengthen the telescope

Exit pupil= diameter of objective lens/ Mag of telescope,

- For gallilean telescope: parallax motion with the motion
- For keplerian telescope: parallax motion against the motion

Chromatic aberration: Dispersion of objective lens must be lower than that of eyepiece

- ARC: 4 % light loss at each uncoated optical surface
- Normal coating - purple green
- Too thick - blue
- Too thin- straw color

Retinal luminance in telescope:

- Exit pupil is large or equal to the patient's pupil, image brightness is equal to that seen by naked eyes.
- Exit pupil is smaller than patient's pupil, image brightness is smaller than naked eyes.
  Here, exit puil= Objective lens diameter/Magnification

Reduction in brightness = (EP)2/(Eye pupil)2

Relative light efficacy = (EP)2
RLP increases by 50% with ARC

Twillight factor : performance in dim illuminance
=√dobj * MTS

Accomodation :
Approximate formula(Sloan - Border) : Aoc= M2U
Froid formula : Aoc= M2U/ (1-dMU)

If Gallilean and Keplerian telescope of same magnification and tube length , keplerian will require greater magnification.

Focal telescope

- Increasing power of objective lens
- Decreasing power of ocular lens
- Increasing the separation between objective and ocular lens

Determing the required magnification
MTS= BCVA/TA

Telemicroscope
Deq= Mts* Dcap

Field of view
Linear field of view of telemicroscope = afocal telemicroscope when viewed at 57 cm

FV= angular fie;d of view of telemicroscope * viewing distance in cm/ 57

Depth of field ∝1/ eq power of system

Near Magnification

General starting point ; 8 point , 20/50 Snellen, 1 M
Guidelines for target acuity levels required for tasks in calculating magnification levels

Visual Task	**Acuity for target distance**
Face recognition within 3 metre	6/24
Novel, Book	N10
Newspaper	N8
Reference	N6
Currency	N16
Writing	N12
Computer screen	N5

Allocation of disability card for visually impaired

- •Deaf blind : red card
- •Blind : Blue card
- •Low Vision : yellow card

Acuity demand of material

- For Snellens acuity = 1000/ no of letters in 1 inch of text
- For point system = 144/ no of letters in 1 inch of text

Lebenson's rule
Mag = denominator of distance acuity/ denominator of target acuity

Kestenbaum's rule
Mag= denominator of distance acuity / numerator of distance acuity

RATIO RULE
BNA/TNA= TD/ NRD

Near acuity contrast - 93.1%
Newspaper contrast = 65.4%

Microscope -

- spectacle mounted convex lens (converging lens to neutralize diverging rays from proximity)
- Largest field of view in near device
- Myopia- low powered microscope
- Hyperopia - high powered microscope

Hand held magnifier

- Near object held at the focal length of lens will create a magnified retinal image without need of add/ accommodation
- RIM= RDM* LVM
- Deq= D1+D2- (d)D1D2
- Hand held magnifier in contact with bifocal Deq= D1+D2
    - Hand held magnifier away from bifocal but within the focal length of magnifier Deq>D1
    - Hand held magnifier atone focal length of magnifier Dew= D1
    - Hand held away from one focal length of magnifier Deq <D1
    - Hand held away from focal length Deq = inverted image as reversed telescope

For refractive error

- Magnifier within the focal length, divergent rays will pass- correcting myopia
- Magnifier away from the focal length , converging rays will pass- correcting hyperopia

Rectangular magnifier - only found in low power. As power of magnifier increases, overall diameter of magnifier will get smaller in order to remove peripheral aberration.

Field of view:

W= (d)(f/h), where d= diameter
f= focal length
h= vertex distance

As distance from magnifier to eye increases, field of view of hand magnifier increases

***CCTV*:**

M= [X][Y]

X = print size on monitor/ actual print size

Y= reference distance / working distance in cm (25/45)

Z= Dioptric power of working distance

EVM

- 50 ° in horizontal direction, 38 ° in vertical
- Mag = 1.7X-7.5X
- Near- 10.5 X
- With reading cap -25X

Vmax - 47 horizontal, 36 bilateral

For field loss

- For glaucoma and RP, less amount of light is absorbed by RPE, increasing glare
- Loss of mid and low spatial frequency due to glare affects contrast and mobility
- Loss of high spatial frequency causes loss in visual acuity
- Illumination of desk lamp shouldnot be more than 75-100 W
- Best source of illumination for low visionpatient

8. WAML (Wide Angle Mobility Light)
9. ITT (Night vision) (40° wide)

Field enhancement

When a prism is used for a patient with hemianopic field defect , prism is placed on the temporal portion of the carrier with the base of prism towards the temporal area and apex of towards nasal area

- Field enhancing lens - glaucoma and RP
- Reverse prism - sighting (2Xtelescope, minify 2X)
- Amorphic lens - minification only limited in horizontal meridian (by use of convex mirror)
- Image minifier - doesn't produce barrel distortion
- Driving- difficulty after more than 20° constriction

Non optical device

Multiple pinhole for media opacity such as corneal involvement and cataract

Distance between two holes should be greater than pupil in normal illumination,

Posture and comfort maintenance

Hold the material at distance equal to individual elbow to middle knuckle.

Angle 70° off vertical , 45° down from vertical

20-50° visual field for good motility and safe orientation

Sensory substitute - hearing and tactile

- Average reading speed - 200-400 wpm
- Speech compression speed - 150-170 wpm
- Best candidate for LVD - VA < 20/200 and VF <-20°
- LVA for during - biotic telescope

Technique: Localization, focusing, spotting, tracing, tracking, scanning

Complete vocalization system- 1) Screen reader

2)Speech synthesizer

Stages of loss

- Shock or denial
- Anger
- Depression
- Bargaining
- Acknowledgement

Conversion of M into Snellen Acuity

Test distance (meter)/ M notation *100/100

Conversion of M into M notation

M= N/8

Community Optometry

Health is a state of complete physical, mental and social well-being and not merely an absence of disease or infirmity"

- **Disease**- diagnosed by a physician or other medical expert. Eg, conjunctivitis
- **Illness**- Ill health that the person identifies themselves with, often based on self-reported mental or physical symptoms Eg, Red eye reported by patients.
- **Sickness-** Social & cultural conception of a person's condition. Eg, sick leave.

Iceberg phenomenon of disease-

- According to this concept, the disease phenomenon may be compared to the tip of the iceberg
- The floating tip of the iceberg is what the clinician sees in the community
- The subclinical part of the disease is similar to the hidden mass of the iceberg that is much larger
- The subclinical portion represents the latent, unapparent, presymptomatic, undiagnosed cases and carriers in the community

The germ theory of disease;

The concept of cause embodied in the germ theory of disease is generally referred to as a one-to-one relationship between causal agent and disease:-

Disease agent → Man → Disease

Epidemiological triad-

Environment, host and agent exist at the same time.

Natural history of disease-

- It explains how a disease evolves on its way from the stage of prepathogenesis to termination.
- Stages:
    - Prepathogesnesis - potentially we all are in pre pathogenesis phase
    - Pathogenesis- The pathogenesis phase begins with the entry of the disease "agent" in the susceptible human host.

Level of prevention:

- **Primordial prevention**: Preventing the development of risk factors
- **Primary prevention**:

    - Risk modification : sanitation, infection control, immunization, protection of food, water, milk supplies, environmental protection, mitigate occupational hazards and accidents
- **Secondary prevention:**
    - Action that halts the progress of the disease
    - Prevents complications
    - Early diagnosis and treatment
- **Tertiary prevention:**
    - Usually the intervention in an advanced stage of the disease
    - Specifically important to prevent the deformities, disabilities and death

Classification

- Preventive medicine
- Clinical medicine
- Social medicine
- Community medicine

Project lifecycle:

- Initiation
- Planning
- Execution
- Monitoring
- Closure

Research Methodology and Biostatistics

Research design

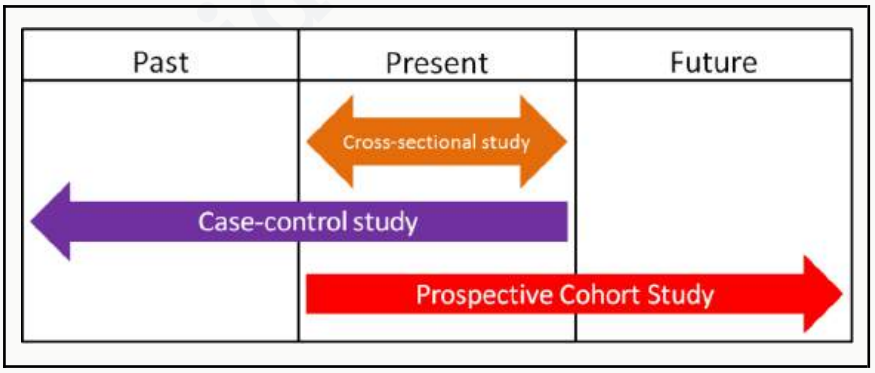
- Qualitative research
    - Phenomenological research
    - Grounded theory
    - Historical research
    - Aeathnographic study
    - Case study
- Quantitative research
    - Descriptive
    - Analytical
        - Experimental
        - Observational
            - Cross sectional
            - Longitutuional
                - Cohort
                - Case control

Cross sectional:

- It is analytical study in which subjects are sampled at a point or period of time and association, absence or presence of risk factor are studied.
- Cannot offer cause and effect relationship

Case control study:

- Retrospective study
- Before the study, both exposure and outcome already occurred.
- ODD's ratio can be calculated



Cohort study

- Prospective study
- Relative risk as well as ODD's ratio can be calculated
- Proceeds from cause to effect

Sampling

Sampling is the process of selecting a sample from a population to conclude the population.

Types of sampling

- **Probability sampling**- Each unit has an equal chance of getting selected.
    - Simple random sampling
    - Systematic sampling
    - Stratified sampling
    - Cluster sampling
    - Multistage sampling
    - Multiphase sampling
- **Non-probability sampling**- The selection of a sample depends entirely upon the judgement of the sampler or investigator.
    - Purposive (judgement)s sampling
    - Convenience sampling
    - Snowball sampling
    - Quota sampling

Characteristics of normal distribution

- The curve is bell-shaped and symmetrical about mean(μ)
- Mean, median and mode are equal.
- The total area under the curve and above the x-axis is one square unit.
- Two tails of the curve never touch the axis
- The normal distribution is completely determined by parameters μ and σ
- The curve has a single peak and is unimodal.
- Area property:
    - μ±σ=68.27%
    - μ±2σ= 95.45%
    - μ±3σ= 99.7%

Hypothesis: It is a guess or assumption about population parameters which may or may not be true.

- Null hypothesis
- Alternate hypothesis
    - One-tailed alternate hypothesis
    - Two-tailed alternate hypothesis

Types of error

Type 1 error: Error that arises due to rejection of null hypothesis when it is true. The probability of making a type 1 error is ***α***

Type 2 error: Error which arises due to acceptance of null hypothesis when it is false. The probability of making a type 2 error is β.

Parametric and non parametric test

Parametric test	**Non-parametric test**
These tests are used for continuous data	These tests are used for discrete data.
Parametric tests assume the underlying distribution is a normal distribution.	Non-parametric test does not assume the underlying test is a normal distribution.
Z test **T-test** **F test**	**Chi2 test** **Man Whitney U test** **Wilcoxon sign rank test** **Kruskal Wallis test**

Correlation: The relationship or association between two continuous (quantitative) variables is called correlation.

Correlation coefficient:

- The measure of the ° of association between variables is known as the correlation coefficient.
- It is denoted by r.
- It lies between -1 to +1.

Types of correlation:

- Perfect positive correlation: r=+1
- Perfect negative correlation r=-1
- Moderately positive correlation r= (0 to 1)
- Moderately negative correlation r= (-1 to 0)
- Absolutely no correlation r=0

Measures of correlation

- Scatter diagram
- Karl Pearson correlation: parametric test
- Speraman rank correlation: non parametric test

Positive test result	True Positive (TP)	False Positive (FP)	**PPV:** TP/ (TP+FP)
Negative test result	False Negative (FN)	True Negative (TN)	**NPV:** TN/ (TN+FN)
	Sensitivity: TP/ (TP+FN)	**Specificity:** TN/(FP+TN)	

Code of Ethics / General Knowledge

- RAAB survey was done in year 2006-2010 with cluster sampling
- National programe for control of childhood blindness - July 1,2010
- Trachoma eliminated in Nepal by May 2018- 1st South East Asia to eliminate trachoma
- REACH(Refractive Error among Children) was done in 2018
- National eye sight programe- 2008 AD
- National low vision programe - 2005 AD
- SHAPU was reported in 1975 AD
- NHPC was formed in 2053 BS
- TIO Who Collaborating center - 21 July 2019
- World sight day - 2nd Thursday in October
- World optometry day- March 23
- NAO established in 2003
- Nepal Eye bank was established in 1994
- First Surgeon to perform perform penetrating Keratoplasty in Nepal is Dr. ND Joshi

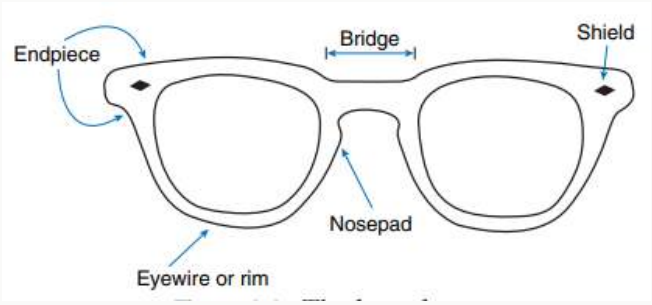
Fundamental principle of Ethics

- Benificence
- Non maleficence
- Autonomy
- Justice

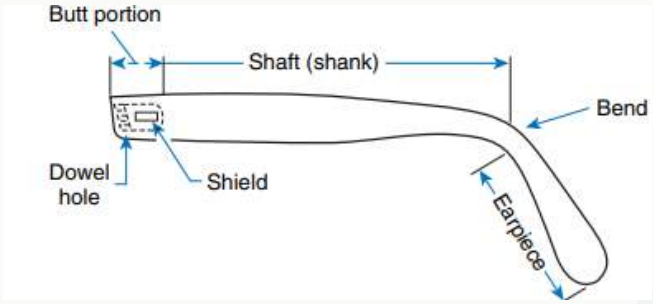
Ophthalmic and Dispensing Optics

Opthalmic dispensing

Parts of frame



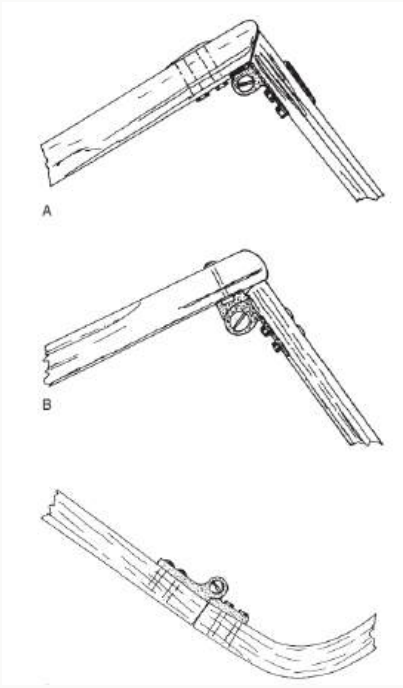
Temple



Categories of frame

- Plastic
- Metal
- Nylon
- Combination frame- having metal chiasis and plastic top rims and temple.
- Half eye-
    - They are constructed to sit lower on the nose than normal, and are only half as high as normal glasses.
    - Usually for near reading.
- Rimless mountings -
    - hold the lenses in place by some method other than eyewires or nylon cords. referred to as 3-piece mountings
- Semirimless mountings ➖
    - similar to the rimless except for a metal reinforcing arm
- Numont mountings
    - hold the lenses in place only at their nasal edge.
- Balgrip mountings ➖
    - secure the lens in place with clips attached to a bar of tensile steel that fits into a nasal and a temporal notch on each side of the lens.
    - The lens can be easily removed by pulling the clips back from the lens

End piece construction



1. Butt type: Where front is straight and temple butt is flat and both meet at 90° angle
2. Mitre type: Temple butt to meet at 45 °
3. Turn back type: Frame front bends around and meets temple end to end.
4. Continuous piece- wrap endpiece design.

Skull

Temple construction:

temple:

- bend down behind the ear and follow the contour of the skull,

Library temples.

- They are practically straight and hold the glasses on primarily by pressure against the side of the head.
- They are also known as straight-back temples.

Convertible temple

- Could be converted from a straight back to a skull design
- Can be fit with a variety of temple lengths

- Can be straightened and re-bent to fit the wearer.

Riding bow temples

- curve around the ear, following the crotch of the ear

- used in children's and safety frames.

Comfort cable temples

- shaped the same as riding bow temples, but are of metal construction with the curl, or behind the ear portion, constructed from a flexible coiled cable.

Frame material

Plastic frame material

- Cellulose nitrate - also known as "zyl", flammable, obsolete

- Cellulose acetate- the most common, thermoplastic - will bend when heated
- Propionate
- Optyl- epoxy resin, thermoelastic- will bend when heated and return to its original shape when reheated.

Nylon based material

- Nylon- highest flexibility, will lose flexibility if not periodically soaked under water, may become brittle over time
- Polyamide-
- Grilamide- many colour possibilities, maybe used with titanium

Carbon fiber:

➔ Strands of carbon fibre combined with nylon, not adjustable, mainly used for frame fronts, only black colour available,

Polycarbonate

➔ Primarily for sport or safety purposes, for nonprescription purposes, the lenses and frame are moulded as one unit, very impact resistant, do not work well for conventional eyeglasses because of their resistance to adjustment.

Kevlar- combined with nylon

Rubber- combination with nylon and rubber, flexible and not adjustable

#Metal based materials

Nickel based materials:

Pure nickel

Nickel silver: Nickel silvers contain more than 50% copper, 25% nickel, and the rest zinc, also known as German silver.

Monel Metal:nickel, copper, iron, and traces of other elements

Aluminum :

- strong and extremely lightweight,
- can be finished in a wide variety of colors and does not corrode.
- Aluminum does not solder or weld well, so must be made such that its parts are assembled with screws or rivets. well adjustment but has no flexibility. If it bends, it stays that way.

Stainless steel:

- mainly from iron and chrome and is highly resistant to corrosion, Strong.
- When made very thin, it has an element of springiness and flexibility that makes it well suited for temples. adjustments are difficult,
- Stainless steel is one of the more nonallergenic materials

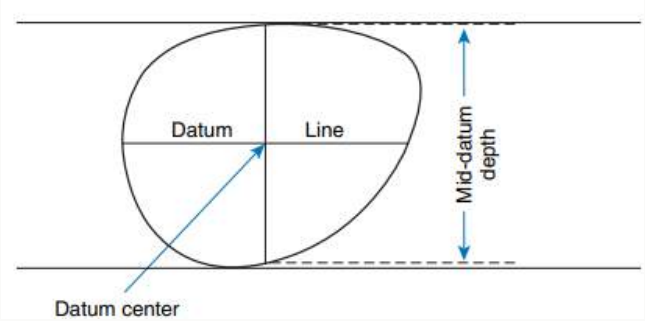
Titanium

- **Certified 100% Titanium**- All major components of the frame are at least 90% titanium by weight, The frame must not contain any nickel.

- **Certified B titanium** -All major components of the frame are at least 70% titanium by weight, The frame must not contain any nickel.

Frame measurement

Dautum system



Boxing system

A size = eye size when referring to frame, lens size when referring to the lens, horizontal measure of the lens.

B size = vertical measure of the box enclosing the lens.

C size = the width of the lens itself along the horizontal midline

DBL=

- The DBL is the distance between the two boxes when both lenses are boxed off in the frame.
- It is also known as bridge size.

Effective diameter=

- ED of a lens is found by doubling the distance from the geometric center of the lens to the apex of the lens bevel farthest from it,
- helps to determine the smallest lens blank from which the lens can be cut.

GCD=

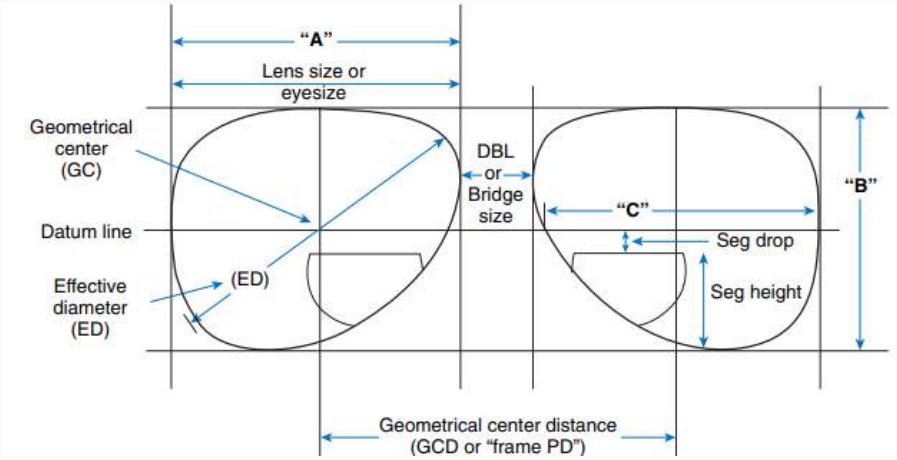
- The distance between the two geometric centers of the lenses is known as the geometric center distance (GCD).
- The GCD is also known by three other names:
    a. Distance between centers (DBC)
    b. Frame center distance
    c. Frame PD

Frame difference=

- A size - B size
- The larger the difference, more rectangular the box will appear.

Seg drop or seg raise= The distance below or above the horizontal midline.

Seg height= The distance from the lower line of the boxing system rectangle enclosing the lens shape.



Example, 5020 means

A size = 50 mm

DBL= 20 mm

#Gold classification

Fine gold	100% pure gold
Solid gold	Gold plus base metal evenly mixed throughout
Gold filled	Base metal inside a "solid gold" coating
Gold plating	A base metal thinly plated with gold
Gold flashing	A base metal with gold thinly and quickly applied in a manner similar to that of gold plating

#Trifocal intermediate

- The intermediate portion will be 50% of the near add.
- Lenses for special intermediate viewing distances may also be obtained having intermediate powers of 61% of the near addition.

 # Bifocal nomenclature

Seg width, is measured across the widest section of the segment area

Seg depth is the longest vertical dimension of the seg is the.

Seg height is measured vertically from the lowest point on the lens to the level of the top of the seg.

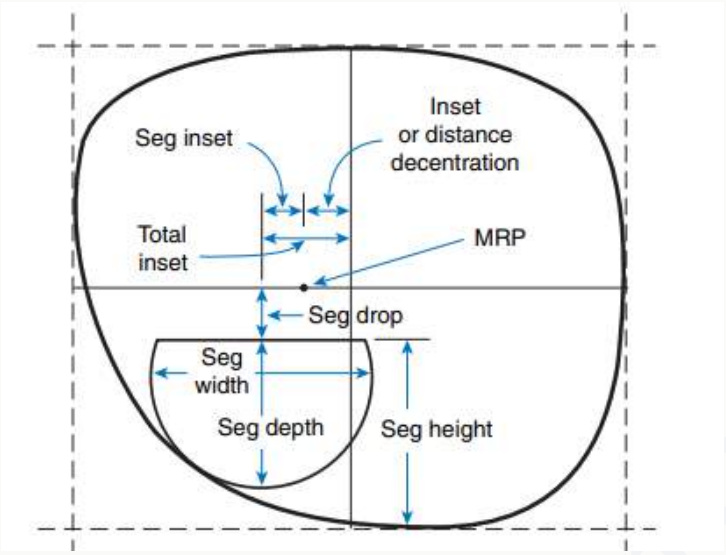
Seg drop is the vertical distance between the major reference point (MRP) of the lens and the top of the seg.

Inset or Outset: The distance portion of the lens that must be decentered from the geometric center of the lens opening of the frame to correspond to the wearer's interpupillary distance (PD).

Seg inset: The segment that must be further decentered to correspond to the near PD.

Inset (or outset) + seg inset = total inset

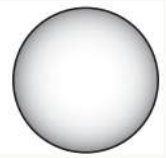
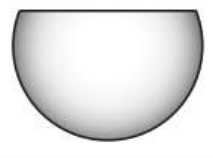
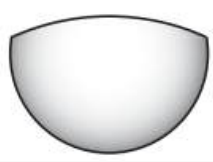
(Outset would be written as a negative number.)



Multifocals based on construction:

1. **Fused multifocal:**
    - Available only for glass
    - Segment made up of higher refractive index than carrier
    - No change in curvature, segment cannot be felt.
2. **One piece-**
    - Made from one material.
    - Any change in power is due to change in refractive curvature.
    - Can be made from any lens material.
    - Eg, round segment lens, franklin style bifocal
3. **Cemented lens:**
    - Small segment lens glued to distance lens,
    - custom made lens
    - Eg, customized bifocal

Bifocal type:

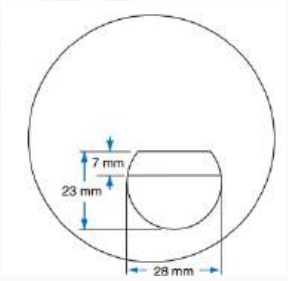
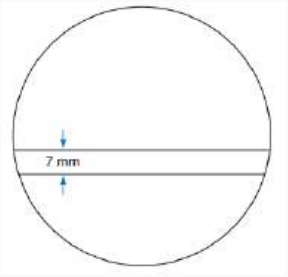
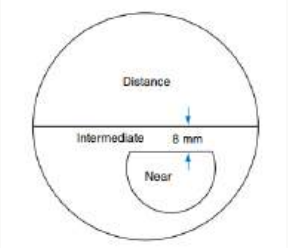
Rounded bifocal	22-40 mm Common is 22 mm	Optical centre is at the centre of the centre of the segment	
Flat top segement D bifocal	Baically rounded bifocal with flat cut off 22 up to 45 mm M/C are usually 28 mm	the segment OC is about 5 mm below the seg line.	
Curve-Top and Panoptik Segments	similar to flat tops, except that the upper line is arched, rather than flat	the segment OC is about 5 mm below the seg line.	
B segment/Brick	B is only **9 mm deep** and is good for someone who must be able to have distance vision below the bifocal area.	the segment OC is about 5 mm below the seg line.	
R segment	The R segment has a 14 mm depth occasionally be used for the correction of vertical imbalance	7 below Seg OC are centered.	

Franklin-style bifocal

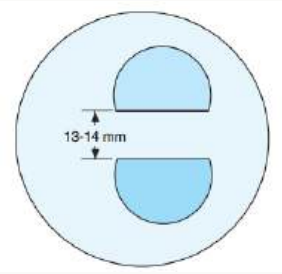
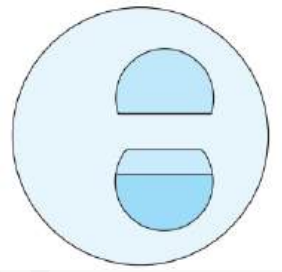
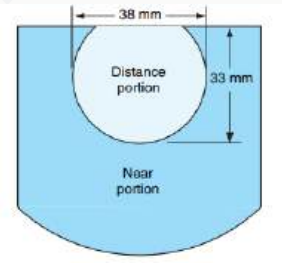
- It is a one-piece lens with the segment extending the full width of the lens
- As the add power increases, the segment ledge gets bigger and more (It is possible to thin the lens by using yoked base-down prism.)
- The Franklin-style bifocal has the segment OC on the segment line. For this reason, some have referred to these lenses as "monocentric" bifocals.
- If Executive lenses are used, it is important to avoid large eye sizes and large effective diameters.

#Types of trifocal lens

Depth more than 8 mm should not be considered regular trifocal, rather occasional wear trifocal.

Flat top trifocal	Width- (22mm-35 mm) Depth-(6-14) mm	
Franklin (Executive trifocal)	a full-width segment lens with a 7-mm full-width intermediate	
The E/D trifocal	combines the characteristics of the Executive-type lens with a 25-mm D (fl at-top) segment	

#Occupational multifocals

Double D segment	For people requiring intermediate and near viewing while looking upwards eg, plumbers, electrician,etc	segements are normally separated by a 13-mm or 14-mm vertical distance.	
Quadrafocal	The quadrafocal lens is a double-segment lens with a flat-top trifocal on the bottom and an upside-down flat top segment on the top		
Rede Rite	Also known as minus added lens,	The segment at the top has more minus power than the rest of the lens.	

[If the segment is 22 mm round, the seg OC will be 11 mm from the top of the seg.]
[The farther from the OC the eye looks, the greater will be the prismatic effect.]

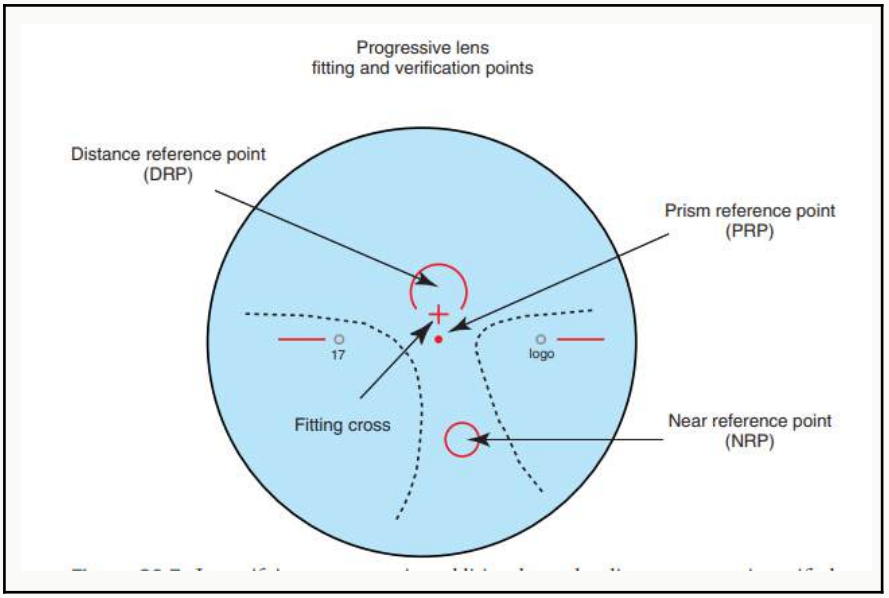
#Progressive additional lens

***Frame selection for progressive lens**

- The frame must have sufficient vertical depth.
- The frame must have sufficient lens area in the lower nasal portion where the near progressive optics are found.
- The frame should have a short vertex distance
- The frame must be able to be adjusted for pantoscopic angle when facial structure will allow. A 10- to 12-° angle is recommended.
- The frame must have suffi cient face form.

Fitting Cross Heights for Children

- If PAL are used by children, lens should be fitted 4mm higher than normal.
- The only time a child would not be fitted 4 mm or higher is if the child has no accommodation, as in case of cataract surgery, then fitting cross is positioned normally.

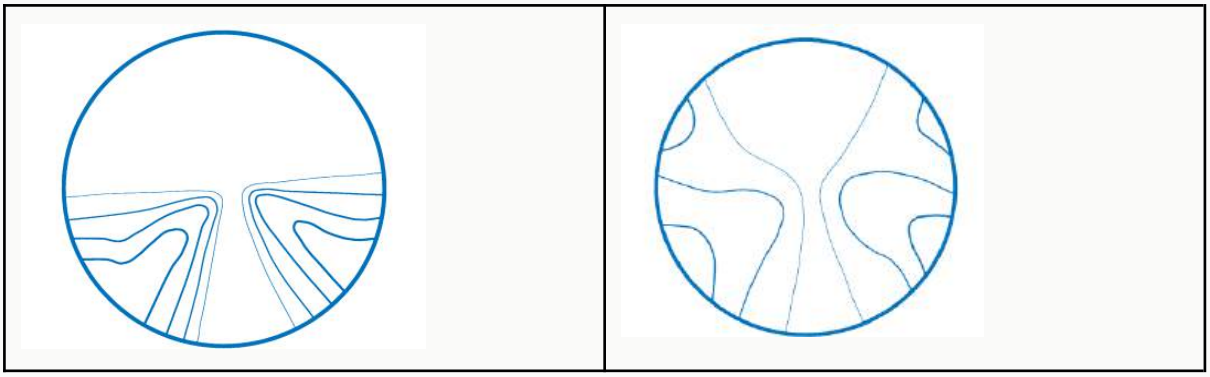


[Power of add is engraved 4mm below the temporal symbol]

- DRP (Distance Reference Point)- centre of the arc
- Fitting cross- centerd in the pupil
- The two horizontal dashes to the left and right side of the lenses help to tell if the lens is tilted.
- Centrally located PRP dots- to verify the prism power
- Circle in the lower part of lens located NRP(Near Reference Point) and used to very near power.

#Hard design vs soft design

Hard design	**Soft design**
Wider areas of stable optics in both distance and near	Longer distance down tothe near viewing area
Narrower intermediate	Wider intermediate
Longer adaptation	Shorter adaptation
Some apparent curving of straight lines	Less apparent curving of straight lines
Highest dioptric value of peripheral distortion of larger than soft designs	A soft design's highest dioptric value peripheral distortion is generally less than for hard designs



Personalized progressive-

The Ipseo lens is designed to match the unique head and eye movement habits of the wearer The Varilux Ipseo uses an instrument called the VisionPrint System to measure head and eye movement.

Occupational progressive(OPL)

Short corridor progressive lens

- Allows PAL to be worn in frame with small vertical dimension
- A faster transition between the distance and near portions of the lens.
- Some sacrifice of larger intermediate corridor.

Near Variable focus lens

- lens of choice for someone working in a small office where intermediate and near vision are the primary viewing needs.
- The reference power is near power instead of distance power. Starting with near power in lower portion and decrease plus power moving upto distance portion, this is also known as digression.

Tolerance of error in cylinder axis

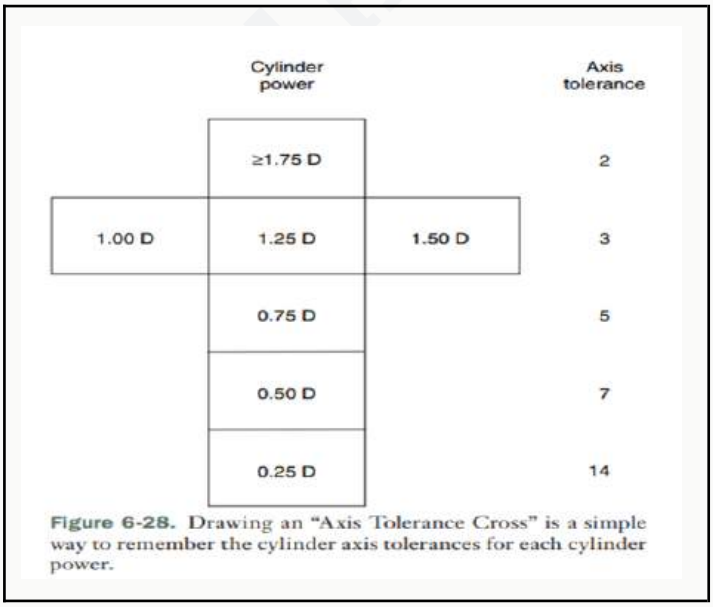


Figure 6-28. Drawing an "Axis Tolerance Cross" is a simple way to remember the cylinder axis tolerances for each cylinder power.

#Frame selection

Basic facial shape	Fitting shapes	Fitting suggestions
Oval	Normal	May wear any type
Oblong	Long face	Deep frame Low temple attachment
Round and Square	Wide face	Narrow frame High temple attachment
Base down triangular △	Erect, Triangular face	Fit size to largest part of lower facial area Dark colors or bolder look are in order
Inverted triangle ▽	Inverted triangular face(base up)	Unobtrusive frame (metal/ Rimless) Light or medium weight frame, lighter color Rounded lens shape Delicate characteristics of frame for women
Diamond♢		

Do's and don'ts while dispensing for high minus wearer

Use	Avoid
Smaller eye size,	Large lenses, Excessive decentration
Round corners	Squared off corner
Light weight lens	Crown glass lenses
High index lens(polycarbonate, high index lens)	Low index lens (e.g., CR-39)

Flatten or hidden bevels	Full V bevels
Polished or rolled edges	Non polished, frosted looking edges
Aspheric/ atoric lens	Normal spheric design
Anti reflection coating	Non coated lens

Do's and don'ts while dispensing for high plus wearer:

Use	**Avoid**
Smaller eye size	Large lenses
Round lens shape	Unusual shape or long corners
Shapes with small frame differences	Shapes with frame differences that are greater than 9mm
Full frame	Nylon cord frames
Sturdy frame	Flimsy construction
Short vertex distance	Large vertex distance
Adjustable (nosepads) bridges	Fixed bridges
Cable or securely fitting temples	Library and straight back temples
High index plastics	Glass and CR-39 lenses
Aspheric/ atoric lens (above +7.00D)	Normal spheric design
Anti reflection coating	Non coated lens

Opthalmic dispensing in sports:

ASTM F513	Eye and face protection for hockey
ASTM F659	Ski and face sheild
ASTM F 803	Badminton, football, volleyball
ASTM F 910	Youth baseball
ASTM 1587	Ice hockey
ASTM F 1776	Paint ball

Opthalmic lens, refractive index

Crown glass	1.523	59
Flint glass	1.65	33
Extradense flint	1.72	30
Barium crown	1.573	57
Dense barium	1.616	55
CR 39	1.498	58
Polycarbonate	1.586	30
Trivex	1.53	43.45
High index plastic	1.64-1.74	42-32

Bifocal prescription:
For adult: segment at lower lid
For child: segment at lower pupillary margin, flat top 28 mm segment
[For child, with accommodation problem, bifocal are better suggested than progressive]

Eye bank

Corneal endothelium:
Average count:
3000 cells /mm2 (average)
0.5% cells are lost/ year.
Critical density: < 500 cells /mm2.
For corneal donation:> 2000 cell/ mm2.
(Specular microscopy required)

Treatment for irreversible corneal edema:
Corneal Transplant – Keratoplasty
Optical – for vision
Therapeutic - for saving eye

Optical Keratoplasty

- Penetrating Keratoplasty (PK) - Full thickness – all 6 layers
- Partial thickness-
    - Superficial lamellar keratoplasty- corneal epithelium and stroma are excised.
    - Deep anterior lamellar keratoplasty(DALK)- Corneal tissue almost to level of Descement's membrane is excised.
    - Endothelial keratoplasty- Diseased endothelium along with Descement's membrane is removed through corneoscleral or corneal inscision
        - DSAEK (Descements stripping automated endothelial keratoplasty)
        - DMEK (Descement's membrane endothelial keratoplasty)
    - Limbal stem cell grafting

[Partial thickness is more successful because endothelium is host's own.
Maximum Rejections against: Endothelium]

Indications of PK:
1. Pseudophakic Bullous Keratopathy – Vesicles/ Blisters of corneal edema –due to corneal endothelium trauma sustained during cataract surgery
2. Non- healing Ulcer
3. Corneal scar
4. Corneal dystrophy
5. Keratoconus
6. Chemical Injuries
7. Fuchs' endothelial dystrophy

Therapeutic Keratoplasty:

- To eliminate infect or repair a structure defect
- Not done for visual rehabilitation

Corneal Donation:
HLA matching is not required
Within 6 hours of death
Preserved in MK media(McCarey Kaufmann) media – 96 hours life
Optisol GS - 14 days
Cornisol -14 days

Contraindications

- HIV
- Hepatitis -B
- Septicemia
- Rabies
- Bacterial/ Fungal keratitis
- Herpes simplex vires
- Creutzfeldt Jacob disease
- Retinoblastoma
- Metastatic Brain Tumor
- Leukemias
- Lymphoma

Age is not C/I, best corneas before 75 years of age
Children can only donate to children

Short term (2-3 days)	Intermediate (7-10 days)	Long term (30 days)	Very long term(1 year)
Moist chamber(94-96hrs) MK medium	K sol Dexsol Optisol Optisol GS	Organ culture medium MEM	Cryopreservation

Eye (cornea, sclera and eyeball) retrived from dead body can be stored
1.Very Long Term: (usually for non optical grade tissue, as an emergency)

- sclera can be preserved for over 1-2 years in 70% ethanol (ethyl alcohol solution) or glycerine.

Cryopreservation:

- tissue can be indefinitely preserved in a liquid nitrogen tank at -160 °s.

2.Long Term:

- Cornea and sclera can be stored in Organ Culture Medium for up to one month at a temperature of +28 to +37 °s Celsius.

3.Medium Term:

- This offers around 1-2 weeks of preservation time at 2-8 °s of temperature.
- Also called as cold-storage system or Hypothermia Method.

A) Cornisol:

- contains mucopolysaccarides as nutrient and steptromicin and gentamicin as antibiotic.
- Maximum time for tissue preservation in Cornisol is 14 days.

B) Optisol-GS:

- contains 2.5% Chondroitin Sulphate and 1% dextran.
- The recommended safe period for tissue storage in Optisol-Gs is 7-10 days.

C) New one is Life4C :

- Similar performances with Optisol-GS,
- even though Life4C contains added glutathione and human insulin.

4. Short-term: Few days of tissue storage (1-4 days)

A) McCarey and Kaufmann (M-K) medium

- at 4 °s for up to 4 days.
- It contains TC-199 culture medium with 5% dextran and no Chondriotin Sulphate.
- Chondroitin Sulphate and Dextran are used as anti-stromal swelling agents (hyperosmotics).

B) Moist chamber:

- when the whole eyeball is enucleated, then the technician stores the eyeball in a tray with moist chamber with the half of eyeball immersed in sterile normal saline.
- In moist chamber, tissue can be kept not more than 2 days at room temperature.
- Typically, moist chamber storage medium is used as a transport medium from the time of tissue retrieval to tissue processing.

Whatever media the cornea is stored in, it should be kept at room temperature for one day before the day of transplant.

Refractive surgery

Correction of myopia

- Surface ablation procedure: PRK, LASEK, epilasek

- LASIK
- Refractive lenticule extraction: SMILE, Smart sight
- Clear lens exchange
- Iris clip (Lobster claw)
- Phakic IOL implant(implantable contact lens, ICL)
- Radial keratectomy

Correction of hypermetropia

- Surface ablation procedure
- LASIK
- Conductive keratoplasty
- Laser thermal keratoplasty
- Clear lens exchange, Phakic IOL

Correction of astigmatism

- Limbal relaxing incision /accurate keratectomy
- PRK/LASEK
- LASIK
- Toric IOL

Correction of presbyopia

- Lens extraction: implantation of accommodating IOL, multifocal IOL
- Conductive keratoplasty
- Laser-induced monovision: Laser refractive surgery to optimize one eye for distance and fellow for near or intermediate distance
- Intracorneal inlays
- Corneal multifocality
- Scleral expansion surgery
- Laser modification of natural lens

Excimer	193 nm	LASIK, PRK
Femtosecond	1054 nm	Cataract, SMILE, Smart sight
ND YAG	1064 nm	PCO Capsulotomy PI (Peripheral iredectomy)
Frequency doubling YAG	832	CSME, Retinal tears
Argon	514	DR
Diode	780-850	DR

Munnerlyn formula
For myopia treatment
The Munnerlyn Formula estimates of the ablation depth in myopic corrections. t = S2 D/3

- t =thickness of the tissue ablated in microns
- S = diameter of the optical zone in millimeters
- D = dioptric correction (spherical equivalent)

[To reduce the effect of glare, halos and regression OZD should be larger than 6 mm]

Residual Stromal Bed

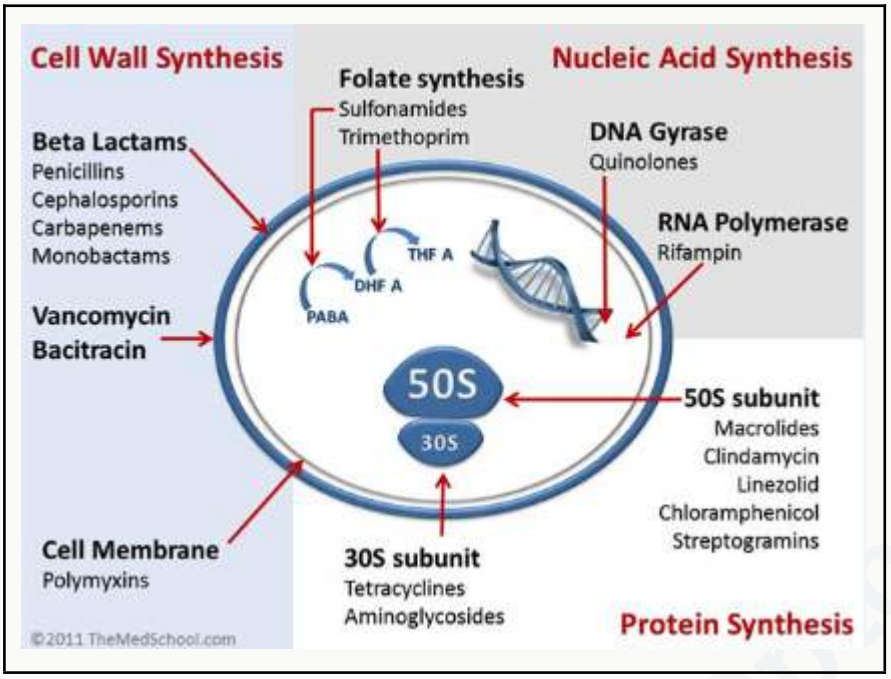
The residual stromal bed (RSB) = central corneal thickness (CCT) - ablation depth - flap thickness.

Historically, a minimal of 250 microns was felt to be the standard, however most surgeons now feel that 300 microns is a safer thickness to avoid post-operative ectasia.

Absolute and relative contraindications of Refractive surgery

- Collagen crosslinking- This procedure combines riboflavin (vitamin B2) with UVA to strengthen the biomechanical properties of the cornea.
-

Pharmacology



Mechanism of action of antibiotics

Cell wall peptidoglycon disruption

- Penicillin
- Cephalosporine
- Carbapenems
- Monobactam

Cell membrane disruption

- Polymycin
- Daptomycin

Folate synthesis

- Sulfonamide
- Trimethoprim

DNA gyrase (inhibition of lipoisomerase)

- Qunilones

RNA polymerase

- Rifampins

50s subunits

- Macrolids
- Chloramphenicols
- Clindamycin
- Linezoids

30s subunits

- Tetracycline
- Aminoglycoside

❖ Penicillin
Amoxicillin, Amphicillin, Methicillin, Cloxacillin, Carbencillin
❖ Cephalosporin
Ceftazidime, Ceftriaxone, Ceftazolin, Cephaxillin
❖ Macrolids
Erythromycin, Azithromycin, Roxithromycin,Clarithromycin
❖ Aminoglycoside
Gentamicin,Tobramycin, Kanamycin,Neomycin,Amikacin,Streptomycin
❖ Tetracyclin
Doxycyclin

***Antifungal (mechanism of action)**

- **Amphotericin B -** aggregates and binds with ergesterol
- **Azole**- Blocking the formation of ergesterol
  - Candida infection with amphotericin B - 0.15% or econazole 1%(natamycin 5%, fluconazole 2%, clotrimazole 1%, voriconazole 1 or 2%)
  - Filamentous infection - natamycin 5%, econazole 1%,(amphoteicin B 0.15%, miconazole 1% or voriconazole 1 or 2%)

Corticosteroids

Mechanism of action

- Reducing capillary permeability
- Maintainence of integrity of the cell wall
- Stablization of lysosome membrane
- Inhibiting granulocyte

Classification

- Short acting : cortisone, hydrocortisone
- Intermediate acting: Prednisolone, Methy prednisolone, triamclone
- Long acting: Dexamethasone, B- methasone

NSAIDS Pharmacodynamics

- Arachnoid acid under influence of cycloxygenase produces prostaglandins which are inflammatory
- NSAIDS inhibits cycloxygenase, thus reducing the prostaglandin formation.

Antiviral drugs

➔ Herpes simples
◆ Acyclovir 3% or gangcyclovir 0.15% gel 5T/D

- ◆ Acyclovir 200-400 mg 5T/D for 5-10 days or Famcyclovir 500 mg TDS for 10 days or valacyclovir 1000 mg TDS for 10 days

Parasympathomimetics - cholinergic drugs, miotics (pilocarpine, carbachol)
Sympathomimetics - adrenaline, dipiverfrine, etc

- Latanoprost - 0.005%
- Travopost, Bimatoprost - 0.03%
- Timolol and Betaxolol- 0.25 and 0.5%
- Briminodine- 0.2%
- Apraclonidine- 1% or 0.5%
- Acetazolamide- 250 mg tablet or 500 mg powder
- Mannitol , glycerol - 1g/kg/ body weight or 5 ml /kg/ body weight

★ Horner
  - Coacine 4%
  - Apraclonidine 0.5 or 1%
  - Phenylephrine 1%

★ Adie's tonic pupil
  - Pilocarpine 0.1-0.125%
  - Hydroxyamphetamine 1%
  - Adrenaline 1%

NHPC(Nepal Health Professional Council

2053.11.3 (Feb 14, 1997 A.D.)

Formation of council

1. Person nominated by government of Nepal
2. Chairperson of Nepal Health Technical Association
3. Chairperson of Nepal Pharmaceutical Association
4. Chairperson of Nepal Radiological Society
5. 3 registered health profressional from pathology, physiology and public health
6. 4 health professional elected by registered health professionals
7. Dean of IOM
8. Representaive of Nepal Medical Council - Member

Status

- Council shall be an autonomous body corporate wit perpetual succession.
- Council shall have separate seal of its own
- Council may like an individual acquire, sell, use and dispose of otherwise manage any movable and immovable property
- Council may like an individual sue by it's name or may be sued by the same name

Ocular Disease

Cataract

Opacification of lens/capsule or both
MCC of blindness in world
Cataract -50 % approximately
Second commonest cause of blindness - Glaucoma
MC Infectious cause of blindness in world
Trachoma
MCC of blindness in children – Vitamin A deciency
MCC of visual impairment - Refractive error

Classification of cataract
Based on morphology

- Nuclear cataract
- Cortical (Anterior/posterior)
- Posterior subcapsular

Based on

- Age related /senile cataract>55-60 years
    - Most common type of cataract- 80%
    - Exposure to UV light
    - Damages lens protein
    - Smokers may have early cataract
    - Exposure to heat, dust, pollution
- Congenital/Developmental
- Traumatic
- Complicated
- Metabolic
- Heat
- Radiation
- Drug induced

1. Nuclear cataract
    - Hemaralopia Day blindness
    - Decreased distant vision>Near vision (due to index myopia)

2. Cortical cataract
    - Nyctalopia- Night blindness
    - Cuneiform cataract- wedge shaped
3. Posterior subcapsualr cataract
    - Maximum loss of vision
    - Maximum glare - closer to nodal point of eye- nodal point lies closer to posterior capsule
    - More posterior the cataract, more vision loss
    - Cupeliform (Cup shaped) cataract
    - Loss of near vision>distant vision, due to pupillary constriction of near vision

A. Congenital/Developmental cataract
    - The critical period of development of foveal fixation- 2-4 months of age
    - Cataracts can lead to loss of foveal fixation
    - Mc type of cataract causing loss of vision in child- zonular/lamellar/Rider's cataract
    - TORCH infection causes cataract
B. Traumatic cataract
    - Blunt trauma
    - Vossius ring- ring of pigment on lens capsule
    - Rosette cataract- flower shaped
C. Complicated cataract
    - Secondary to intraocular disease -
        - Uveitis
        - Glaucoma
        - Retinitis Pigmentosa
    - High myopia
    - Charecterstics
        - PSC
        - Bread crumb appearance
        - Polychromatic lusture
D. Metabolic cataract
    - Due to systemic disease
        - Diabetes- Snowflake/ snowstorm cataract
        - Wilson's disease- sunflower cataract, Keisher Fleischer's ring
        - Galactosemia- oil droplet cataract
        - Myotonic dystrophy- Christmas tree cataract
E. Heat cataract

- True exfoliation cataract
- Glass blower's cataract

F. Radiation cataract
- Ionizing radiation (mc- X-ray)
- Non-ionizing does not cause cataracts - microwave, radio frequency as in phone radiation
- PSC
- The earliest structure to be damaged in eyes- the lens (most sensitive to radiation)

G. Drug-induced cataracts
- Amiodarone
- Busulphan
- Chlorpromazine
- Chloroquine
- Dexamethasone
- Ecothiphate

Stage of cataract

1. Incipient
2. Immature
3. Mature
4. Hypermature

➢ Incipient
- Earliest stage
- Mild blurring of vision
- Glare
- Loss of contasensitivity

➢ Immature
- Partially opaque
- Moderate blurring of vision
- Yellowish grey/iris shadow

➢ Mature
- Completely opaque
- Severe loss of vision
- White
- Intumescent
- May lead to glaucoma

➢ Hypermature
- Loss of volume- lens shrinks

- Loss of zonular support - phacodonesis- subluxation/dislocation of lens
- Classification
  - Morgagnian(cortical)-
    - Cotex liquifies and the nucleus falls into it
  - Sclerotic (Nuclear)-
    - Cataract Brunescent, brown
    - Cataract Nigra, black, hardest

Treatment

- Glasses
- Surgery
- Indication of surgery-
  - Visual handicap
  - Advanced cataract- mature/Hypermature
  - Avoidable in young patients- as it leads to loss of accomodation

Surgery

1. ICCE
2. ECCE with IDL
3. Phacoemulsification
4. FLACS

A. ICCE

➔ Remove cataract+Capsule
➔ Aphakia, Corrected by glass
➔ Diplopia
➔ Only indication of ICCE- Subluxated/Dislocated lens

Aphakia(Sign/Symptoms)

- Diplopia
- Jack in the box scotoma/ roving ring scotoma
- Pincushion defect
- Problems of alignment and orientation
- Deep AC
- Jet black pupil

B. ECCE (with PCIOL)

➔ Cataract removed, capsule left in situ
➔ PCIOL implanted
➔ Pseudophkaia
➔ PMMA IOL- Polymethyl methacrylate

C. Phacoimulsificaiton

➔ Self-sealing

➔ Foldable IOL
➔ Silicone/ Acrylic IOL

D. FLACS- Femto laser-assisted cataract surgery
➔ Advantages - a perfectly circular, centred capsulorhexis

Postoperative complication

1. PCO
2. Cystoid Macular Edema
3. Endopthalmia

PCO

- Most common complication of cataract surgery
- Pathology- During cataract surgery, trauma to the LEC in the anterior capsule- stimulates the proliferation of LEC- migration of Lens Epithelial Cells (LEC) from the anterior capsule to the posterior capsule
- Symptoms
    - Slow painless blurring of vision, loss of contrast
- Types
    - Elsching's pearl
    - Soemmering's ring
- Management
    - ND YAG Laser Capsulotomy(1064 nm)

Cystoid Macular Edema (CMO)

- Slow painless loss of vision
- Metamorphopsia
- Decreased contrasensitivity
- Predisposing factors- Diabetes, uveitis, posterior capsule rupture
- Irvine Gass syndrome - CME after cataract surgery - peaks t 4-6 weeks

Postoperative Endopthalmitis

- Serious intraocular infection - infection of the vitreous cavity - of 2 types
- Early onset- 6 weeks
    - Most commonly within 3 days
    - Most common cause- Staph aureus, Staph epidermis
- Late onset - >6 weeks
    - Most common cause - Propino bacterium acnes
- Symptoms-
    - Loss of vision, redness, pain
    - Lid oedema/hazy cornea/ hypopyon
- Treatment -

    - DOC- Intraviteral antibiotics - Vancimycin(Gram +), Cetazidime/Amikacin(Gram-)
    - Intracameral antibiotics-
- Most important prophylaxis - clean the eyelid/eyelashes with pivodine iodine

Classication:

- Anterior Uveitis: MC
    - Iritis
    - Iridocyclitis (only pars plicata)
- Intermediate
    - Pars planitis
    - Vitritis
- Posterior Uveitis
    - Choroiditis
- Panuveitis
    - Sympathetic Ophthalmitis

Anterior Uveitis:
Causes:

- Idiopathic
- HLA-B27 Spondyloarthropathies
- Ankylosing spondylitis
- Inflammatory Bowel disease-Crohn's
- disease /Ulcerative colitis
- Psoriatic arthritis
- Reactive arthritis (Reiter's Syndrome)
- Conjunctivitis, Urethritis, Arthritis (CUR)
- JRA (Juvenile Idiopathic Arthritis)
    - Pauciarticular, ANA positive,
    - RF Negative
    - IOLs contraindicated

Symptoms:
Redness, pain, Blurring of vision
Signs:

- ❖ Circumciliary/Circumcorneal congestion.
- ❖ Reddish-violet color.
- ❖ Cells-WBC in AC
- ❖ Sign of activity
- ❖ Flare–Protein deposition in aqueous humor
    - ➢ Earliest sign of uveitis
- ❖ KPs -Keratic precipitates –
    - ➢ Neutrophils and lymphocytes on corneal endothelium
- ❖ Arlt's triangle

- ❖ Mutton-fat KP's
- ❖ Iris Nodules -
  - ➢ Koeppe's –on pupillary margin
  - ➢ Busaca's- on iris surface
- ❖ Synechiae – adhesions of iris to surrounding structures
- ❖ Anterior- cornea, Glaucoma
- ❖ Posterior- lens, Cataract
- ❖ Miosis
- ❖ Low IOP
- ❖ Festooned Pupil –irregular pupil due to posterior synechiae
- ❖ Hypopyon- collection of cells at the bottom of AC

Intermediate Uveitis:

- Pars planitis with vitritis
- Idiopathic
- Sarcoidosis
- Floater's/Muscae volitantes
- CME- MCC of loss of vision

Signs -

- Snowballs and Snowbanks

Posterior Uveitis:

- Infections Non-infectious
- Toxoplasmosis Sarcoidosis
- Tuberculosis
- Toxocariasis

Choroiditis
O/E

- Choroiditis
- Chorioretinitis/ Retinochoroiditis
- Vitritis
- "Head light in fog"

Treatment

A. Anterior Uveitis

- Topical steroids (DOC)
  - MC S/E of topical steriod-Glaucoma
  - MC S/E of systemic steroids-Cataract
- Cycloplegics –
  - Mechanism of action- Relax ciliary spasm
  - Dilate pupil, break posterior synechiae

For further study on ocular diseases, refer to the ophthalmology notes by Dr. Sashwat Ray.

References

References

Brilliant, R. L. (1999). *Essentials of Low Vision Practice* (R. L. Brilliant, Ed.). Elsevier - Health Sciences Division.

Brooks, C. W. (2023). *System for Ophthalmic Dispensing*. Elsevier.

Chaudhry, M. (2007). *Contact Lens Primer*. Jaypee Brothers Medical Publishers.

IV, G. O. W., & Waring, G. O. (2024). *2024-2025 BASIC AND CLINICAL SCIENCE COURSE, SECTION 13: Refractive Surgery*. American Academy of Ophthalmology.

Khurana, A. K., Khurana, A. K., & Khurana, B. (n.d.). *Theory and Practice of Optics and Refraction*. Elsevier India.

Pine, K. R., Jacobs, R. J., & Sloan, B. H. (2015). *Clinical Ocular Prosthetics*. Springer International Publishing.

Salmon, J. F. (2024). *Kanski's Clinical Ophthalmology: A Systematic Approach*. Elsevier Health Sciences.

Scheiman, M., & Wick, B. (2008). *Clinical Management of Binocular Vision: Heterophoric, Accommodative, and Eye Movement Disorders*. Wolters Kluwer Health/Lippincott Williams & Wilkins.

Wright, K. W., Spiegel, P. H., & Thompson, L. (Eds.). (2006). *Handbook of Pediatric Strabismus and Amblyopia*. Springer.

Salmon, J. F. (2024). *Kanski's Clinical Ophthalmology: A Systematic Approach*. Elsevier Health Sciences.

Scheiman, M., & Wick, B. (2008). *Clinical Management of Binocular Vision: Heterophoric, Accommodative, and Eye Movement Disorders*. Wolters Kluwer Health/Lippincott Williams & Wilkins.

Wright, K. W., Spiegel, P. H., & Thompson, L. (Eds.). (2006). *Handbook of Pediatric Strabismus and Amblyopia*. Springer.