The Neotia University

THE NEOTIA UNIVERSITY
ज्ञानम् आत्म प्रदीपाय

Ophthalmic Instruments II
Practical Manual
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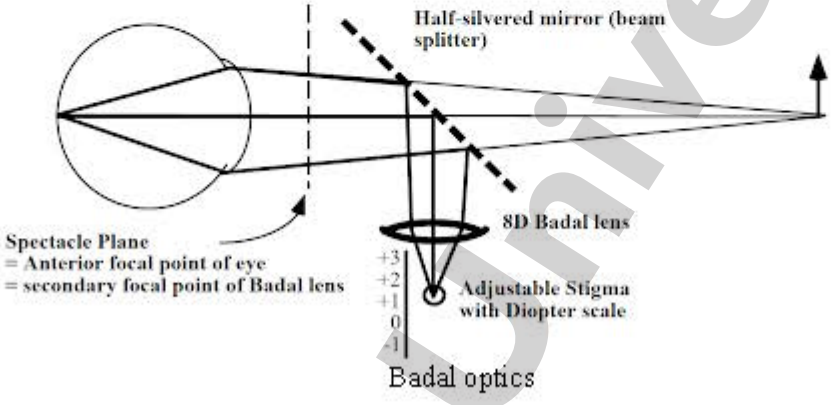
PRACTICAL 1: LENSOMETER

Working principle

The Lensometer works on Badal principle which states that if the eye is placed at the focal point of a positive lens, the virtual image of an object located between the lens and the anterior focal point will always subtend the same visual angle.



Badal optics

A Lensometer consists of an illuminated target which is movable, a powerful convex lens and a afocal telescope as eyepiece. When a lens of unknown power is introduced, the image of the illuminated target is made out of focus. The refractive power of the unknown lens can be measured by moving the illuminated target closer to or further from the convex lens.

Parts & their operation

Lensometer

1. Eyepiece: The eyepiece is mounted on a screw type focusing knob. The eye should be set at 'zero' before measuring a lens power. This is done by rotating the focusing knob towards the plus first and towards minus until the reticule becomes clear.

2. Chrome curled sleeve: It is reticule adjust knob. The reticule is rotated to orient the prism base.

3. Prism compensating device knob: A rotary prism is attached in it which can be operated to dial in 0 to 25 Prism Dioptre anywhere from 0 to 360 degree.

4. Lens marker: It consists of three spring operated pins which can be dipped into water soluble ink. It is used to spot the optical centre or the prism reference point.

5. Gimbal: It is pivoting lens holder place and hold the lens or frame in position.

6. Spectacle table: The spectacle frame or the lens is kept on it and can be centred by raising or lowering the table.

7. Magnifier: It is a convex lens which magnifies the axis scale.

8. Cylinder axis wheel: It is used to determine cylinder axis. By rotating the axis wheel primary and secondary power meridian can be adjusted.

9. Filter control lever: It is a small knob sued to apply green filter for better visibility.

10. Instrument inclination control and locking lever: It is used to adjust the viewing angle of the Lensometer and the instrument can be locked by a knob at this desirable viewing angle. The Lensometer is adjusted according to individual's height and posture and then it should be locked in that position.

11. Power drum: Is it a hand wheel scaled with reading ranging from +20 to -20 Dioptre. It is rotated on either side until the mire become clear while measuring the power.

12. Spectacle table lever: It is used to raise or lower the spectacle table.

PRACTICAL 2: HVF - ANALYSIS OF PRINTOUT

Introduction

Humphrey Visual Field analyser is an instrument used to assess the defects in visual field due diseases of optic nerve and visual pathway. It consists of a bowel positioned at fixed distance from the eye. A series of white light stimuli of varying intensity are projected trough out the bowel where as the bowel is uniformly illuminated. The patient is given a hand-held button and is instructed to press the button whenever the light stimulus appears in the bowel.

Testing strategies

There are two types of basic strategies

1. *Threshold test:* Threshold test uses the threshold stimulus to diagnose and assess the progression of glaucoma and neurological diseases.

2. *Supra-threshold test:* It is a screening test performed to detect glaucoma which uses supra-threshold stimulus.

Testing programs

1. Central 30-2: It measures central 30 degree area from the point of fixation. It tests 76 points and the point density is 6 degree.

2. Central 24-2: It tests 54 points with in central 24 degree from the point of fixation. The distance between two points is 6 degree.

3. Central 10-2: Number of testing points are 68 with in central 10 degree from the point of fixation. Distance between two points in this program is 2 degree.

4. Macular program: It tests 16 points in macular region which extends to 5 degree from the point of fixation. Point density in this program is 2 degree.

Testing algorithms

1. *Full threshold:* It uses a supra-threshold stimulus to project at each location based on the threshold values tested on prior points. The intensity of light is decreased at a certain increment rate until the stimulus become invisible and again increased at a certain rate until it is visible.

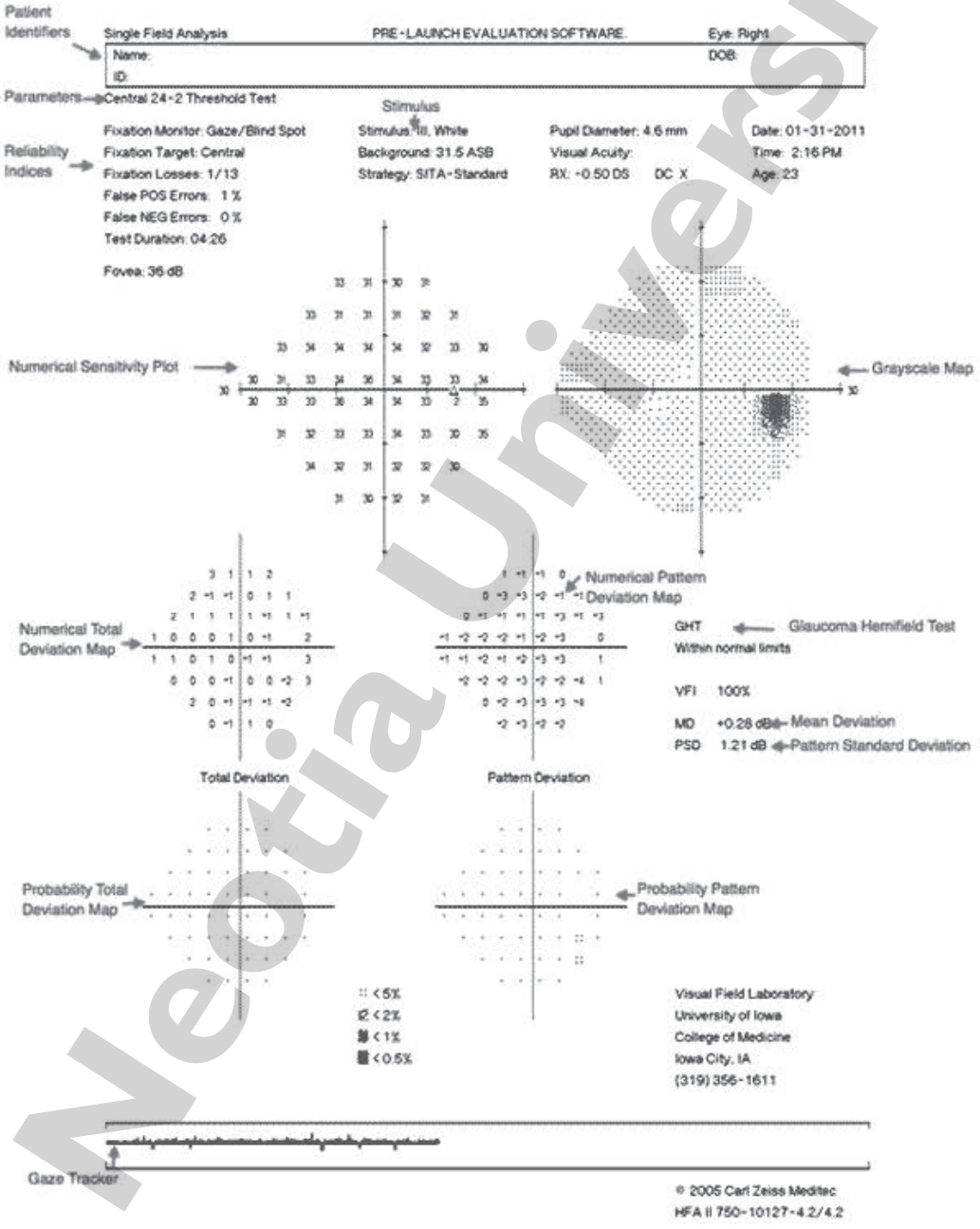
2. *FASTPAC:* The FASTPAC algorithm tests the threshold by increasing the stimulus intensity with a rate of 3dB until the threshold value is reached.

3. SITA: SITA stands for Swedish Interactive Threshold Algorithm. This algorithm takes less time without compromising the reliability of the tests.
SITA Standard takes 7 minutes for each eye whereas SITA fast takes 4 minutes for each eye.

Analysis of HVF printout

Reliability Indices: The parameters used to determine reliability of the test are -

1. *Fixation loss:* It is determined by providing stimulus to the blind spot and fixation loss is recorded if the patient responds to the stimulus. If the fixation loss is more than 20% it is denoted by XX and the result of the test is not reliable



Humphrey Visual Field test printout

2. *False positive:* False positive is recorded when patient responds to the sound stimulus and in absence of light stimulus. False positive more than 33% is denoted by XX and the test is considered to be unreliable.

3. *False negative:* False negative is recorded when patient does not respond to the light stimuli. It is tested by providing brighter stimuli to a pretested point where the patient has already responded to dull stimuli. Again a high false negative is denoted by XX and the test result is not reliable.

Sensitivity values:

1. *Numerical display:* The Numerical display represents the threshold value of retinal sensitivity in dB. More the value in dB, higher the sensitivity and vice versa.

2. *Grey scale:* The Grey scale is nothing but the graphical representation of Numerical display. The area of lower sensitivity and higher sensitivity are represented by the darker and lighter tone respectively.

3. *Total deviation:* Total deviation represents the difference between measured value of retinal sensitivity and age related normal value of the population at a particular point. If the difference is negative it indicates that sensitivity is less than normal at that point and in case of negative value, the sensitivity is more than normal.

4. *Pattern deviation:* The pattern deviation represents the generalised reduction of vision caused due to generalised diseases other than optic nerve disorders.

5. *Probability value plot:* Probability value plot represents the percentage of threshold at a point. There are four categories i. e., 5%, 2%, 1% and 0.5%. Darker the point lesser the percentage and lesser the percentage more will be probability of that point to be defective.

Global indices: Global indices are helpful in diagnosing glaucoma.

1. *Mean deviation:* It represents the overall mean deviation from the age related normal value and it is derived from the total deviation. A negative value indicates presence of field loss and positive value indicates that field is better than average.

2. *Pattern Standard deviation:* The PSD measures the focal loss of vision. Age related sensitivity at each point have a pattern standard deviation as zero. A increased PSD is indicator of defective vision.

Visual field index: VFI measures the overall visual field function and it is expressed in percentage. The normal age related value is 100% and any reduction in the percentage indicates the loss of visual field.

Glaucoma hemifield test: The GHT analyser is used to compare five points in the superior field with five corresponding and mirrored points in the inferior field. This is available in 30-2 ans 24-2. The possible results are -

1. *Outside the normal limit:* If the difference found in 1% population.
2. *Borderline:* If the difference is found in 3% population.
3. *Abnormally low sensitive:* If the best sensitive part is found in less than 5% population.
4. *Abnormally high sensitive:* If the best sensitive part is found in more than 99.5% population.
5. *Within normal limit:* GHT can be considered as normal if all the above conditions are not found.

PRACTICAL 3: A-SCAN

Introduction

B-Scan stands for brightness scan. It is two dimensional ultrasonic scan which can directly be performed on eye by making the eye anesthetized or over the eyelid by putting a coupling jelly on it. Uses of B-Scan Ultrasonography include diagnosis of retinal and choroidal detachment, detection of intraocular foreign bodies, detection of intraocular tumors, visualization of lesions with their location, shape, size and borders.

Principle

A-Scan probe transfer a single beam of ultrasound through the ocular tissues. When the sound beam encounters at the junction of two medium an acoustic interface is created at the junction of two medium with different sound velocities. Part of the sound wave is reflected back and an echo is created. Strength of the echo is dependent on the difference in sound velocity at the interface. More the difference greater the strength of the echo.

A-Scan biometry uses a formula

Distance = Velocity x time

Basic Components:

A-Scan Biometer

1. Transducer: It is a piezoelectric probe consisting of a Pulsar and a Receiver
2. Amplifier
3. Display

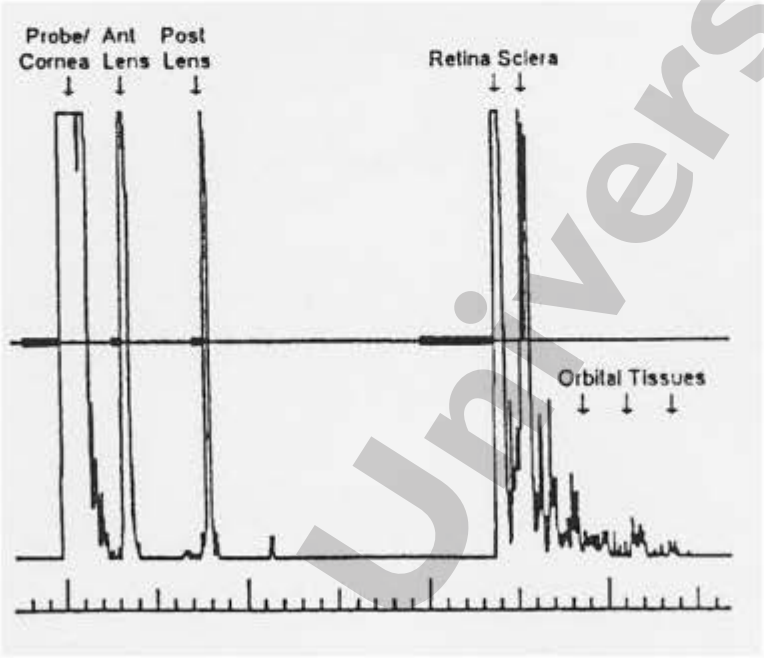
Analysis of the result

The parameters

1. *Gain:* The gain is measured in decibels and it affects on both the resolution and amplitude. Highest the gain widest will be the sound beam and hence the spike height will be maximum. Lower the gain, smaller the spike height.

2. *Resolution:* It is the ability to represent two separate interfaces lie in close proximity, one directly behind the other.

3. *Gates:* Gates are the electronic measuring callipers which measures the distance between two points.



A-Scan display

- ✧ The first spike is the tallest one and it represents the probe interface with cornea.
- ✧ Then there are two spikes separated by a short distance represent the anterior and posterior surface of crystalline lens.
- ✧ After the lens spikes there is a flat horizontal line representing the vitreous.
- ✧ Distal to the vitreous echoes there are series of spikes which are progressively decreased in height. The three spikes represent retina, sclera and orbital tissues respectively.
- ✧ In case of retinal or vitreous detachment additional spikes are found in the flat region with variable amplitudes.
- ✧ In presence of intraocular foreign bodies there will be high reflectivity of the echoes.

PRACTICAL 4: B-SCAN

Introduction

Subjective refraction is the technique of determining the refractive status of the eye following the subjective response of the patient.

Aim of the subjective refraction is to provide maximum visual acuity by providing the spherical and cylindrical lenses in front of the eye. Other than proving best corrected visual acuity subjective refraction also helps in assessing amount of vision loss due to an ocular pathology, visual status of a treatment or surgical procedure.

Principle

B-Scan probe transfer a high frequency ultrasound into the ocular tissues. The high frequency produces shorter wavelength hence enhances the resolution of the echoes. When the sound waves encounter with the ocular tissues the sound waves are reflected back and an echo is created. Multiple short echoes are produced in a second and the reflected echoes are detected, processed and displayed as a two dimensional image.

Components

C-Scan machine

1. Transducer: It consists of a pulsar which converts electrical energy into sound energy and a receiver which converts the sound energy into electrical energy.

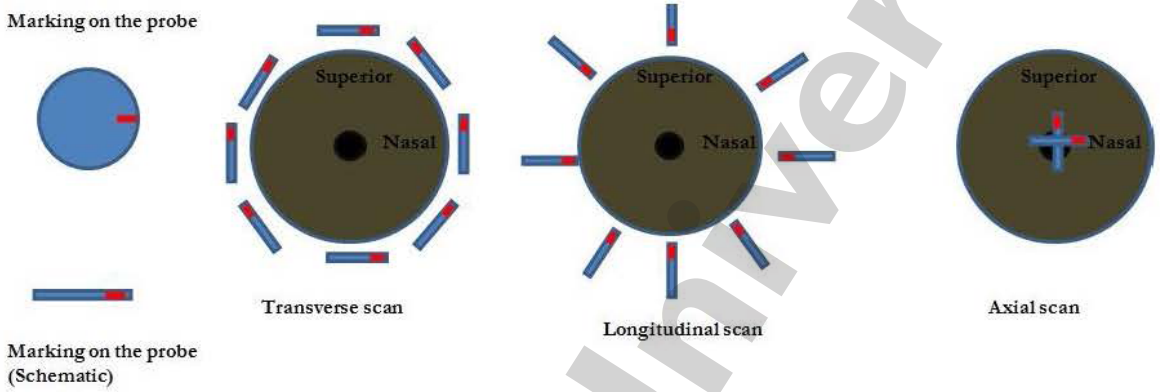
Probe: It produced sound beam and consists of a mark on it which indicates beam orientation.

B-Scan probe

2. Amplifier
3. Display

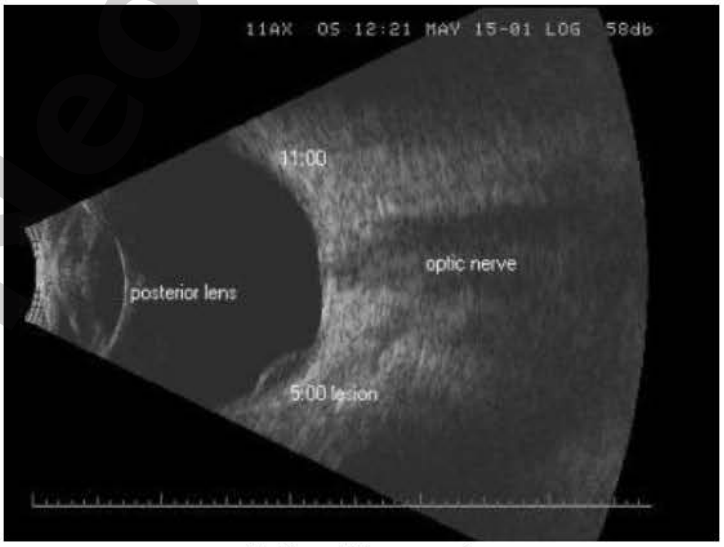
Probe orientation

1. Transverse
2. Longitudinal
3. Axial



- ✧ ***Transverse scan:*** The probe mark is kept parallel to the Limbus and movement of the probe is sideways from Limbus to fornix. It provides the lateral extension of the lesion.
- ✧ ***Longitudinal scan:*** The probe mark is kept perpendicular to the Limbus towards the centre of cornea. It provides the antero-posterior extension of the lesion
- ✧ ***Axial scan:*** The probe is kept axially and on the centre of cornea while the patient looks at primary gaze. The probe mark can be orientated as horizontal-axial, vertical-axial and oblique-axial. It detects lesion in posterior pole and also assess optic nerve.

Analysis



B-Scan Ultrasound

Normal B-Scan Ultrasound characteristics:

Lens: Oval highly reflective structure

Vitreous: It is echo lucent

Retina, Choroid and Sclera: All three together reveal a highly single reflective structure

Optic Nerve: It resembles a wedge shaped acoustic void in retro-bulbar region.

Extraocular muscles: Extraocular muscles are found as echo lucent to low reflective structures.

Orbit: It is a highly reflective to ultrasound

Abnormal B-Scan Ultrasound characteristics:

Anechoic: No echo

Attenuation: When sound wave is absorbed. It is indicative of tumour.

Shadowing: When sound wave strongly reflected and nothing passes through it. This may be found in Choroidal Osteoma, Optic disc drusen and presence of air bubbles.

Reverberation: There will be presence of thick echoes bouncing back and forth. It is indicative of intraocular foreign bodies.

Fine dot like echoes: These may be found in vitreous haemorrhage, vitreous floaters and vitreous exudation.

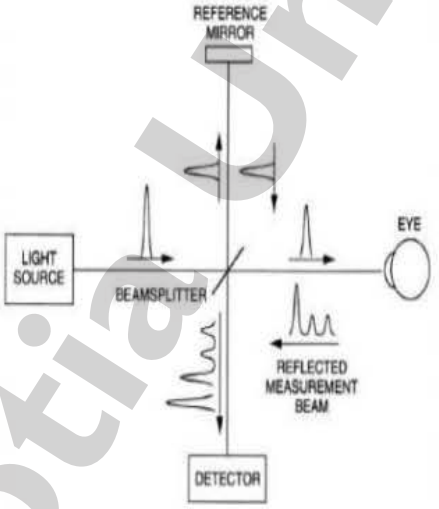
Membranous echoes: This is suggestive of vitreous membrane, posterior vitreous detachment and retinal detachment.

Thick mass like echoes: These are observed in retinal or choroidal tumour.

PRACTICAL 5: OPTICAL COHERENCE TOMOGRAPHY-ANTERIOR

Principle

Optical Coherence Tomography is based on the principle of Michelson's Interferometry. Interferometry is the procedure of superimposing two or more images. When light rays with same frequency and same phase are projected form the different sources, the sources are termed as coherence sources. If the light rays originated form coherence sources are superimposed together, they will add each other due to constructive interference.



Optics of OCT

In light from a source is directed on a partially reflecting mirror which splits the light rays into a reference and a measuring beam.

The measurement beam reflected from the specimen with different time delays.

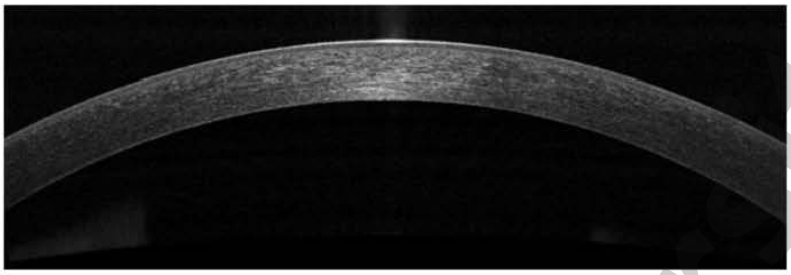
The light from a reference beam is reflected from a reference mirror at a variable distance which produces a variable time delay.

The light from the specimen consisting of multiple echoes and light from the reference mirror consisting of a single echo at a known delay are combined and detected.

Basic features and their analysis

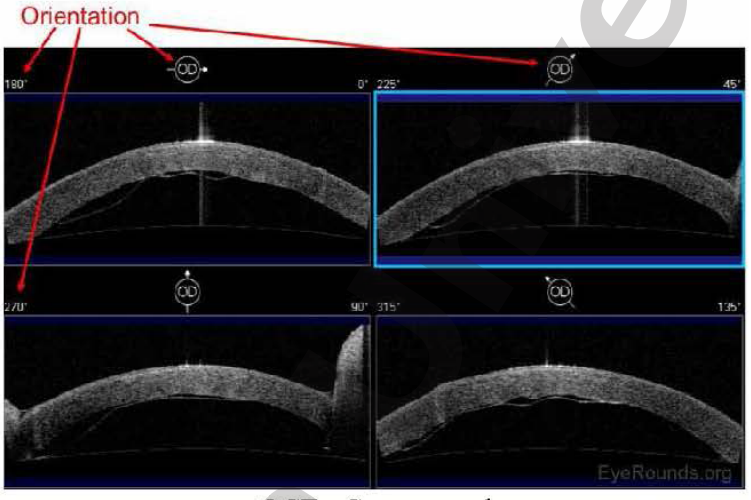
Imaging modes:

1. High resolution cornea single



OCT - Cornea single

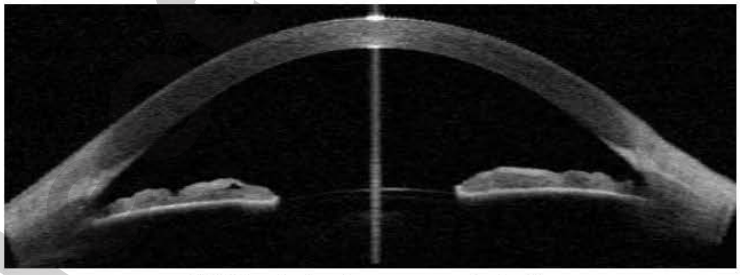
2. High resolution cornea quad



OCT - Cornea quad

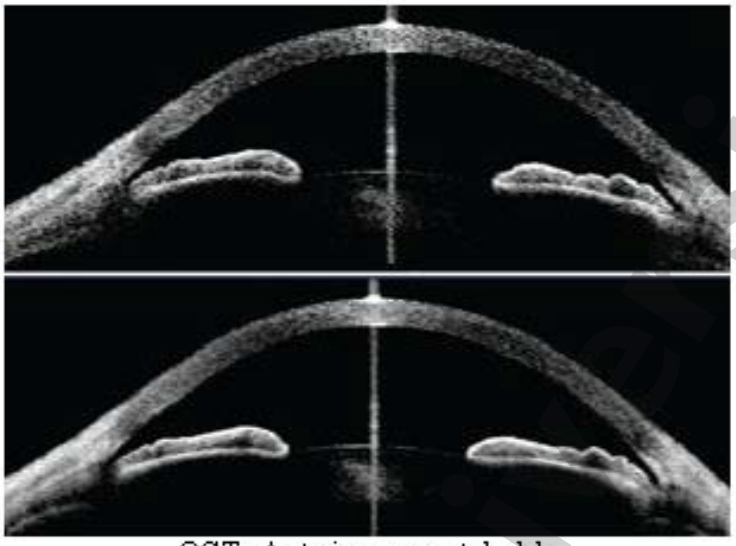
3. Pachymetry

4. Anterior segment single



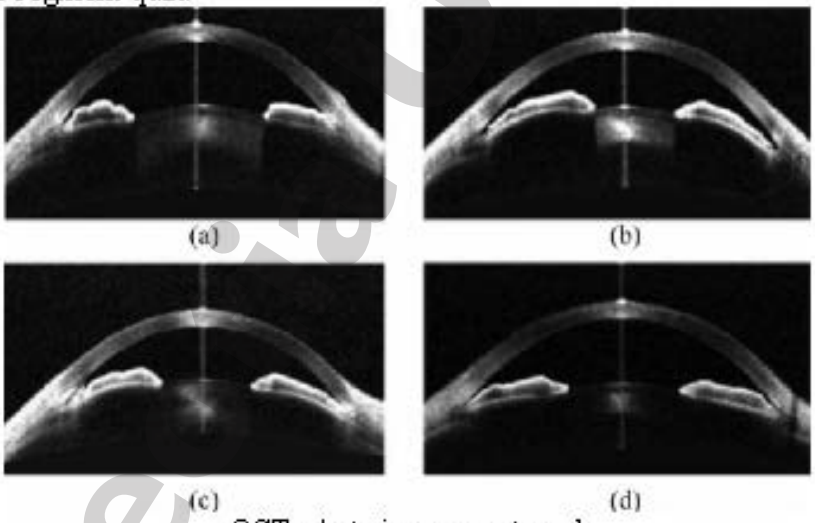
OCT - Anterior segment single

5. Anterior segment double



OCT - Anterior segment double

6. Anterior segment quad



OCT - Anterior segment quad

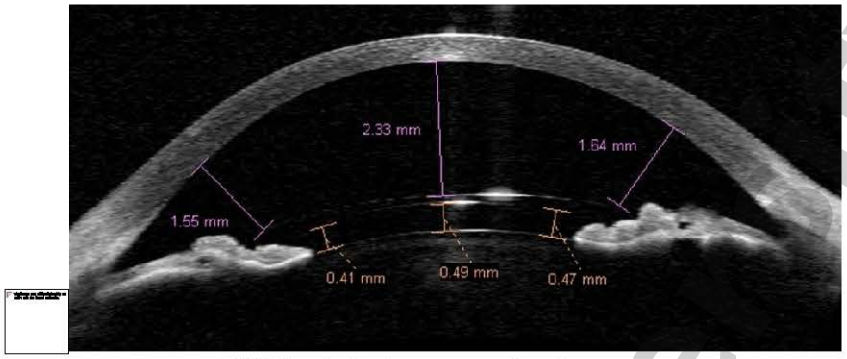
Resolution modes of imaging:

1. *Standard resolution imaging:* This imaging provides broader view of anterior segment which includes cornea, anterior chamber, iris and both angles. Imaging extends at 16 mm in width and 6 mm depth and provides 256 scans in 0.125 seconds.

2. *High resolution imaging:* Imaging area is 10 mm in width and 3 mm in depth. It provides detailed imaging of cornea or any other structure in anterior chamber. 521 scans are taken in 0.250 seconds.

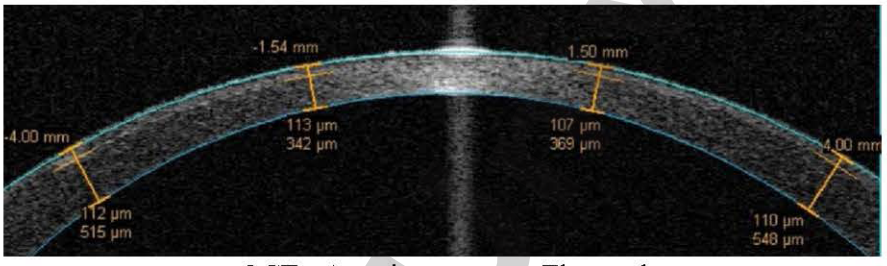
Measurement tools:

1. Calipers



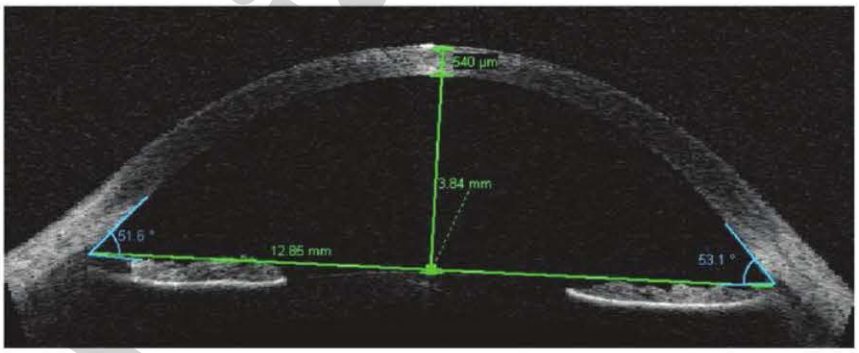
OCT - Anterior segment calipers

2. Flap tool



OCT - Anterior segment Flap tool

3. Angle tools
    i. Iridocorneal angle tool
    ii. Anterior chamber angle tool
4. Chamber tools for anterior chamber depth and width measurement

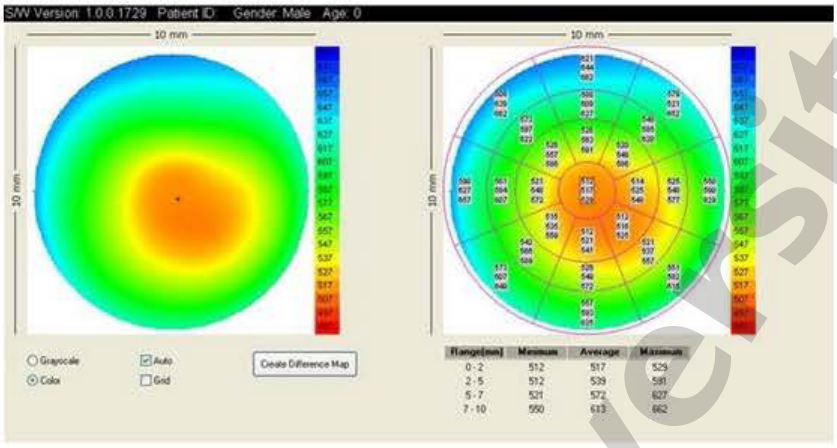


OCT anterior segment; tools to measure AC depth, width and angle

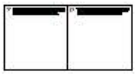
5. Anterior chamber refractive tool set

Global Pachymetry map:

It provides thickness of the cornea from centre to periphery and the map is formed from 16 modified high resolution scans.



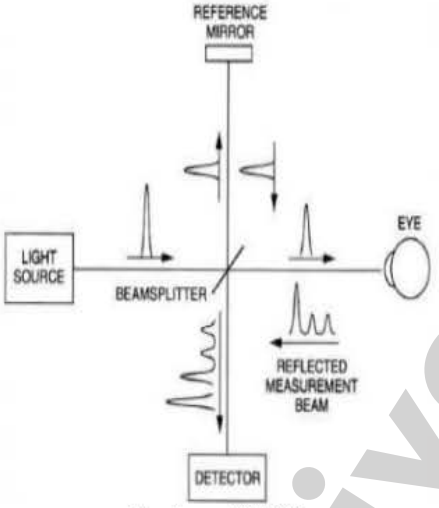
OCT - Anterior Segment; Pachymetry



PRACTICAL 6: OPTICAL COHERENCE TOMOGRAPHY- POSTERIOR

Principle

Optical Coherence Tomography is based on the principle of Michelson's Interferometry. Interferometry is the procedure of superimposing two or more images. When light rays with same frequency and same phase are projected form the different sources, the sources are termed as coherence sources. If the light rays originated form coherence sources are superimposed together, they will add each other due to constructive interference.



Optics of OCT

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The measurement beam reflected from the specimen with different time delays.

The light from a reference beam is reflected from a reference mirror at a variable distance which produces a variable time delay.
The light from the specimen consisting of multiple echoes and light from the reference mirror consisting of a single echo at a known delay are combined and detected.

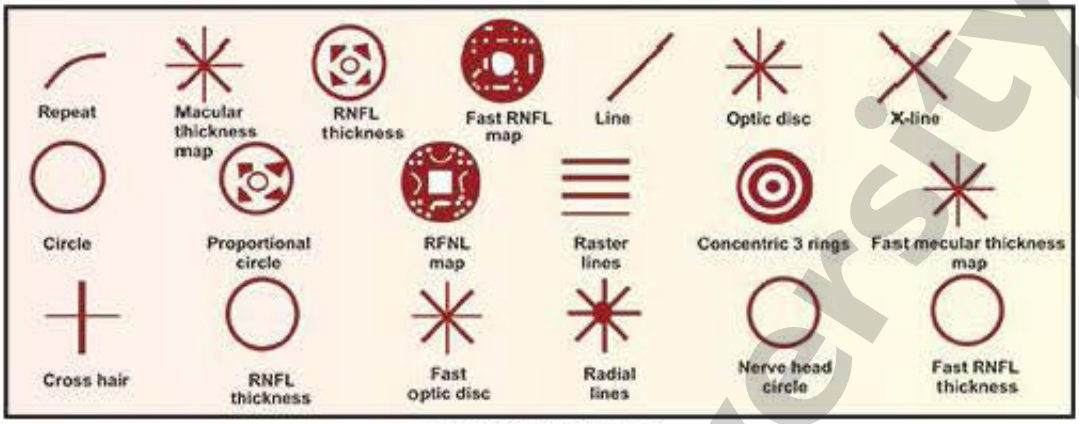
Scanning protocols

Retinal scan & Macular scan: Features include in this are -

1. Line scan
2. Redial line scan
3. X line and circle scan
4. Raster lines scan
5. Cross hair scan
6. Macular thickness scan
7. Fast Macular thickness scan

Retinal nerve fibre layer scan

1. RNFL thickness scan (3.4 mm)
2. Fast RNFL thickness scan (3.4 mm)
3. Proportional circle scan
4. Concentric 3 rings scan
5. RNFL thickness scan
6. RNFL maping

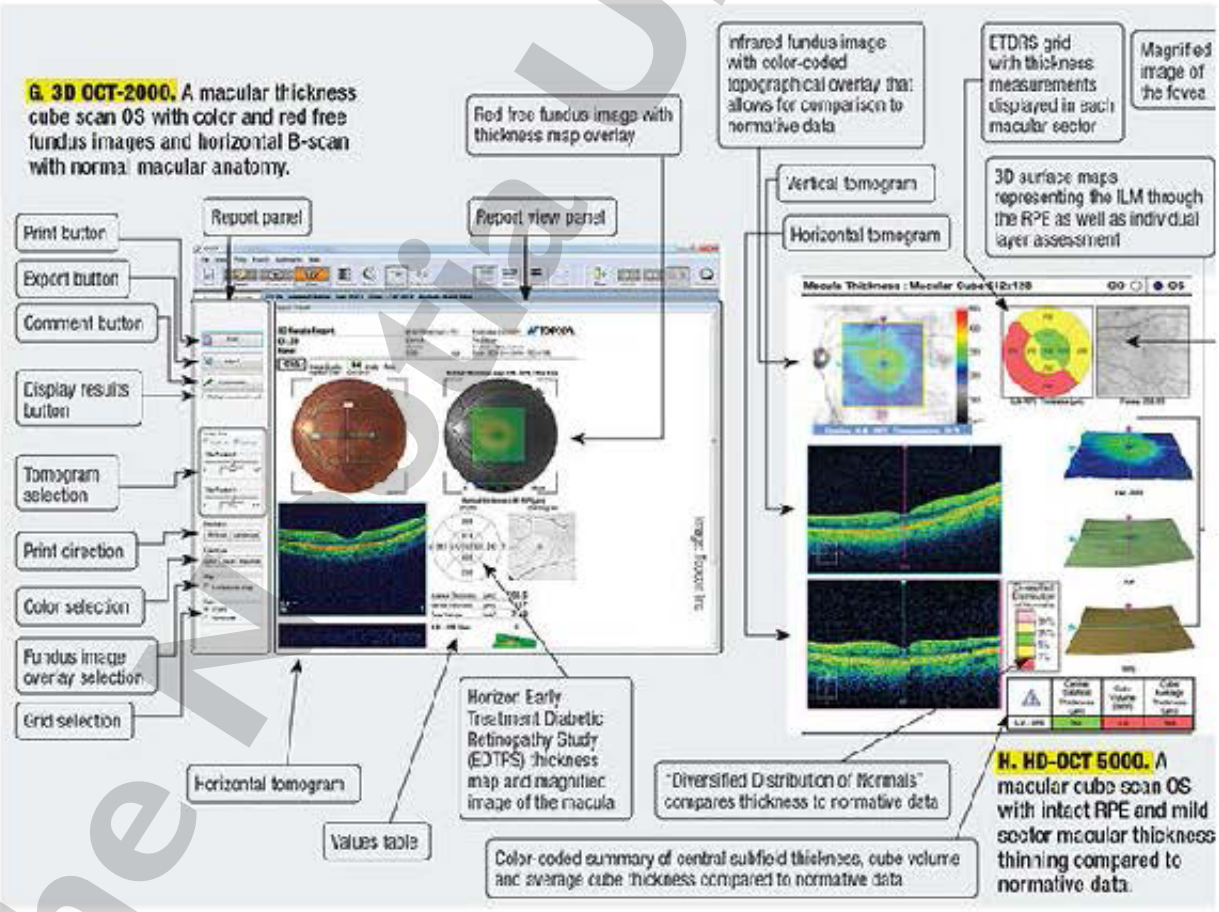


OCT- Scan protocol

Optic nerve head scan

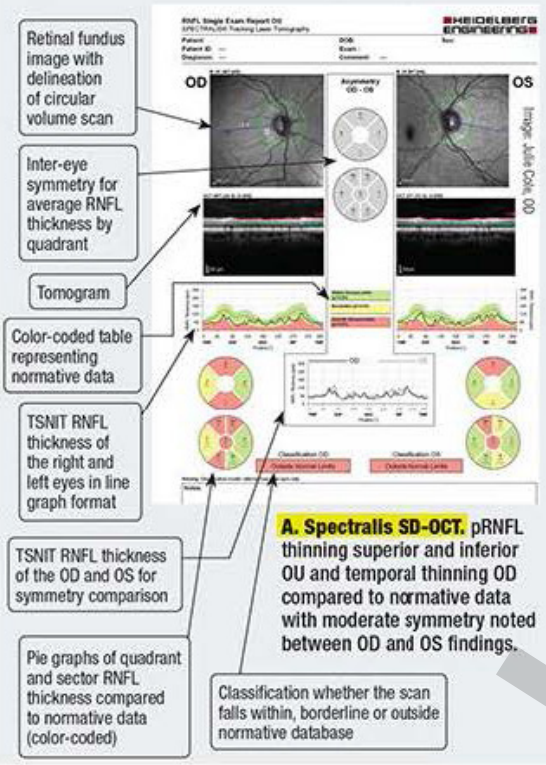
1. Optic disc scan
2. Fast Optic disc scan

Analysis of OCT

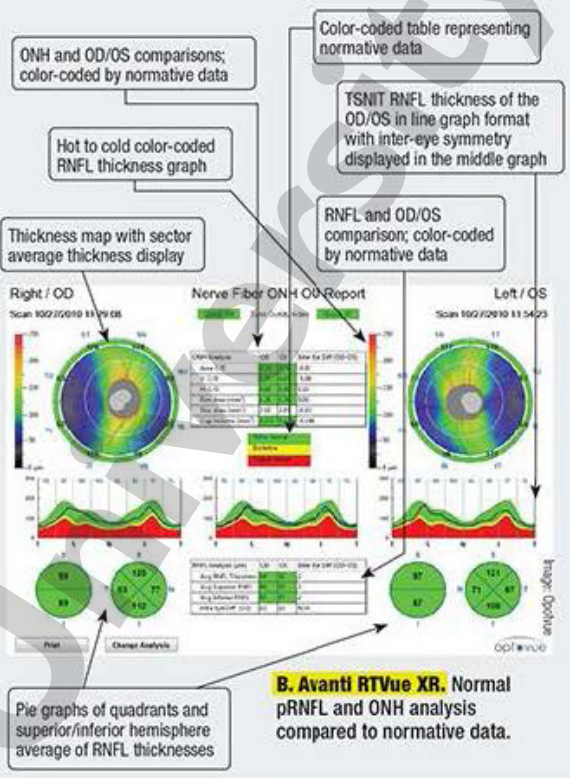


OCT - Macula

Figures A-D. RNFL Thickness Analysis By Manufacturer

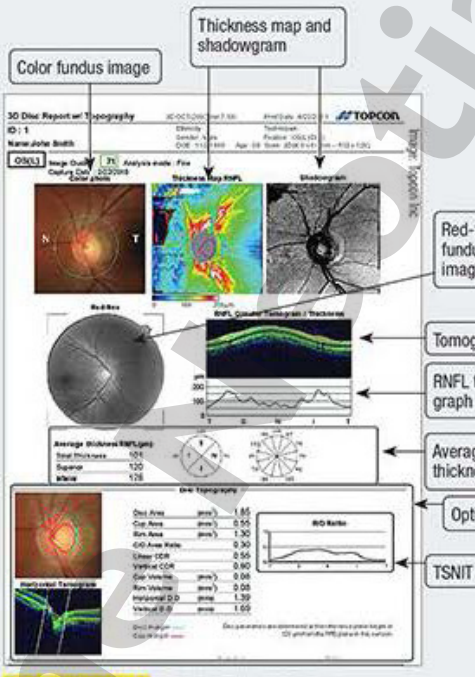


A. Spectralis SD-OCT. pRNFL thinning superior and inferior OU and temporal thinning OD compared to normative data with moderate symmetry noted between OD and OS findings.

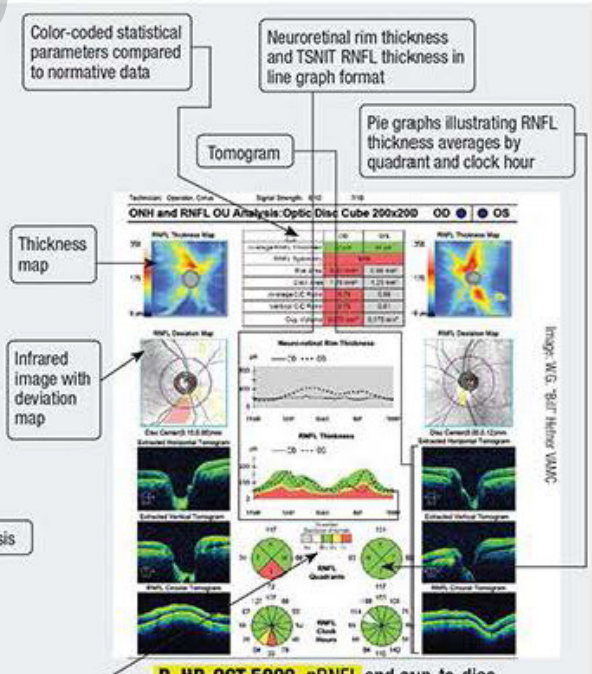


B. Avanti RTVue XR. Normal pRNFL and ONH analysis compared to normative data.

OCT - RNFL



C. 3D OCT-2000. A tilted nerve OS with topographical summary and no apparent pRNFL thinning or ONH statistical outliers.



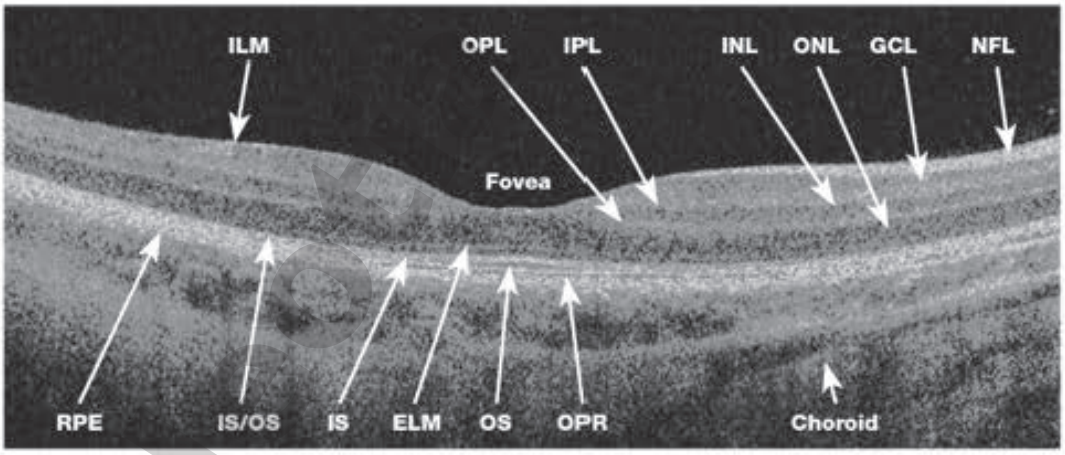
D. HD-OCT 5000. pRNFL and cup-to-disc asymmetry OD greater than OS with inferior pRNFL thinning OD compared to normative data.

Distribution of normal: green correlates to a 95% normal distribution; yellow indicates less than 5% but greater than 1% normal distribution; red is associated with less than a 1% normal distribution, meaning that less than 1% of normal patients will have this measurement compared to Zeiss' defined normative data

OCT - ONH

Normal features of retinal OCT

- ✧ Posterior Hyaloid is found as very faint, fine and slightly reflective line
- ✧ Internal limiting membrane is can easily be demarcated as there is difference in contrast between reflective retina and non-reflective vitreous.
- ✧ The nerve fibre layer is visible as a highly reflective line and visibility is more on nasal side due to the density of papillomacular bundle.
- ✧ Fovea is shown as a depressed structure in macular scan.
- ✧ The outer retina is bounded by highly reflective band which represents the retinal pigment epithelium. This band can be divided into three layers. The first one is a thin hyper reflective layer represents the junction of inner and outer photoreceptors. The second one is hypo reflective outer segment and the third one is the most hyper reflective.
- ✧ The Bruch's membrane and the choriocapillaries are seen as a single reflective membrane.
- ✧ The larger vessels are located indirectly by the shadow of cones as they are found on the posterior layer.
- ✧ The OCT image can be displayed in colour and alternately on gray scale where highly reflected light is brighter than less reflected light.



NFL: Nerve fiber layer
ILM: Inner limiting membrane
GCL: Ganglion cell layer
IPL: Inner plexiform layer
INL: Inner nuclear layer
OPL: Outer plexiform layer
ONL: Outer nuclear layer
ELM: External limiting membrane
IS: Photoreceptor inner segment
OS: Photoreceptor outer segment
IS/OS: Interface between IS and OS
RPE: Retinal pigment epithelium
OPR: Outer photoreceptor/ RPE complex

OCT - HD Retinal scan

- ✧ Highly reflective lights are indicated in brighter colours i. e., red and yellow.
- ✧ Low reflective lights are represented in darker colour i. e., black and blue
- ✧ Intermediate reflectivity is represented in green.

PRACTICAL 7: FUNDUS FLUORESCE ANGIOGRAPHY

Principle

Fluorescence is the luminance property of certain molecules to emit light of larger wavelength when these are stimulated by the light of shorter wavelength.

Sodium Fluoroscein is stimulated to light energy in between 465 nm to 490 nm and become fluorescence at wavelength ranging from 520 nm to 530 nm. The excitation wavelength which is absorbed by the sodium Fluoroscein belongs to blue light and the emitted wavelength is green-yellow.

When Fluoroscein dye is injected intravenously, 80% of the dye is bounded to the protein and only 20% is available for fluorescence. The blue filter present in front of flash light of the Fundus camera filters out all other lights and the blue flash excites the unbound dye and changes the structures in the eye to green-yellow light at 520 nm to 530 nm. A green-yellow barrier filter is used in front of the camera to block any blue lights reflected from the Fundus and the green-yellow light is allowed to pass through it.

Phases of Angiogram

1. ***Choroidal phase:*** It is also called pre-retinal phase. In this phase blood fills the choroidal circulation which usually takes 9-15 seconds after injection of dye. There will be initial patchy filling followed by a diffuse filling as the dye leaks out of the fenestration of choriocapillaries.

2. ***The Arterial phase:*** There will be filling of choroidal arteries and it starts after 1 second of choroidal filling.

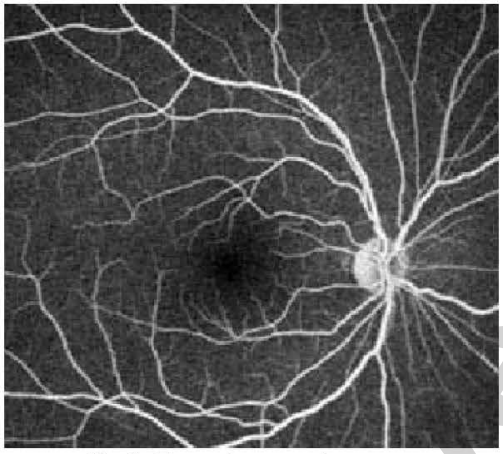
3. ***The Arterio-venous phase:*** This is also called capillary phase. In this phase there will be total filling of retinal arteries and capillaries with early linear flow of dye into the vein.

4. ***The Venous phase:*** In early venous phase artery and capillaries are completely filled and there will be lamellar venous flow. In mid venous phase some veins will be filled completely and will have lamellar flow. In late venous flow all the veins will be filled completely and the arteries start to empty.

5. ***Late phase:*** Late phase shows the process of elimination of dye from the choroidal and retinal circulation. In each moment the intensity of dye is reduced while the disc shows some staining. In about 10 minutes there will be complete elimination of dye from retinal circulation.

Interpretation

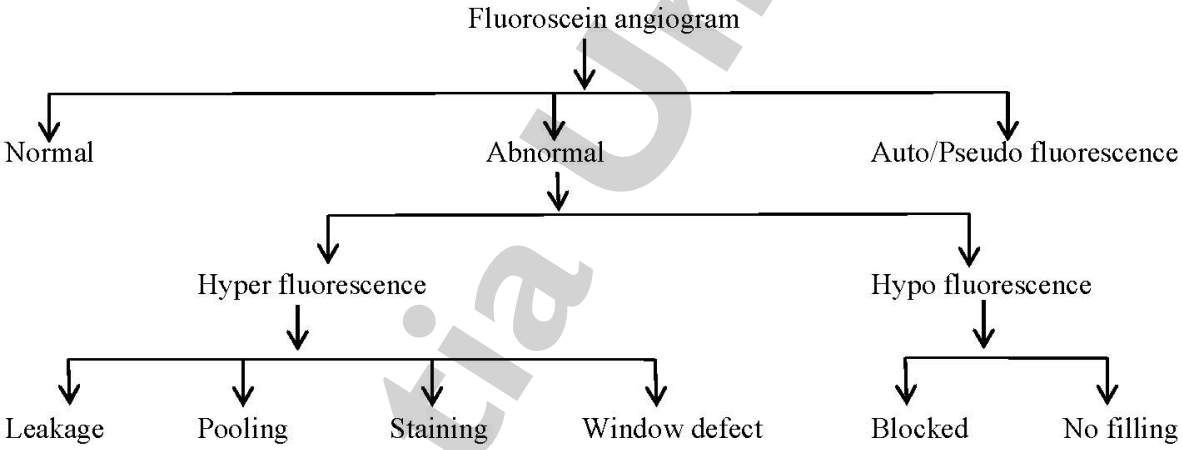
Normal Angiogram: There will be patchy filling of choroid which is due to outer blood retinal barrier, filling of retinal blood vessels for which inner blood retinal barrier is responsible. Foveal avascular zone is dark. There will be absence of hypo dense or hyper dense in retina.



Dark Foveal avascular zone

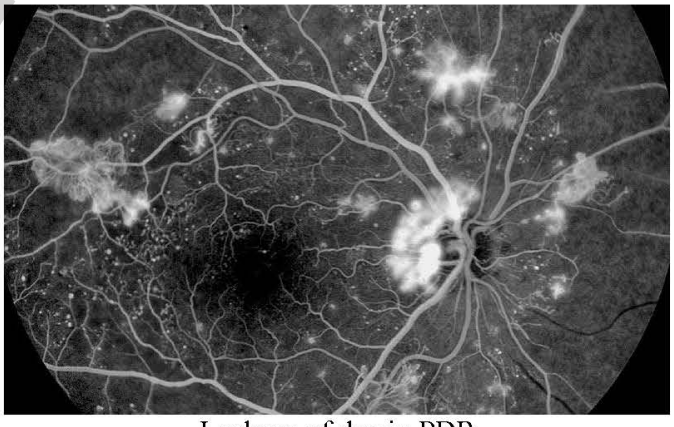
Abnormal angiogram:

Flowchart for FFA interpretation



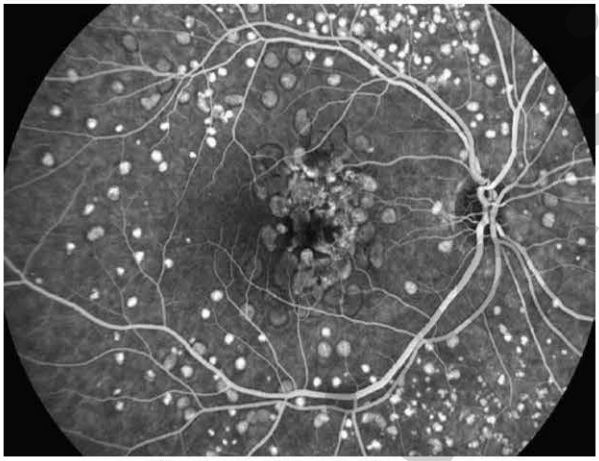
Hyper fluorescence: Hyper fluorescence is the condition in which greater level of fluorescein is found than normal angiogram due to increased density of dye.

Leakage: Leakage is characterised by escape of Fluoroscein from the blood vessels due to increase permeability. Leakage is found in diseases like proliferative diabetic retinopathy, retinal vein occlusion, cystoid macular edema, Papilloedema.



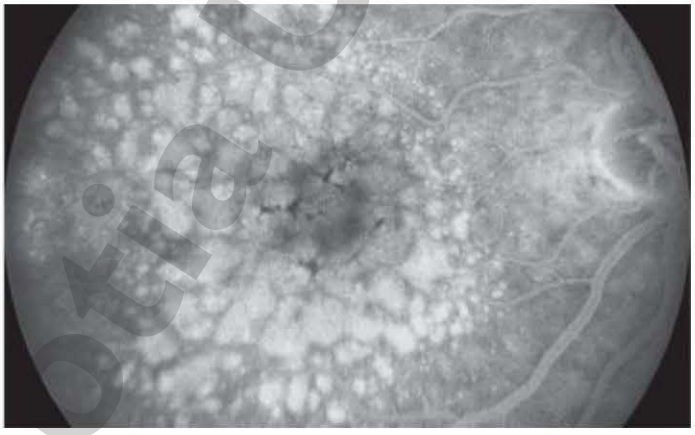
Leakage of dye in PDR

Pooling: It is characterised by accumulation of dye with in anatomical space which is due to break down of outer blood retinal barrier, e. g., central serous retinopathy.



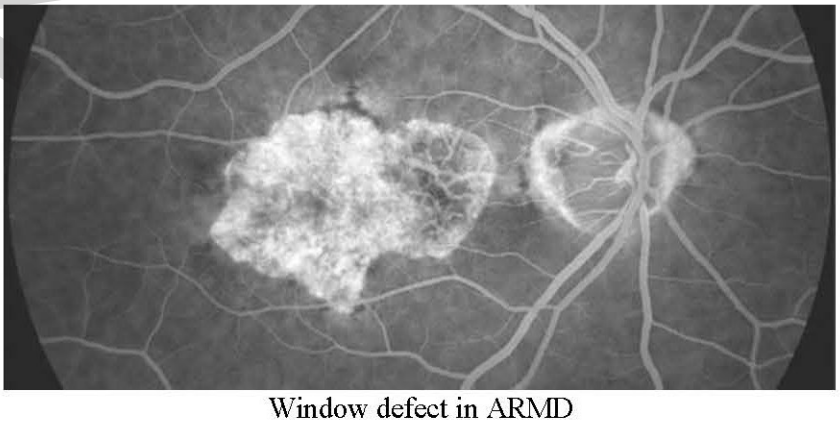
Pooling of dye in Drusen

Staining: Staining is accumulation of dye with in tissue due to prolong retention. It may be seen in late phase of angiogram as normal and in abnormal conditions such as drusen, fibrous tissue, exposed sclera.



Staining of dye in Drusen

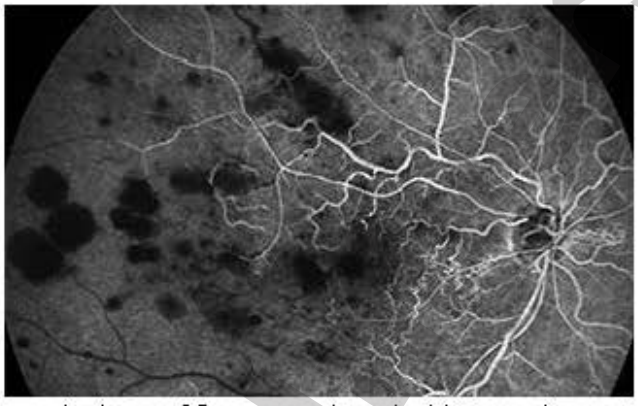
Window defect: There will be increased transmission of dye due to absence of RPE. The conditions in which window defect is found are age related macular degeneration, RPE tear, full thickness macular hole and some kind of drusen.



Window defect in ARMD

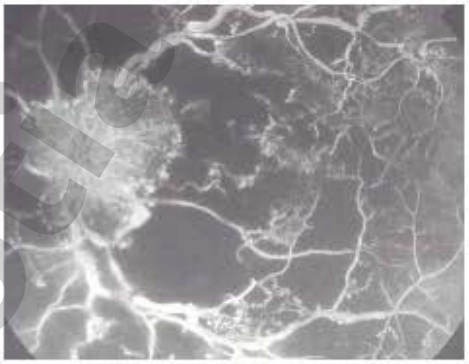
Hyporfluorescence: It is characterised by reduction or absence of dye. There are two causes of Hyporfluorescence.

Blocked fluorescence: there is optical obstruction of normal fluorescence density due to potential lesion anterior to retina. Examples are vitreous opacity, vitreous haemorrhage, intra-retinal haemorrhage, hard exudates, RPE hypertrophy and choroidal neovascularisation.



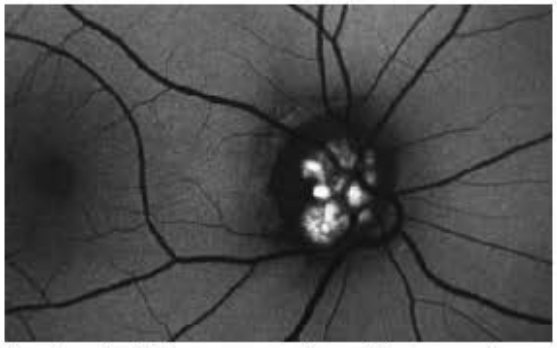
Blockage of fluorescent in retinal haemorrhage

Filling defects: Inadequate perfusion of tissue which results in low fluorescence content. Examples are vascular occlusion of retinal artery, vein and capillary, choroidal circulation, myopic degeneration.



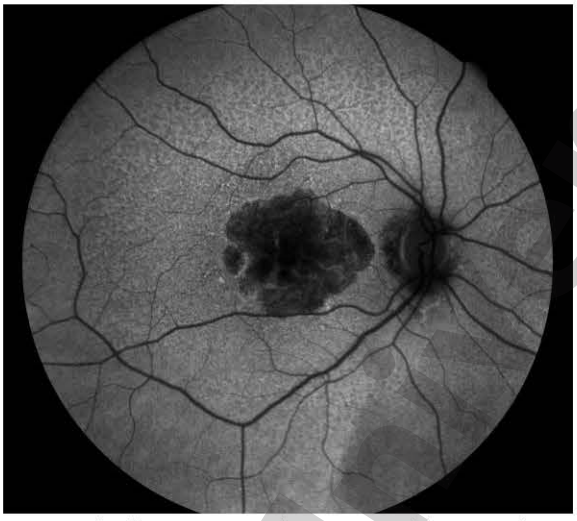
Filling defect in CRVO

Autofluorescence: Autofluorescence is the innate property of ocular tissue to absorb blue light and emit yellow-green light in absence of dye. It is exhibited by the conditions such as optic nerve head drusen, astrocyrtic Hamartoma.



Fundus Autofluorescence in optic nerve drusen

Pseudo fluorescence: It refers to non fluorescence reflection of light prior to injection of dye. It is due to overlap of wavelengths passing through the excitation and then barrier filters. It causes nonfluorescent structure to appear as fluorescent.



Pseudo fluorescence in Geographic atrophy

PRATICAL 8: ELECTRORETINOGRAM

Introduction

Electroretinogram is the corneal measurement of action potential generated by retina when it is stimulated by light of adequate intensity. By providing the light stimulus, the electrical activities from the photoreceptor cells, Muller cells and retinal pigment epithelium are recorded.

Principle

When a brief illumination of retina is done, there will be simultaneous activation of the cell to generate electrical energy. The generated electrical energy the combined and transferred through the vitreous and extracellular spaces. The electrical energy is prevented from passing posteriorly by RPE and the electrical energy passing through cornea is recorded.

Types of ERG

1. *Full field ERG:* It is mass electrical response of the retina to the stimulus. It has got two components; the Scotopic or dark adapted response and the Photopic or light adapted response.

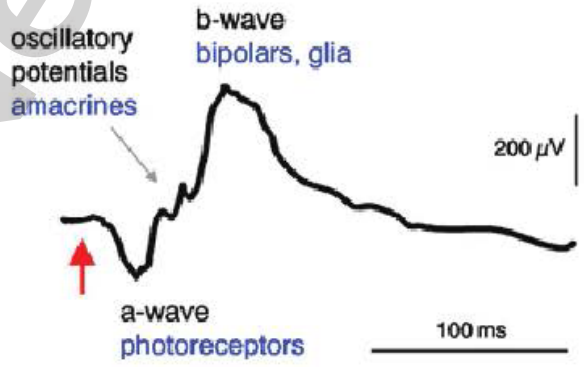
2. *Focal ERG:* Focal ERG primarily measures the electrical response in central part of the retina hence it is useful to assess function of the retina.

3. *Multifocal ERG:* IT measures the electrical responses at different retinal locations by cross correlation technique. It assess the retinal function in central 30 degree of macula.

4. *Pattern ERG:* The pattern ERG measures the electrical response of the retina by providing reversing dark and white checkerboard or sinewave gratings. It is used to assess the macula and retinal ganglion cells.

Analysis

Normal Waveform



Normal ERG response

a-*Wave:* It is a negative wave representing the function of photoreceptors in dark adapted condition.

b-*Wave:* It is a positive wave arising from Muller cells and representing the action of bipolar cells. The oscillatory potential of b-wave is due to rippling current and it is produced by inner plexiform layer.

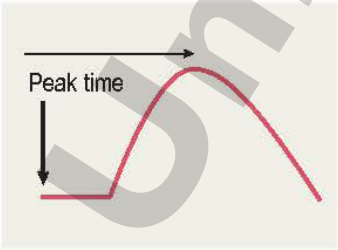
c-*Wave:* c-wave is prolonged positive wave with small amplitude. It represents the metabolic activities of RPE in response to rod cells.

ERG responses

A normal ERG has five distinct responses which are from individual rods and cones and a combined response of both the rods and cones.

Rod response, Maximal combine response and Oscillatory potentials are the response of dark adaptation where as Single flash cone response and 30 Hz flicker response are the response of light adaptation.

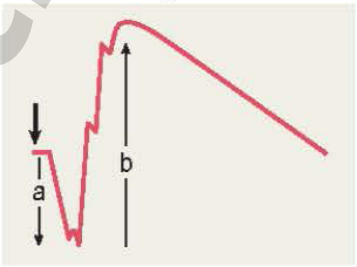
Rod response: It is assessed by dark adapting the patient for 20 minutes followed by dim light flash below the cone threshold.



Dark adapted 0.01 ERG (rod response)

It is measured form the through of a-wave to the peak of b-wave.

Maximal combined response: It is a large waveform produced by bright light flash during dark adapted state which maximally stimulate both rods and cones.

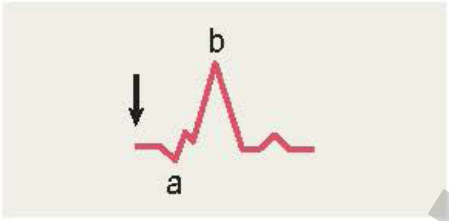


Dark adapted 3.0 ERG (combined rod and cone response)

Oscillatory potentials: These are high frequency wavelets riding on b-wave

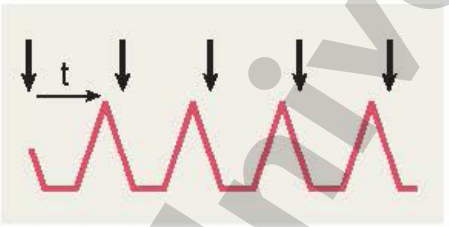
Dark adapted 3.0 ERG (oscillatory potentials)

Single flash cone response: It is assessed in light adapted state and by providing bright white flash.



Light adapted 3.0 ERG (cone response)

30 Hz flicker response: A flickering stimulus at 30 Hz is provided in light adapted state to assess it.



Light adapted 3.0 ERG (flicker response)

Time sequence

Latency: Latency is the time interval between the onset of stimulus and beginning of the a-wave response normal value of which is 2 ms.

Implicit time: It is the time from the onset of light stimulus to the maximum a-wave or b-wave response. It is less than 1/4th of a second.

Interpretation

B-wave with a potential of less than 0.19 mV or more than 0.54 mV is considered as abnormal.

Supernormal response: It is characterised by a potential above upper limit of normal value. This type of response may be found in conditions like cone dystrophy, albinism, optic atrophy, retinal vascular disorders.

Subnormal response: Subnormal response is achieved when potential is less than 0.08 mV. It is suggestive of large area of retina is not functioning and the conditions may be early RP, quinine toxic amblyopia, retinal detachment.

Extinguished response: There will be total absence of response. It may be found in conditions such as advance RP, complete retinal detachment, and choroideremia.

Negative response: It is characterised by a large a-wave. It indicates a gross disorder in retinal vascular circulation which may be found in conditions such as arteriosclerosis, giant cell arteritis, CRAO, CRVO.

PRACTICAL 9: ELECTRO OCULOGRAM (EOG)

Introduction

Electro-oculogram is the measurement of standing potential between cornea and retina during full dark adapted and fully light adapted condition. EOG is used to assess the function of RPE layer and the interaction between RPE and the photoreceptors.

Principle

The eye acts as a dipole in which anterior pole is positive and posterior pole is negative.

In left gaze, the cornea approaches the electrodes near the outer canthus of the left eye resulting in a negative trending change in the potential difference.

In right gaze, the cornea approaches electrodes near the inner canthus of the left eye resulting in a positive trending change in the potential difference.

EOG recording

The fixation lights are fixed on both the left and right sides and the patient is asked to move the eyes sideways to fix on both right and left fixation lights alternately. The patient has to keep their eyes for few seconds at each fixation point during which the recording is done.

In the beginning the stimulus light is on and the recording is started and then it is done in every 1 minute.

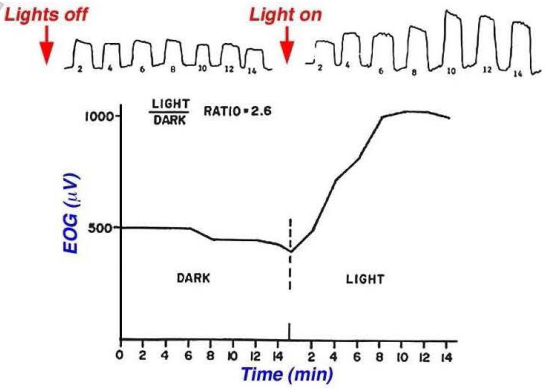
After a standardised period of light adaptation the stimulus light is switched off and recording is done in dark adaptation state for 15 minutes.

The stimulus light is turned on again and the response is recorded in light adapted period for 15 minutes.

Measurement and Interpretation

During the dark adaptation state the resting potential is decreased progressively and a dark through is reached in 8-12 minutes of dark adaptation state where as it takes 6-9 minutes reach to a light peak in light adaptation period.

Normal EOG reporting

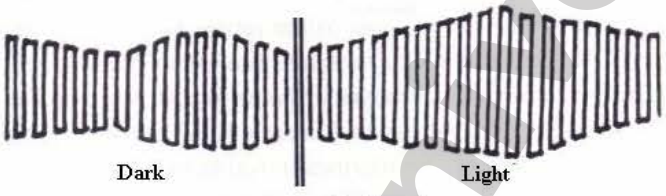


Normal EOG recording

The normal EOG report should include

1. Light peak: dark through ratio
2. Amplitude of dark through in mV
3. Time from start of light adapted phase to light peak
4. Type of adapting light source
5. Pupil size
6. Deviation from normal protocol including patient compliance, inconsistence eye movement.

Arden's ratio: It is the ratio of light peak in light adaptation phase to the dark through in dark adaptation phase.



$$\text{Arden index (EOG ratio)} = \frac{\text{Light peak}}{\text{Dark trough}} = 2.0$$

Arden's ratio in normal subject

- ✧ The result can be considered as normal if the Arden's ratio is greater than 1.80
- ✧ It is borderline if the Arden's ratio is in between 1.65 and 1.80
- ✧ It is subnormal if the Arden's ratio is less than 1.65
- ✧ If the difference of the Arden's ratio in both eyes is more than 10% it is significant.

PRACTICAL 10: VISUAL EVOKED POTENTIAL

Introduction

The Visual Evoked Potential is an electrophysiological potential by the visual cortex and responded to the visual stimulus. The Visual Evoked Response is recorded in electroencephalography (EEG) at the scalp. It is helpful in assessment of visual functioning beyond the retinal ganglion cell. In other word it can also be said that VEP is used to assess the functional integrity of the visual pathway.

Electrodes

Reference electrode: It is the occipital electrode placed near the visual area.

Active electrode: The vertex electrode which placed on non-visual area to detect the activity in response to visual stimulation.

Ground electrode: it is placed over the forehead.

Type of VEP

Flash VEP: The electrophysiological potential is assessed by providing bright light flash as stimulus and it is not affected by the ocular media opacities.

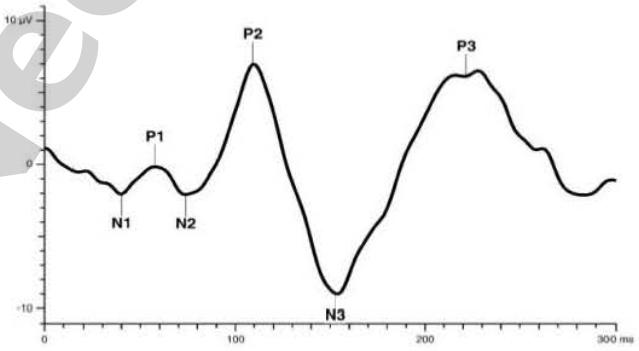
Pattern VEP: The VER is assessed by providing dark and white checker board pattern as stimulus. It is again of two types:

1. *Pattern appearance VEP:* The checker board is presented in on-off sequence.

2. *Pattern reversal VEP:* There will be reversal of the pattern i. e., the dark is changed to white and white is changed to dark. It is helpful in rough estimation of visual acuity.

Analysis

Normal Flash VEP waveform:



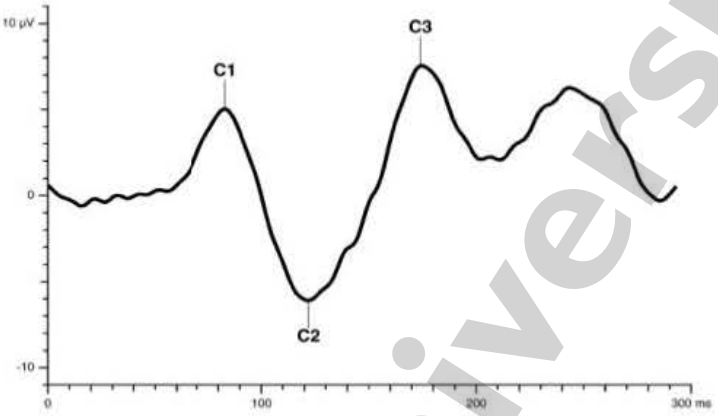
Normal Flash VEP waveform

The normal flash VEP response consists of a series of negative and positive waves.

The earliest component has a peak time of approximately 30 ms post stimulus whereas highest peak is recorded as 300 ms.

The most robust components of the flash VEP are N2 and P2 which are having a peak latency of 70 ms and 125 ms respectively.

Normal Pattern onset/offset VEP waveform:



Normal Pattern onset/offset VEP

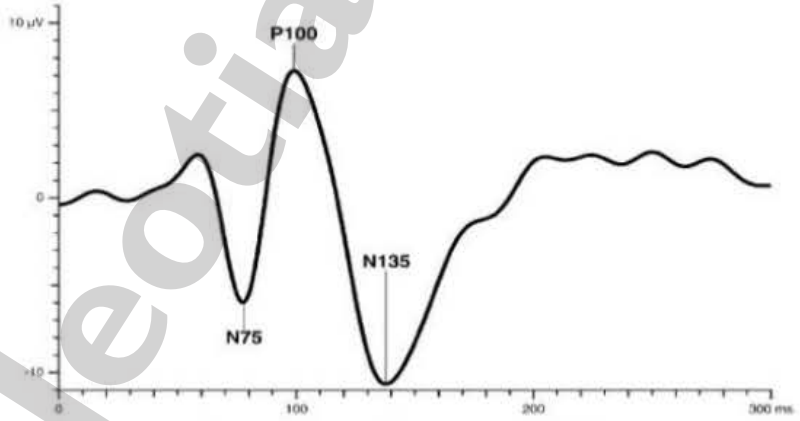
The normal Pattern onset/offset VEP has got three main peaks.

C1 is a positive component which has a peak latency of approximately 75 ms.

C2 is a negative component with a peak of approximately 125 ms.

C3 is a positive component having a peak of approximately 150 ms.

Normal Pattern reversal VEP waveform:



Normal Pattern reversal VEP

The normal Pattern reversal VEP consists of three peaks namely N75, P100 and N135

N75 is a negative component and it has got a latency of 75 ms.

P100 is a positive peak having latency of 100 ms.

N135 is a negative peak with latency of 135 ms.

Interpretation

VEP parameters:

1. *Amplitude:* It is the height of the wave which is measured for the peak.

The amplitude of P100 wave is affected in ischemic disorder of optic nerve.

2. *Latency:* It is the time duration form the onset of the stimulus to the peak response of a wave.

The latency is reduced in Demyelinating disorders of optic nerve.

3. *Bizzare waveform:* Both the latency and amplitude are affected in compressive disorders.

The normal and abnormal VEP response:

The normal VEP pattern consists of initial positive wave followed by a negative wave to be followed by a hyperpolarisation before the potential returned to resting level. Normal response is of the order of 10 to 25 μV which is established by the age of 6 months.

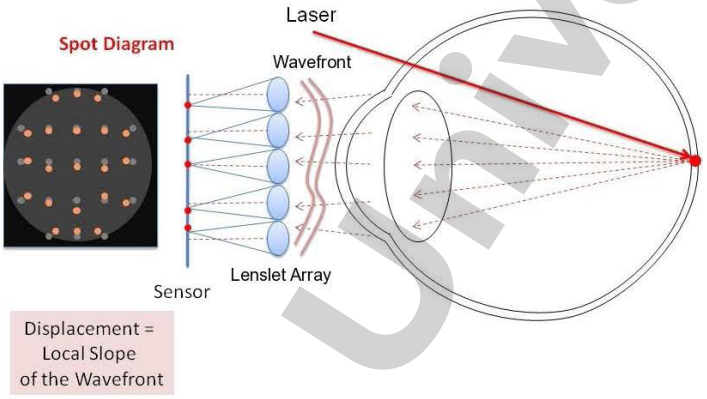
In presence of any optic lesion in visual pathway there will be reduction in amplitude and delay in latency period.

PRACTICAL 10: ABERROMETRY

Introduction

Aberrometry measures the wavefront of light that passes through the the optical medium of the eye. There are three different Aberrometry techniques based on three different principles i. e., Hartmann-Shack Aberrometry, Tsherning Aberrometry, Ray tracing Aberrometry. It is helpful in measuring the different types of lower order and higher order aberrations which are nothing but the distortions of wavefront due irregularities in optical medium.

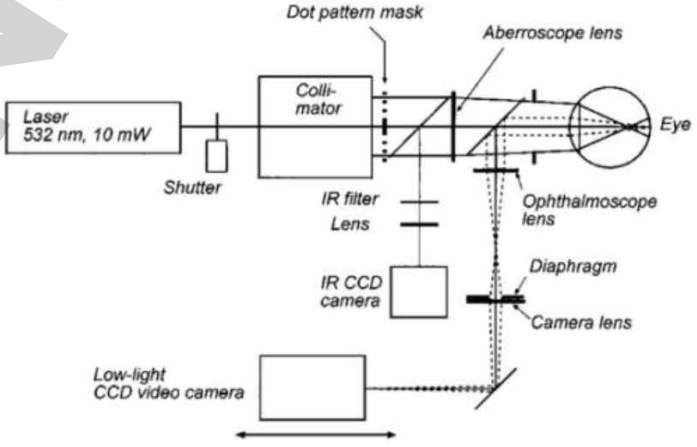
Principles



Hartmann-Shack Optics

1. Hartmann-Shack Aberrometry: It uses a small light source which is projected into the retina to form a spot of light on retina. This spot of light acts as a pseudo point source. While reflecting back from the pseudo point source, the light rays pass through the optical medium of the eye and produce an aberrated wavefront. A Hartmann-Shack lens let array system is placed at the conjugate focal plane of exit pupil of the eye which divides the ocular wavefront into smaller areas. Each of the small area of wavefront is then focused into a CCD camera to detect the individual image shift in x and y axes. The shifting of the image is directly proportional to the wavefront slopes. An array of image shift over the entire pupil is collected and a reconstructed algorithm is applied to obtain the wavefront.

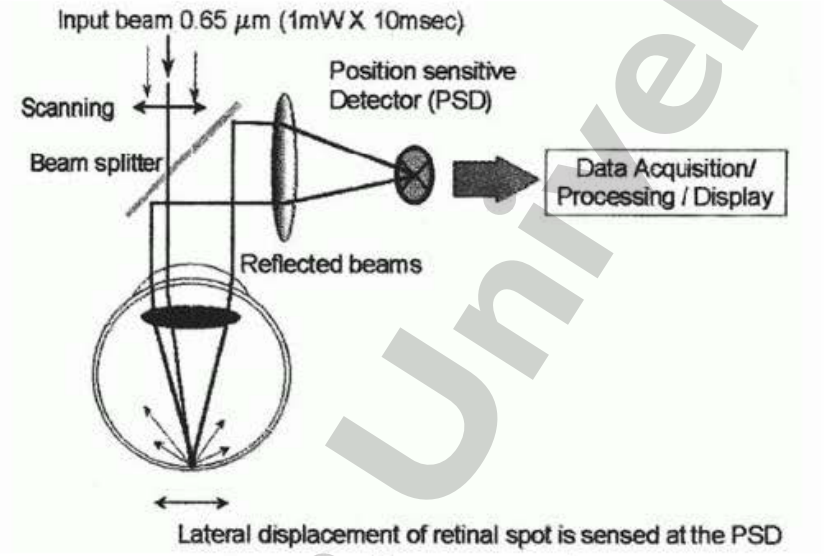
2. Tsherning Aberrometry



Tsherning Abberometer Optics

A dot pattern mask is used to project the light rays into retina originated from a collimated light source. In presence of aberration, light rays passing through different parts of the pupil will be projected on different positions on the retina. The spot pattern on the retina can be captured by a direct ophthalmoscope and a wavefront pattern is reconstructed. The shifting of the light images is measured in both x and y axes from the reference spots and the shifting is proportional to the wavefront slope at the measuring point.

3. *Ray tracing Aberrometry*



Ray tracing Aberrometry optics

Ray tracing method uses a thin beam of laser light parallel to the visual axis which is projected into the retina. The reflected light rays from the retina are then captured by a CCD to assess the location where the laser beam reaches the retina. Aberrations causes deflection of the laser beam and the shifting of the laser beam can be measured in both x and y axis against a known reference line. Similar to Tsherning Aberrometry the shifting of laser beam is proportional to local wavefront slope.

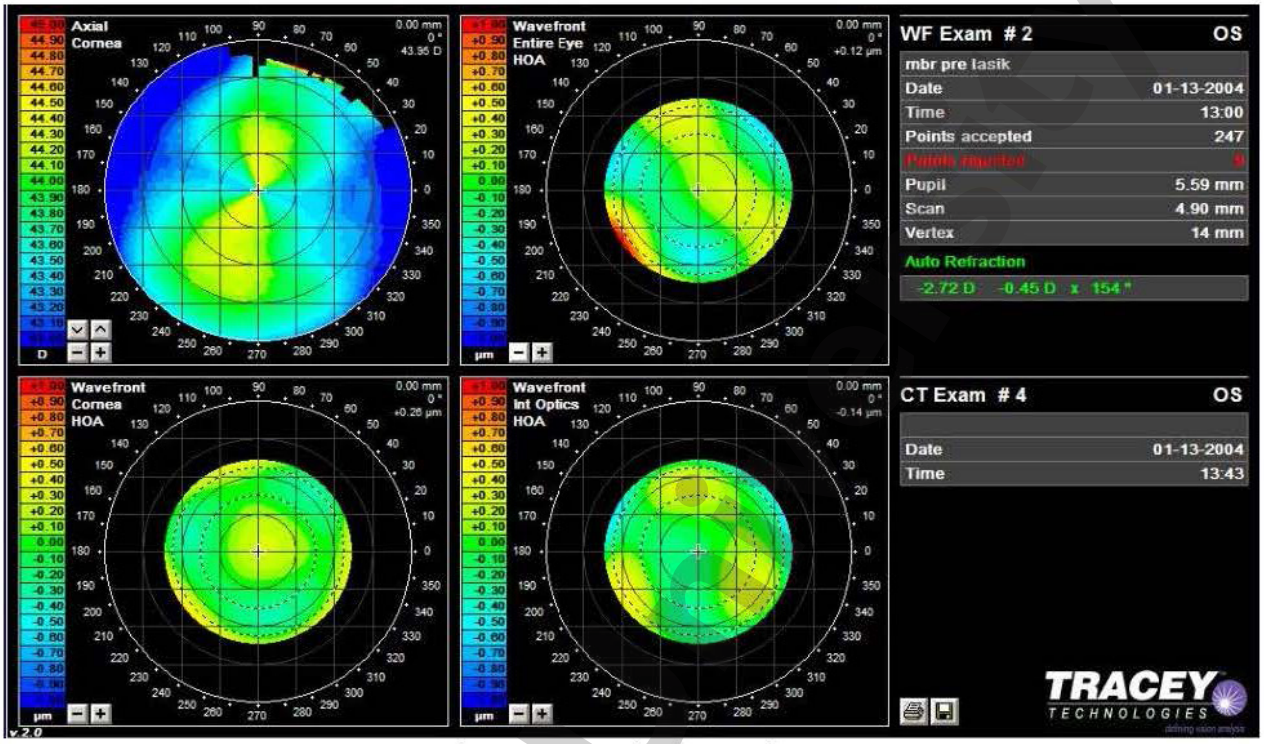
Analysis and interpretation

Basic data graphs:

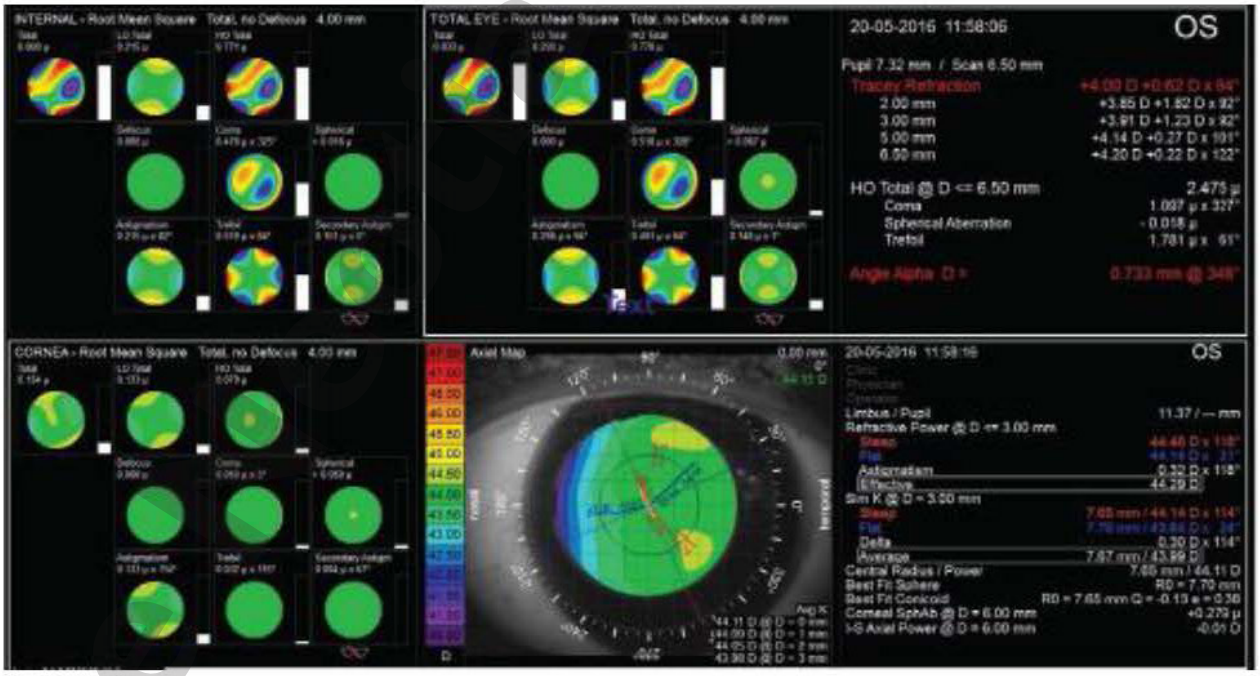
Wavefront map of total and higher order aberration: These maps show colour coded wavefront aberrations of the eye which measure the error in micro level. The measurement is taken from the entrance pupil and it can be either positive or negative.

The worm colours indicate that the wavefront is in front of the reference plane while cool colours indicate that the wavefront is behind the reference plane. Absence or very little amount of aberration is indicated by green colour while worm colours indicate advance aberrations.

The type of aberration controlling the refractive error of the eye can easily be determined. The common types of higher order aberrations found are coma, spherical aberration, higher order astigmatism and trefoil.

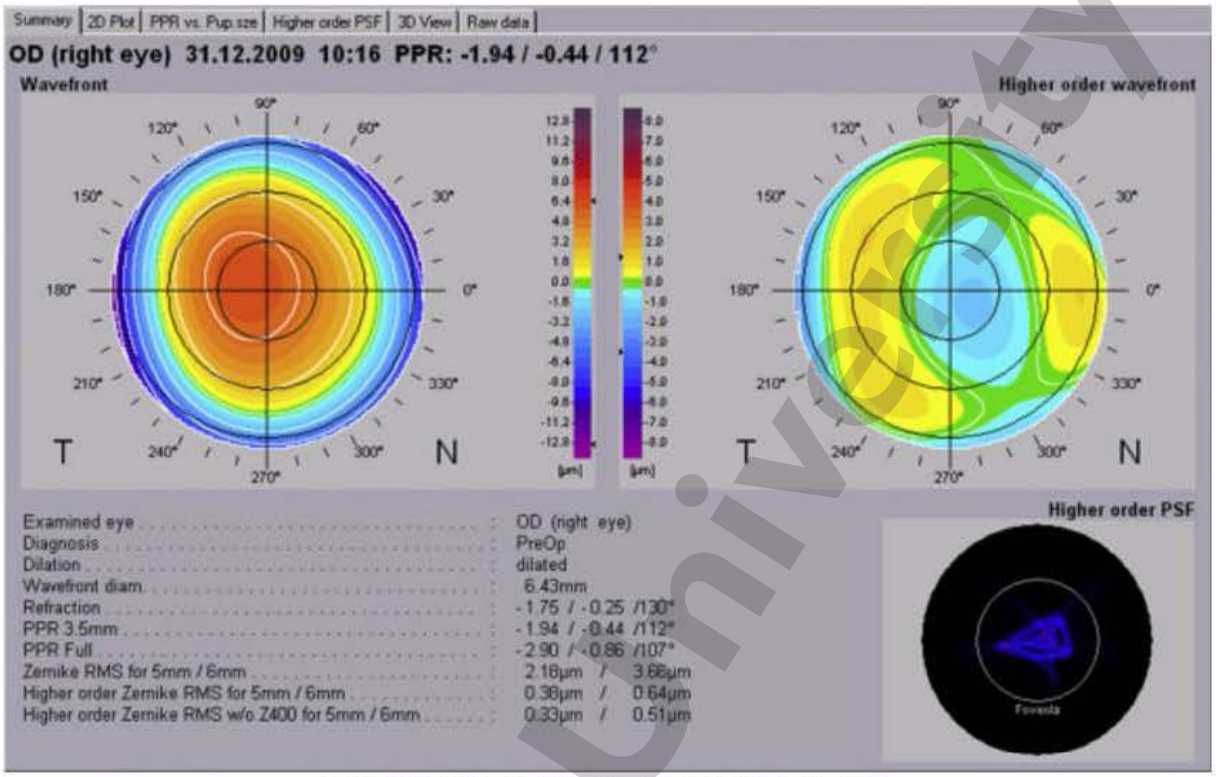


Wavefront map total of normal eye



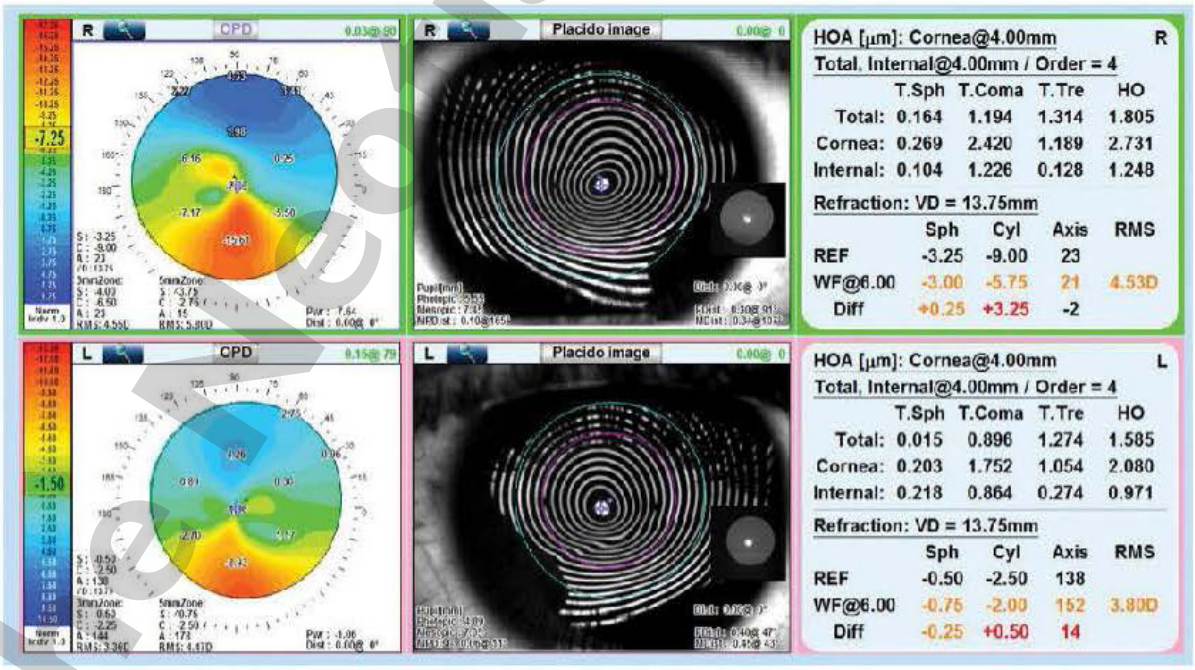
Higher order aberrations wavefront map

The Root Mean Square (RMS): It is square root of sum of square of Zernike coefficient. The magnification of total wavefront aberration can be calculated by RMS. A total RMS value for total aberration and a specific RMS value for each Zernike component of the aberration can be obtained.



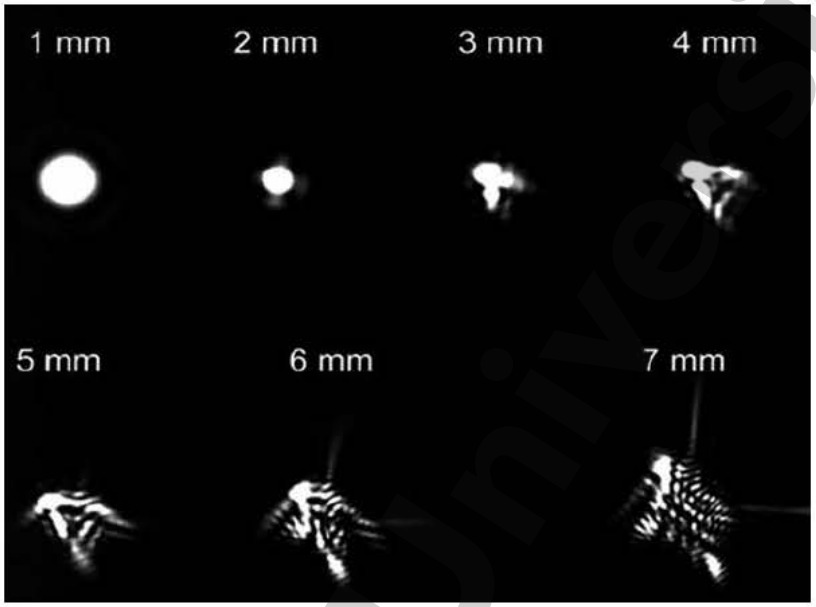
A wavefront map showing Zernike RMS values

Total refractive and higher order aberration refractive map: This map represents the total refractive power of the eye in dioptre. The Emmetropia is indicated by green colour. Warmer colours like red represent myopia whereas cooler colours like blue represents hypermetropia.



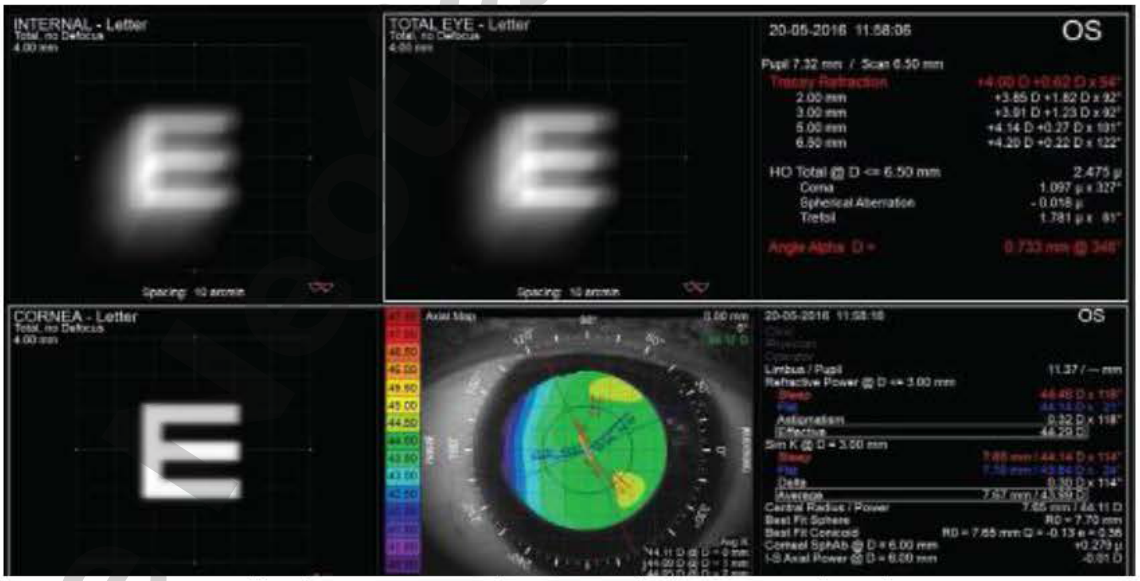
Wavefront refraction map

Point Spread Function (PSF) total and higher order aberration: It represents the equality of the image of an optic system determined by the aberrations to simple point of light. PSF describes the response of an imaging system to a point source of light.



The effect of pupil size on PSF

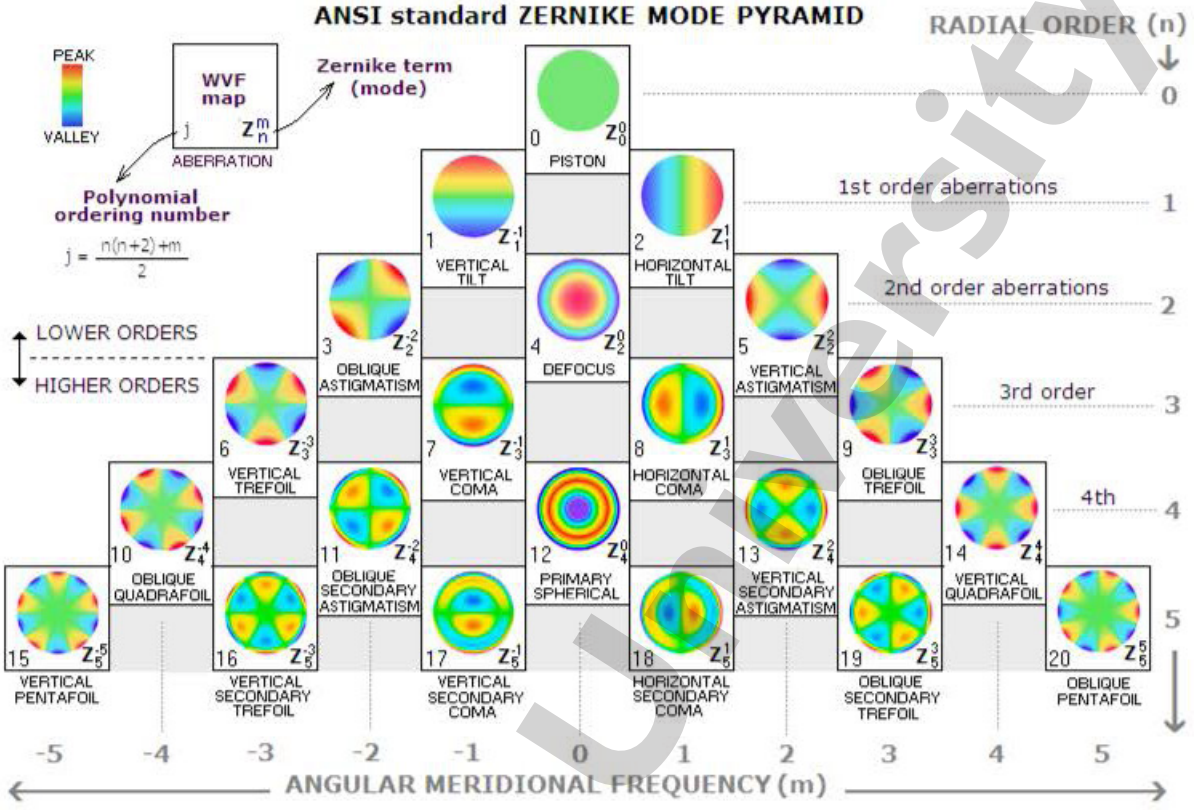
Snellen letter total and high order aberrations: This feature is provided in Ray tracing Aberrometry. A simulated Snellen 'E' of different sizes is used to assess how a patient sees the letter in different defects in optical medium.



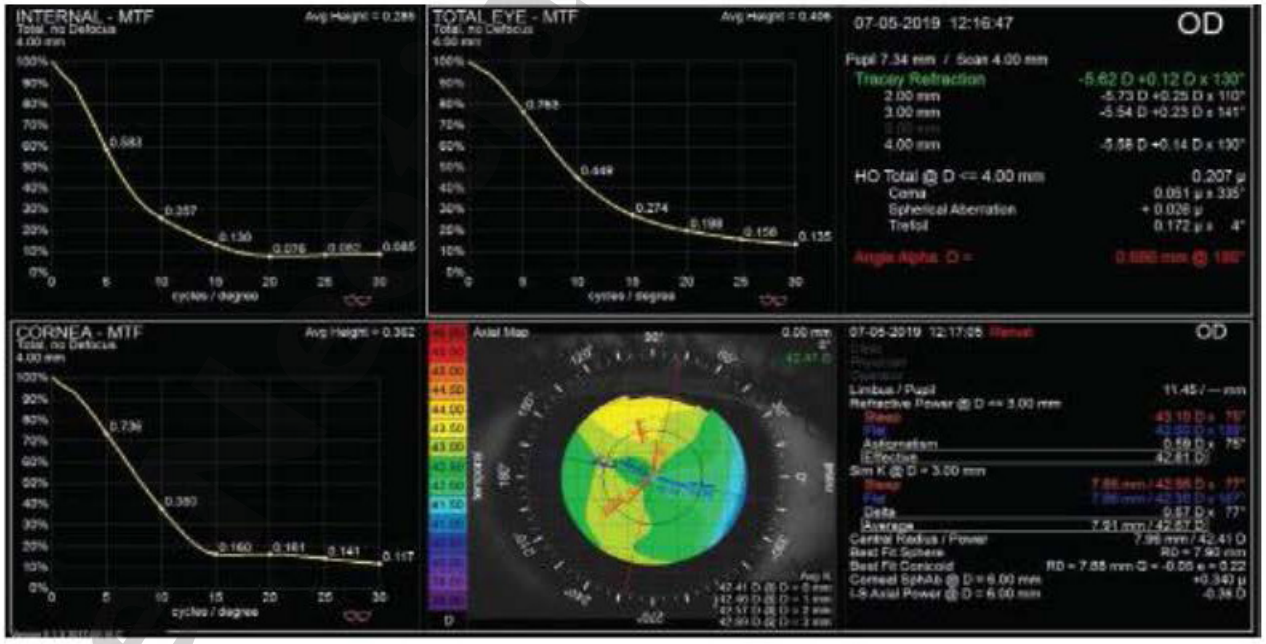
Snellen letter representation as seen by hypermetropic patient

Zernike polynomials: It consists of a bar graph and a table of polynomials of Zernike. It provides detail analysis of the specific aberrations in the eye.

Modulation Transfer Function (MTF): It is produced by the optical system in terms of details of the object. It is a measure of resolution of the image assessed at different spacial frequency of the object and is used as an objective measure of the ocular contrast sensitivity.



Zernike Polynomial



Itrace image showing modulation transfer function graph