Dissertation on

CORRELATION OF " DISC DAMAGE LIKELIHOOD SCALE" WITH FIELD DEFECTS IN ESTABLISHED GLAUCOMAS –AN ANATOMICAL VERSUS FUNCTIONAL CORRELATION

Submitted in partial fulfillment of requirements of

M.S. OPHTHALMOLOGY

BRANCH - III

REGIONAL INSTITUTE OF OPHTHALMOLOGY

MADRAS MEDICAL COLLEGE

CHENNAI- 600 008

THE TAMILNADU

DR.M.G.R. MEDICAL UNIVERSITY

CHENNAI

APRIL 2017

CERTIFICATE

This is to certify that this dissertation entitled "**CORRELATION OF "DISC DAMAGE LIKELIHOOD SCALE" WITH FIELD DEFECTS IN ESTABLISHED GLAUCOMAS –AN ANATOMICAL VERSUS FUNCTIONAL CORRELATION**" is a bonafide record of the research work done by **Dr. ANJANA .R ,** post graduate in Regional Institute of Ophthalmology and Government Ophthalmic Hospital, Madras Medical College and Government General Hospital, Chennai-08, in partial fulfillment of the regulations laid down by The Tamil Nadu Dr. M.G.R. Medical University for the award of M.S. Ophthalmology Branch III, under my guidance and supervision during the academic years 2014-2017.

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ACKNOWLEDGEMENT

I express my sincere thanks and gratitude to **Prof. Dr.M.K.Muralidharan M.S, M.Ch,** Dean, Madras Medical College and Government General Hospital for permitting me to conduct this study.

I express my sincere gratitude to **Prof. Dr. Waheeda Nazir, M.S., D.O.,** Director and Superintendent, Regional Institute of Ophthalmology and Government Ophthalmic Hospital, Madras Medical College, Chennai for her valuable advice in preparing this dissertation.

I am extremely grateful to **Prof. Dr.P.S.Maheswari, M.S., D.O.,** my Unit Chief and my guide for her valuable guidance and constant support at every stage throughout the period of this study.

I am extremely thankful to **Prof. Dr.M.R.Chitra, M.S., D.O.,** for her valuable guidance at every stage throughout the period of this study.

I am very grateful to my Assistant Professors and my co-guides **Dr.M.S.Gokila, M.S,D.O** ,and **Dr.R.Saravanan,** for their valuable guidance and support not only during the study but also throughout my course in all aspects.

I am grateful to my unit Assistant Professors **Dr.T.Vimala ,M.S,** and **Dr.V.Savithiri M.S,D.O,DNB** for rendering their constant support during the study period.

I wish to express my sincere thanks to all the professors, assistant professors, all my colleagues and my juniors who had helped me in bringing out this study.

Finally, I am indebted to all the patients for their sincere co operation for the completion of this study.

INSTITUTIONAL ETHICS COMMITTEE
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To
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Dear Dr.Anjana.R.

The Institutional Ethics Committee has considered your request and approved your study titled **"CORRELATION OF DISC DAMAGE LIKELIHOOD SCALE WITH FIELD DEFECTS IN ESTABLISHED GLAUCOMAS - AN ANATOMICAL VERSUS FUNCTIONAL CORRELAION "- NO. 18042016.**

The following members of Ethics Committee were present in the meeting hold on **05.04.2016** conducted at Madras Medical College, Chennai 3

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13.Tmt.Arnold Saulina, MA.,MSW.,	:Social Scientist

We approve the proposal to be conducted in its presented form.

The Institutional Ethics Committee expects to be informed about the progress of the study and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

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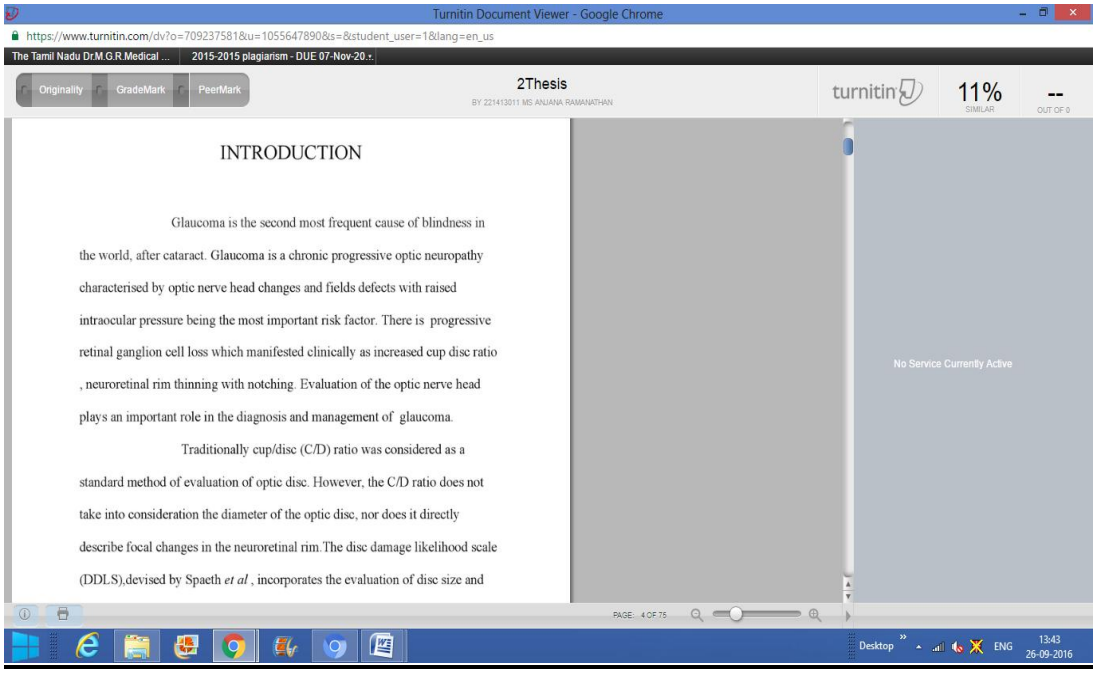
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INTRODUCTION
Glaucoma is the second most frequent cause of blindness in the world, after cataract. Glaucoma is a chronic progressive optic neuropathy characterised by optic nerve head changes and fields defects with raised intraocular pressure being the most important risk factor. There is progressive retinal ganglion cell loss which manifested clinically as increased cup disc ratio , neuroretinal rim thinning with notching. Evaluation of the optic nerve head plays an important role in the diagnosis and management of glaucoma.
Traditionally cup/disc (C/D) ratio was considered as a standard method of evaluation of optic disc. However, the C/D ratio does not take into consideration the diameter of the optic disc, nor does it directly describe focal changes in the neuroretinal rim.The disc damage likelihood scale (DDLS),devised by Spaeth et al , incorporates the evaluation of disc size and
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DECLARATION BY THE CANDIDATE

I hereby declare that the dissertation entitled "**CORRELATION OF "DISC DAMAGE LIKELIHOOD SCALE" WITH FIELD DEFECTS IN ESTABLISHED GLAUCOMAS – AN ANATOMICAL VERSUS FUNCTIONAL CORRELATION"** is a bonafide and genuine research work carried out by me under the guidance of Prof.Dr.P.S.Maheswari.

DATE: **DR.ANJANA.R**

PLACE:

CONTENTS

PART – I

INTRODUCTION

Glaucoma is the second most common cause of blindness in the world, after cataract. Glaucoma is a chronic progressive optic neuropathy characterised by optic nerve head changes and fields defects, with raised intraocular pressure being the most important risk factor. There is progressive retinal ganglion cell loss which is manifested clinically as increased cup disc ratio, neuroretinal rim thinning with notching. Evaluation of the optic nerve head plays an important role in the diagnosis and management of glaucoma.

Traditionally cup/disc (C/D) ratio was considered as a standard method of evaluation of optic disc. However, the C/D ratio does not take into consideration the diameter of the optic disc, nor does it directly describe focal changes in the neuroretinal rim. The disc damage likelihood scale (DDLS), devised by Spaeth *et al*, incorporates the evaluation of disc size and rim width in clinical grading of the disc.

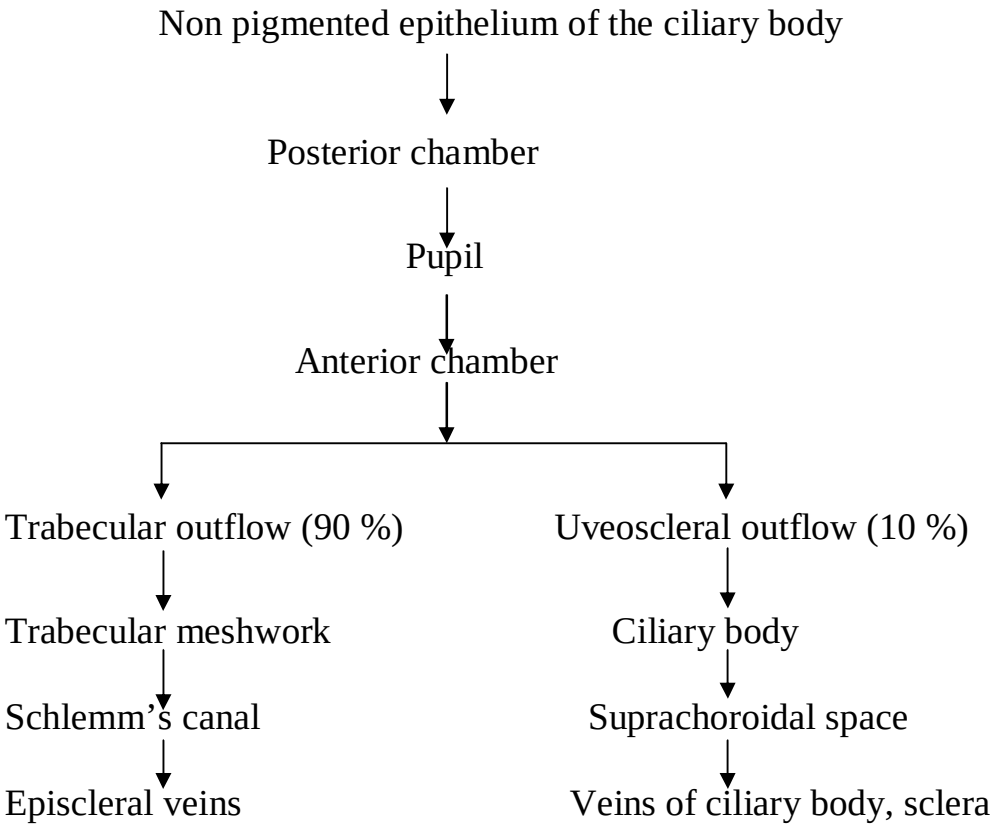
The DDLS relies on the optic nerve as a direct indicator of disease. Because the scale divides glaucomatous progression into 10 stages, it can also aid to monitor the disease progression. The DDLS helps in quantification of the amount of damage that the optic nerve has sustained.

ANATOMY

AQUEOUS HUMOUR:

Intra ocular pressure is mainly determined by the dynamic equilibrium between the production and drainage of aqueous. Aqueous humour is produced by the non pigmented epithelium of the ciliary body in the posterior chamber. From the posterior chamber, aqueous flows through the pupil into the anterior chamber. The anterior chamber contains about 0.25 ml of aqueous. From the anterior chamber, the aqueous drains through two routes

1. Trabecular outflow- the conventional pathway
2. Uveoscleral outflow – the unconventional pathway



Flow chart showing aqueous humour formation

AQUEOUS FORMATION:

Aqueous humour is formed by the following processes

1. Diffusion(which contributes to 10% of formation)
2. Ultra filtration (which contributes to 20% of formation)
3. Active transport by Na-K ATPase pump which is the major process involved in formation of aqueous (which contributes to 70% of formation)

ANGLE OF ANTERIOR CHAMBER:

From the posterior chamber, aqueous enters the anterior chamber through the pupil. The peripheral part of anterior chamber forms a recess called the angle of anterior chamber which plays an important role in drainage of aqueous.

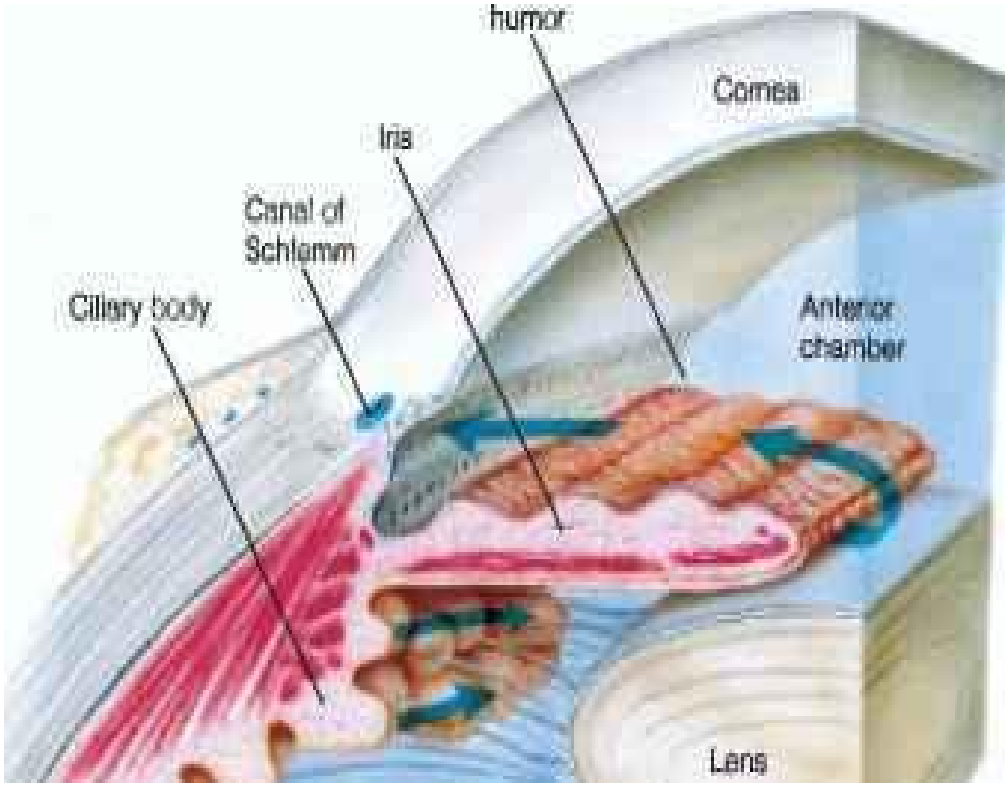


Figure showing the pathway of aqueous

STRUCTURES FORMING THE ANGLE OF ANTERIOR CHAMBER:

From anterior to posterior

1. Schwalbe's line:

It is formed by the peripheral termination of the descemet's membrane. Gonioscopically, it is visualised as a fine ridge in front of the trabecular meshwork.

2. Trabecular meshwork:

It is found between the schwalbe's line and the sclera spur. It has an anterior non pigmented part and a posterior pigmented part which is the functional part. Pigmentation of trabecular meshwork varies with age.

3. Scleral spur:

It is the part of the ciliary sulcus where the ciliary body is attached posterior . Gonioscopically it appears as a prominent white line.

4. Ciliary body band:

It is the anterior part of the ciliary body found between the scleral spur and root of the iris. Gonioscopically it appears as grey or dark brown band.

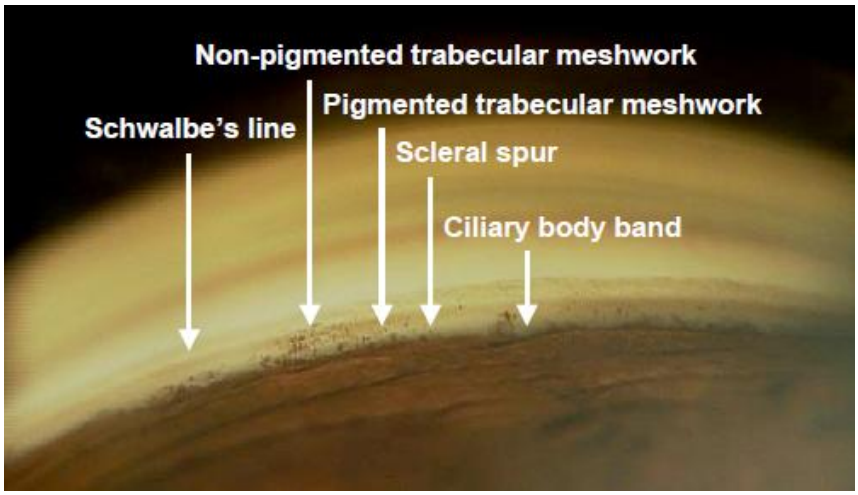


Figure showing angle structures as visualised by gonioscopy

GRADING OF ANGLE OF ANTERIOR CHAMBER:

SHAFFER'S GRADING: Most commonly used gonioscopic grading

Grade	Structures visible on gonioscopy	Angle width
1V	All four structures viz schwalbe's line , trabecular meshwork,scleral spur , ciliary body band are visible	35-45°
III	Schwalbe's line , trabecular meshwork and scleral spur are visible	25-35°
II	Schwalbe's line , trabecular meshwork are visible	20°
I	Only schwalbe's line is visible	10°
0(closed)	None of the angle structures are visible	0°

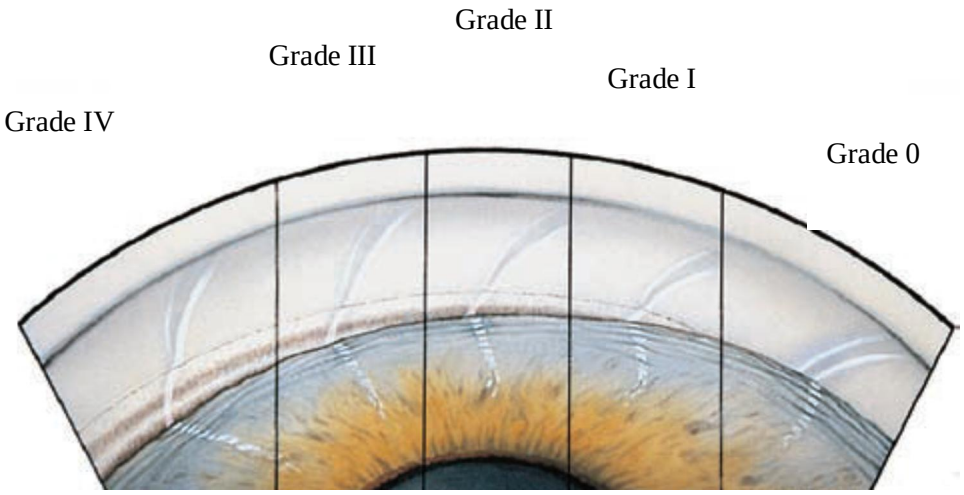
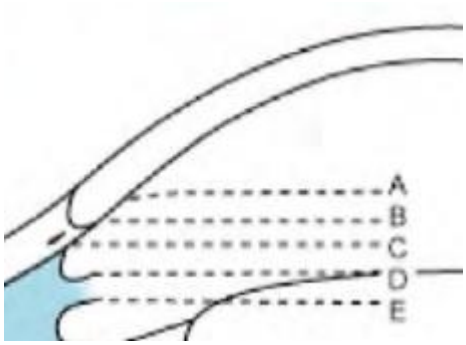


Figure depicting the Shaffer's grading

SPAETH GRADING:

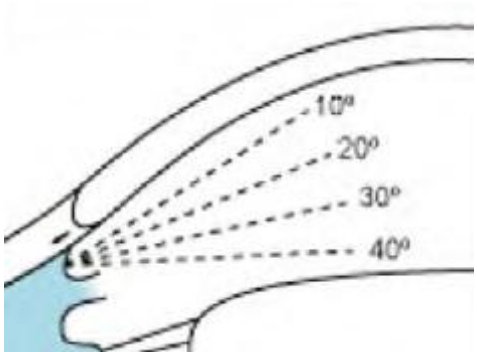
It is based on four factors

1. Site of iris insertion

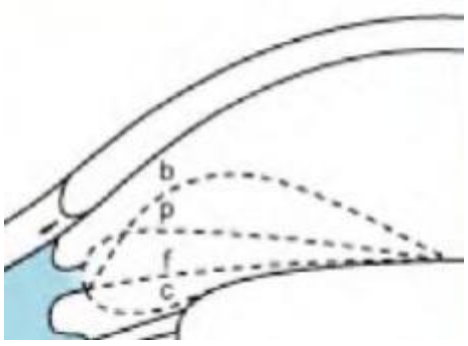


A. Anterior to the trabecular meshwork
B. Behind the schwalbe s line
C. Centered at the sclera spur
D. Deep to the sclera spur
E. Extremely deep

2. Width of angle



3. Peripheral iris configuration



b-bowing anteriorly (1 to 4)

p –plateau iris configuration

f -flat iris configuration

c- concave iris configuration

4. Trabecular meshwork pigmentation

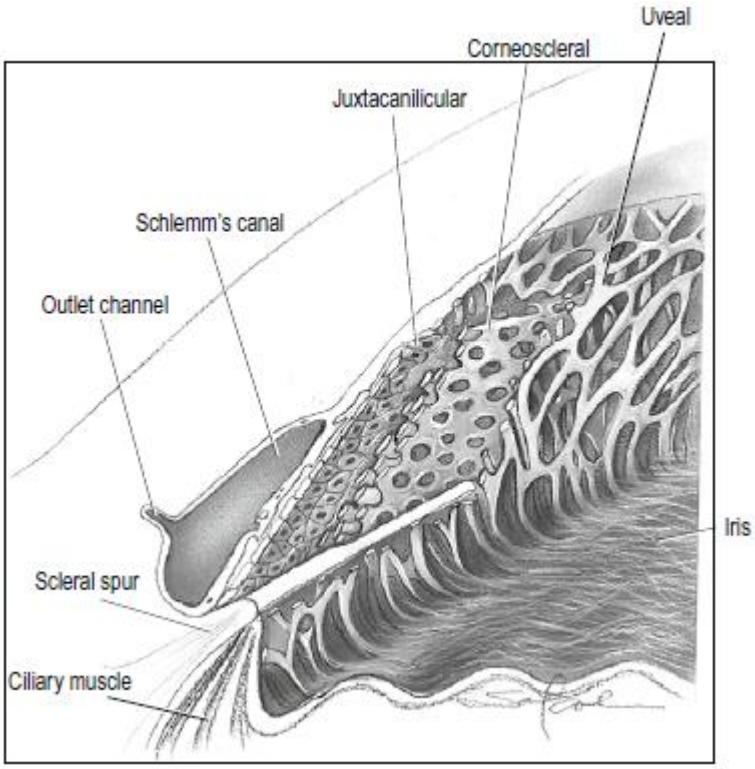


Figure depicting parts of trabecular meshwork

CANAL OF SCHLEMM:

It is present within the scleral sulcus .It is an endothelial lined channel through which aqueous drains in to the venous system

COLLECTOR CHANNELS:

They are valveless, endothelial lined channels which are 25-35 in number. From the collector channels, the aqueous drains into the episcleral veins.

AQUOEUS OUTFLOW SYSTEM:

Trabecular meshwork:

It is a sieve like structure present in the angle of anterior chamber through which the aqueous drains. It bridges the sclera sulcus. It has three parts

1. **Uveal meshwork :**

It constitutes the innermost part of the trabecular meshwork. It extends from the iris root and the ciliary body to the schwalbe's line. The trabeculae of this part are cord like with irregular openings in between.

2. **Corneoscleral meshwork :**

It constitutes the middle portion. It extends from the scleral spur to the lateral wall of sclera sulcus. It consists of sheets of trabeculae with irregular openings in between which are smaller than that of uveal meshwork.

3. **Juxtacanalicular meshwork:**

It constitutes the outermost portion of the trabecular meshwork. This part offers maximum resistance to aqueous outflow.

EPISCLERAL VEINS:

The episcleral veins drain via the anterior ciliary and superior ophthalmic veins into the cavernous sinus.

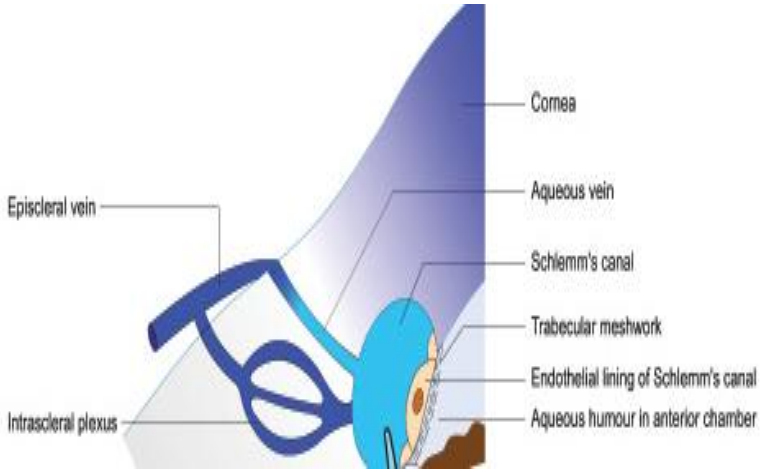


Figure depicting the aqueous outflow channels

MECHANISMS OF AQUOEUS TRANSPORT:

Vacuolation theory:

According to this theory, the aqueous is transported across the inner wall of schlemm's canal by formation of vacuoles across the endothelial cells.

Other theories include:

Leaky endothelial cells:

Aqueous drains through endothelial cells which are leaky.

Endothelial pores:

Endothelial cells have pores which aids in the aqueous outflow.

Contractile microfilaments:

Contractile filaments present in the endothelial cells are responsible for transport of aqueous across the cells.

OPTIC NERVE HEAD:

The intraocular portion of optic nerve is called “optic nerve head”. It comprises of axons of ganglion cell layer of the retina which bend acutely to exit the globe through fenestrations of sclera called the lamina cribrosa. The size of optic nerve head shows variations in relation to race and refractive error (0.85-2.43 mm). The average vertical diameter is 1.88mm and horizontal diameter is 1.77mm.

PARTS OF THE OPTIC NERVE HEAD:

Histologically the optic nerve head has the four parts from anterior to posterior

1. Surface nerve fibre layer
2. Prelaminar region
3. Laminar region
4. Retrolaminar region

A. SURFACE NERVE FIBRE LAYER:

It is the innermost portion of the optic nerve head .It is composed of nerve fibres predominantly with minimal glial tissue. The amount of glial tissue increases as the nerve courses posteriorly .

B. PRELAMINAR REGION:

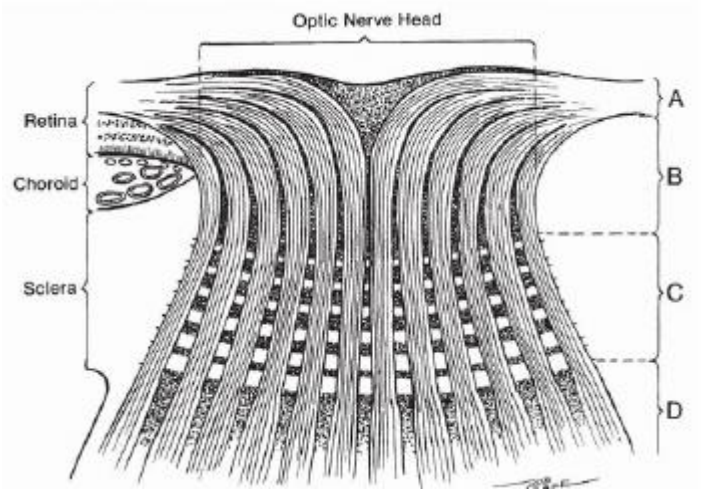
This portion is composed of axons of retinal ganglion cell which are grouped into bundles called fascicles. These fascicles are separated by glial tissue.

C. LAMINAR REGION:

Lamina cribrosa of sclera is composed of fenestrated sheets of connective tissue with few elastic fibres through which the fascicles traverses.

D. RETROLAMINAR REGION:

In this portion, there is decrease in number of astrocytes with acquisition of myelin.



VASCULAR SUPPLY:

ARTERIAL SUPPLY:

1. Surface nerve fibre layer: supplied by branches from central retinal artery. Fibres of the temporal region are occasionally supplied by the cilioretinal artery.
2. Prelaminar and laminar regions: supplied by short posterior ciliary artery which forms a perineural plexus called the circle of zinn-haller.
3. Retrolaminar region: supplied by both ciliary and retinal circulations.

VENOUS DRAINAGE:

Venous drainage is mainly through the central retinal vein and there is minimal drainage through the choroidal system.

CONNECTIVE TISSUE SUPPORT:

LAMINA CRIBROSA:

It has specialised extracellular matrix composed of collagen type 1-4, laminin, fibronectin. Abnormalities in the extra cellular matrix may increase the susceptibility to glaucoma. The superior and inferior portions of lamina cribrosa have larger fenestrations and less glial tissue support making the axons more susceptible to damage from elevated intraocular pressure .This accounts for the appearance of superior and inferior notching clinically in early glaucoma.

ARRANGMENT OF RNFL:

Axons of the ganglion cell constituting the retinal nerve fibre layer are arranged in a characteristic pattern. Fibres from the temporal periphery arch above and below the horizontal raphe constituting the superior and inferior arcuate fibres. Fibres from the centre and macular fibres constitute the papillomacular bundle. Fibres from the nasal retina constitute the superior and inferior radiating fibres.

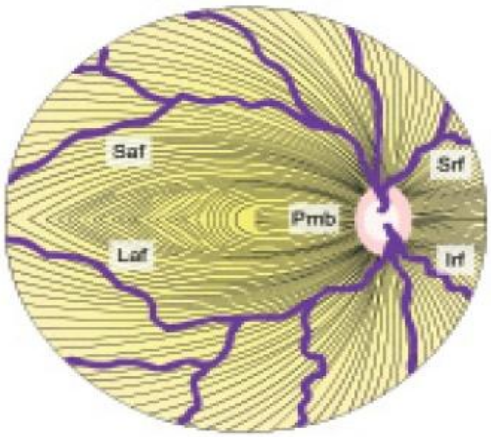


Figure showing arrangement of RNFL fibres

Saf-superior arcuate fibres, Iaf –inferior arcuate fibres,

Pmb-papillomacular bundle,

Srf-superior radiating fibres , Irf-inferior radiating fibres

AXONS OF OPTIC NERVE HEAD:

The superior and inferior temporal portions of the optic nerve head are occupied by the arcuate fibres. The peripheral portion of the nerve is occupied by fibres from the periphery. The papillomacular bundle occupies the distal one third of the optic nerve, mainly inferior temporally. The axonal density is highest in this portion. In early glaucoma, the arcuate fibres are the first to be affected. Even in advanced glaucoma, the central vision is preserved because the papillomacular fibres are very resistant to damage.

PATHOPHYSIOLOGY OF GLAUCOMATOUS DAMAGE:

There are various theories related to pathogenesis of glaucomatous optic neuropathy. Jaeger[1] proposed that vascular abnormality was the main cause of glaucomatous atrophy .The vascular theory suggests that ischemia plays a role in the axoplasmic flow obstruction in response to elevated IOP. Schnabel[2] (1892) suggested that atrophy of neural elements created empty spaces , which pulled the nerve head posteriorly (Schnabel cavernous atrophy).

Muller's[3] mechanical theory proposed that physical alterations in the optic nerve head causes misalignment of the fenestrate in the lamina cribrosa and results in axoplasmic flow obstruction .

Several studies have shown that CSF pressures were lower in patients with primary open angle glaucoma. The translaminar pressure, which is the difference between the IOP and the CSF pressure, plays an important role in the pathogenesis of glaucomatous optic atrophy.

OPTIC DISC EVALUATION

CLINICAL APPEARANCE OF OPTIC NERVE HEAD:

NORMAL OPTIC NERVE HEAD:

Optic nerve head is vertically oval .The central portion of the optic nerve head consists of a depression called cup, which does not contain any axon, with the exposure of lamina cribrosa.The cup is pale . The tissue between the disc margin and cup is called the neuroretinal rim. The neuroretinal rim contains axons of ganglion cell layer .It is red-orange in colour due to its blood supply.

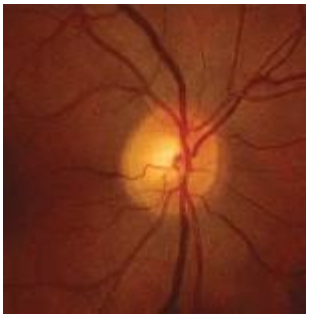


Figure depicting normal optic nerve head

NEURORETINAL RIM:

The neuroretinal rim is broadest in the inferior quadrant, followed by the superior and nasal quadrant and narrowest in the temporal quadrant – “ISNT Rule”. This rule is altered in glaucomatous optic neuropathy.

RETINAL NERVE FIBRE LAYER:

In normal eyes, retinal nerve fibre layer can be seen as striations due to light reflecting from the bundles of axons of nerve fibre. They are best seen in posterior pole and peripapillary region.

GLAUCOMATOUS OPTIC NEUROPATHY:

OPTIC NERVE HEAD CHANGES:

There is vertical enlargement of cup due to the selective loss of neuroretinal rim .This occurs initially in the inferotemporal and superotemporal region due to increased susceptibility of superior and inferior arcuate fibres. The focal atrophy of neural rim begins as a small defect in the inferotemporal quadrant known as polar notching or focal notching. This enlargement of cup is due to the ganglion cell apoptosis with loss of supporting glial tissue. The underlying lamina cribrosa is exposed which can be seen opththalmoscopically as grey pores .This is known as “laminar dot sign”

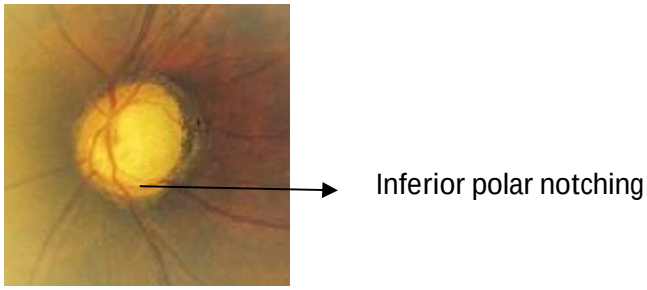


Figure showing vertical cupping with inferior polar notching

VESSEL CHANGES:

These include nasalisation and bayoneting of vessels due to loss of neuroretinal rim. Splinter hemorrhages at the margin of the disc known as “Drance hemorrhage” can occur and are more commonly associated with normotensive glaucoma[4].

Baring of the circumlinear vessel was first described by Herschler and Oscher [6].Circumlinear vessel, a branch of central retinal artery /vein has a curved path along the disc margin. In glaucoma, as the cup enlarges due to ganglion cell loss, the margin recedes and there is a space between the vessel and the margin.

PERIPAPILLARY CHANGES:

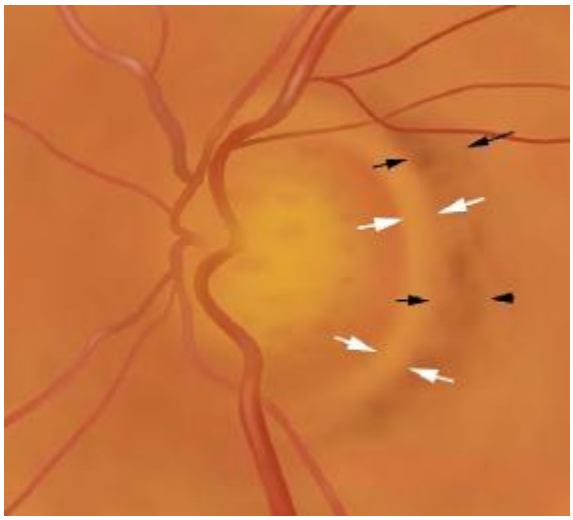
It was showed by Primrose [5] that the presence of peripapillary atrophy was more common in glaucoma. There are two zones of peripapillary atrophy.

1. Zone alpha:

This consists of irregular hypo and hyperpigmentation of RPE and thinning of chorioretinal tissue.

2. Zone beta:

This zone is present close to the disc margin. Zone beta is due to atrophy of RPE and reduction in photoreceptors which leads to visibility of sclera and choroid vessels. Zone beta is more significant in glaucoma.



- Black arrows –Zone alpha
- White arrows – zone beta

RETINAL NERVE FIBRE LAYER DEFECTS:

Wedge shaped defects in the peripapillary area, parallel to the normal retinal striations is pathognomonic of glaucoma.

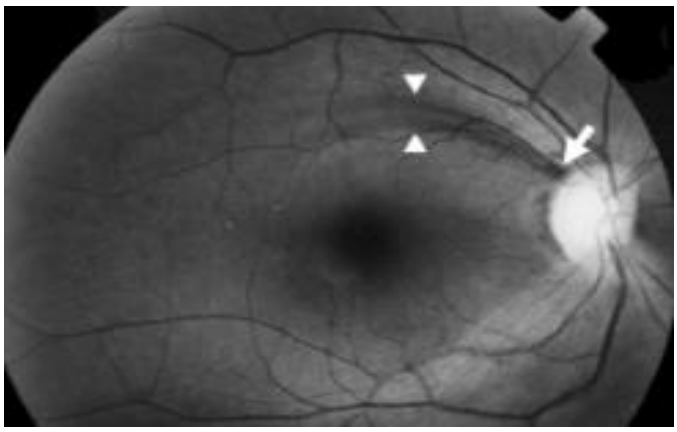


Figure showing RNFL wedge defects

There are various techniques of documentation of disc findings which include

1. Disc drawings
2. Disc photographs

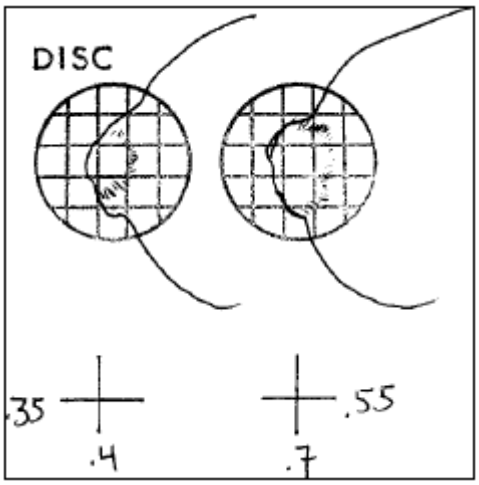


Figure showing disc drawing and depiction of cup disc ratio and NRR

STAGING DISC DAMAGE:

There are various systems used for staging of disc damage Armaly's Cup/ Disc (C/D) ratio system:

In this system, the vertical diameter of the cup is compared to that of the disc[7] . The average normal value is around 0.3, that is the cup normally occupies 30% of the total disc area .Armaly's CD ratio is only an indirect estimation of amount of neuroretinal rim tissue, because larger diameter of disc may be associated with a larger cup despite normal number of axons. Asymmetry of cup disc ratio of more than 0.2 is an important risk factor for glaucoma.

DISC DAMAGE LIKELIHOOD SCALE:

This system of quantification of disc changes was first devised by Spaeth et al[8,9] . Traditionally cup/disc (C/D) ratio was considered as a standard method of evaluation of optic disc. However, the C/D ratio does not take into consideration the diameter of the optic disc. The disc damage likelihood scale incorporates the evaluation of disc size and rim width in clinical grading of the disc[10].

STEP 1: DISC CLASSIFICATION:

Disc diameter is calculated with a + 60D to +90D lens with appropriate corrective factors. For Volk +90 D lens corrective factor of 1.33 is used. For +66 D, no correction factor is required and for +78 D a correction factor of 1.1 is multiplied.

Disc can be classified as follows

1. Small ,with disc diameter less than 1.5 mm
2. Medium, with disc diameter between 1.5 - 2 mm
3. Large ,with disc diameter more than 2 mm

STEP 2: NRR assessment:

The unit of measurement of DDLS scale is the rim/disc ratio, that is, the radial width of the rim compared to the diameter of the disc in the same axis. When there is no rim remaining, the rim/disc ratio is 0. The circumferential extent of rim absence is measured in degrees. Actual absence of rim should be differentiated from sloping rim .Sloping rim can occur temporally in myopes .Because rim width is a function of disc size, disc size must be evaluated prior to attributing a DDLS stage.

STAGES OF DDLS:

The DDLS relies on the optic nerve as a direct indicator of disease. Because the scale divides glaucomatous progression into 10 stages, it can also aid to monitor the disease progression. The DDLS helps in quantification of the amount of damage that the optic nerve has sustained.

For small discs (disc diameter less than 1.5 mm), the DDLS scale is increased by one .For large discs (disc diameter more than 2 mm), the DDLS scale is decreased by one.

Figure showing calculation of DDLS using +90 D lens

IMAGE ANALYSERS:

Optic nerve head and RNFL imaging are used in the diagnosis of preperimetric glaucoma, that is, very early stages of glaucoma without established field defects .Diagnosing at earlier stage is crucial in delaying the progression of glaucoma.

Commonly used technologies to assess the ONH(optic nerve head) and RNFL(retinal nerve fibre layer) are

1. OCT (Optical Coherence Tomography):

The three dimensional structure of the optic nerve head and the peripapillary thickness of the retinal nerve fibre layer can be assessed quantitatively with accuracy and precision using OCT. OCT is a high resolution, cross sectional imaging of the ONH,RNFL and macula.

It is based on the principle of Michelson's interferometry. In glaucoma, the optic disc scan and the RNFL scans are commonly used.

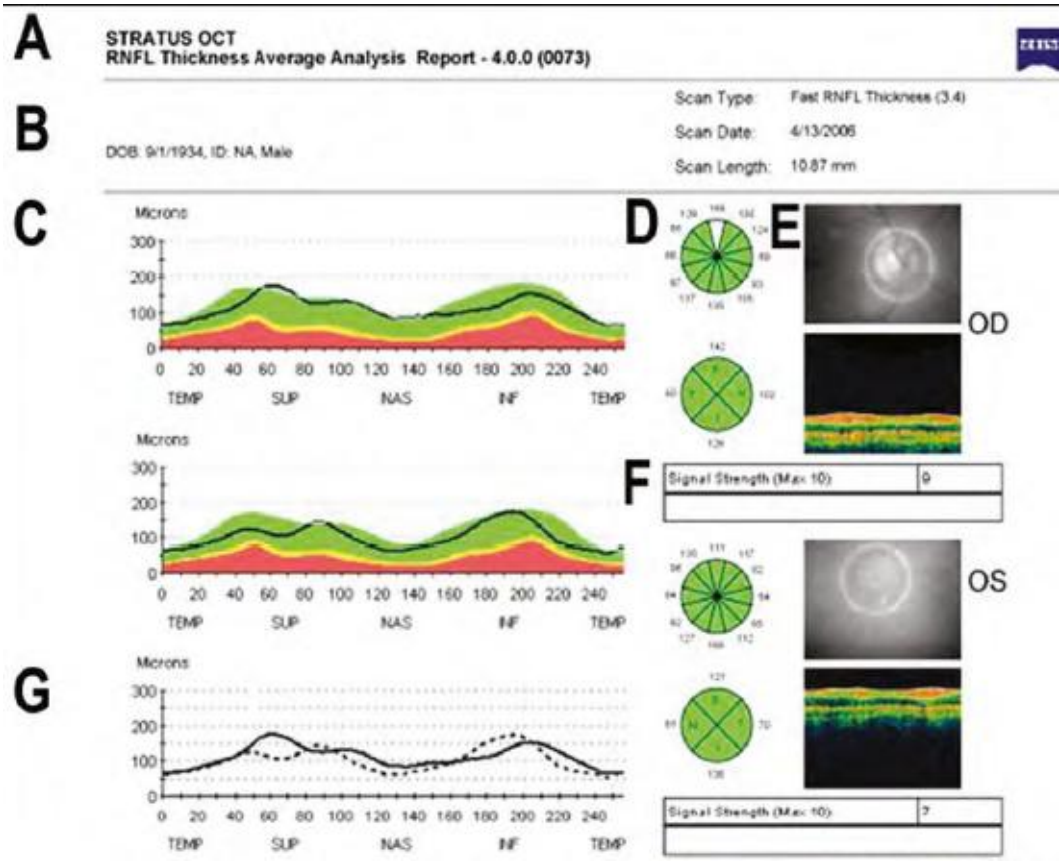


Figure showing OCT RNFL analysis

2. Heidelberg Retina Tomograph(HRT):

It is based on the principle of confocal scanning laser ophthalmoscopy. This tool can analyse three dimensional images of the optic nerve head and peripapillary retina. The parameters which are analysed in HRT are area and volume of the neuroretinal rim and optic cup .

In HRT , Moorfields regression analysis(MRA) is used . This helps to differentiates between glaucomatous and healthy ONHs by detecting diffuse and focal changes of the neuroretinal rim area.

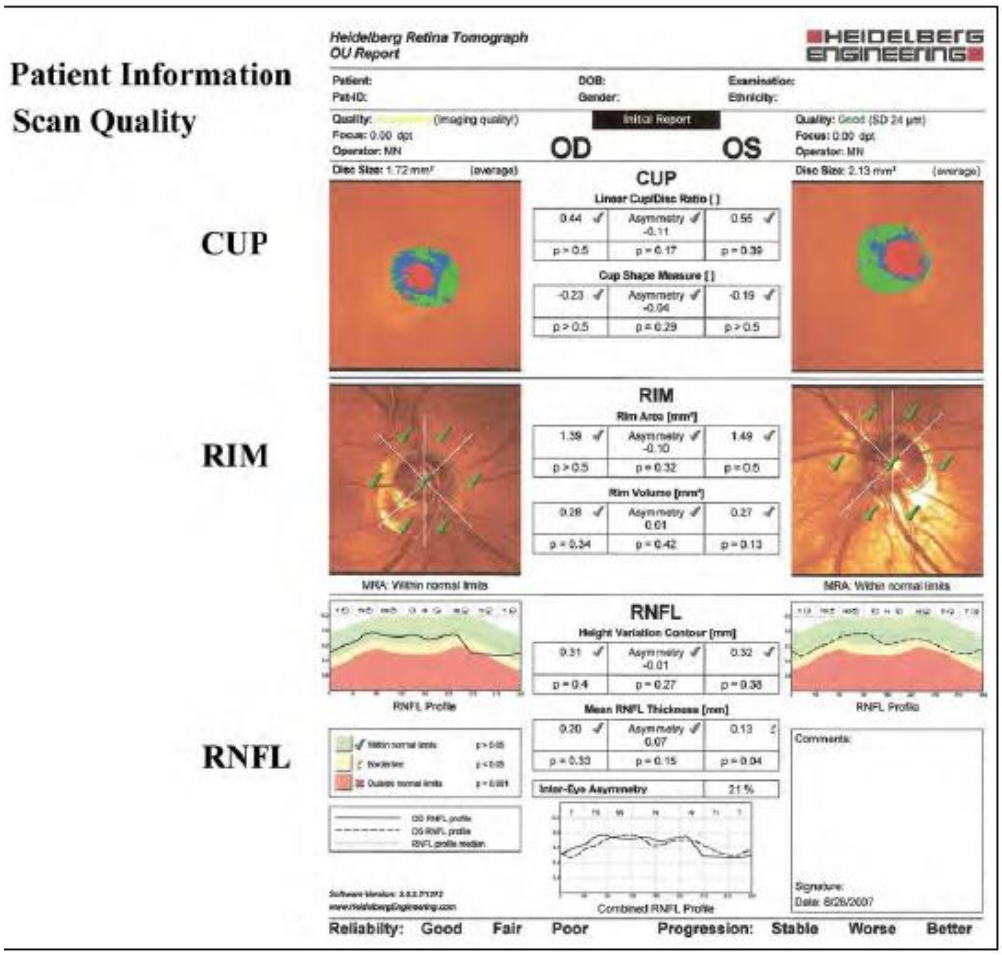


Figure showing HRT report

3. GDx –VCC (Glaucoma Diagnosis –Variable Corneal Compensation)

GDx is based on scanning laser polarimetry.This is mainly used to image and quantify the peripapillary RNFL thickness.Gdx is based on the principle of birefringence.

VCC stands for variable corneal compensator, created to account for the variable corneal birefringence. GDx measures the RNFL thickness point to point in the peripapillary region . Any deviation from the age matched normative data is indicated and denotes RNFL thinning in the particular quadrant.

PERIMETRY

Perimetry is the method of examination and quantification of visual fields.

VISUAL FIELDS:

Harry Moss Traquair (1875-1954) described visual fields as "an island of vision or hill of vision surrounded by a sea of blindness"[11]. The extent of visual fields is 60° superiorly and nasally , 100° temporally and 75°inferiorly.

PERIMETRY IN GLAUCOMA:

Perimetry is an important investigation in the diagnosis of glaucoma. Perimetry also has prognostic value in that it aids to monitor the disease progression and helps to decide on the treatment protocol. The central 30° visual field examination is usually preferred.

TYPES OF PERIMETRY:

1. Kinetic Perimetry:

Kinetic perimetry measures extent of visual fields by plotting isopters. Stimulus of a particular size and intensity is passed from non seeing area to seeing area along a particular meridian at the rate of 3 – 5 deg per sec. Examples include Confrontation method , Bjerrum screen, Arc perimetry.

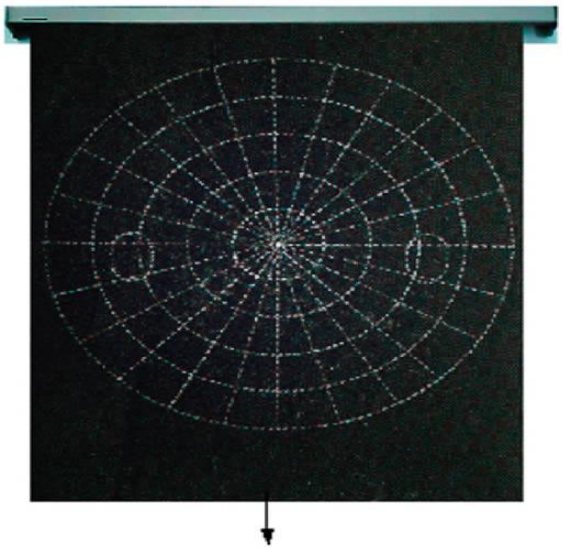


Figure showing Bjerrum's screen

2. Static Perimetry:

In static perimetry, the location, size and duration of stimulus is kept constant and the luminance is gradually increased until stimulus can be seen. The main advantage is that the actual estimation of retinal sensitivity is measured at predetermined locations in the visual fields.

Examples:

Humphrey and octopus perimeter.

OCTOPUS PERIMETRY:

PARAMETERS USED IN OCTOPUS WHITE ON WHITE PERIMETRY:

- Background luminance: 31.4 asb
- Stimulus size : Goldmann size III and V
- Exposure time: 100 ms
- Stimulus source: direct projection system with a pseudo-infinite target in to the eye.
- Stimulus intensity: Octopus - 0 to 1000 apostilbs (40 to 0 dB)

THRESHOLD STRATEGIES

THRESHOLD:

Threshold stimulus luminance is defined as the luminance of the stimulus which is perceived with a probability of 50% as described by the frequency-of-seeing curve (FOSC).

STRATEGIES USED IN OCTOPUS:

- Full threshold
- Dynamic
- TOP (Tendency Oriented Program)

- **FULL THRESHOLD STRATEGY:**

This estimates the visual sensitivity in each tested point.It uses bracketing strategy or the 4-2-1 step strategy. The main disadvantage of full threshold strategy is that it is time consuming and takes 10 – 15 min for each eye.

- **DYNAMIC STRATEGY**

In this strategy, the step size adapts to the slope of Frequency of Seeing Curve. Small steps are used for steep FOSC and large steps for

wider FOSC. The major advantage is that it reduces approximately 30 – 50 % of testing time. Accuracy is also comparable to normal threshold strategy in the zones of normal sensitivity.

- **TENDENCY ORIENTED PROGRAM:**

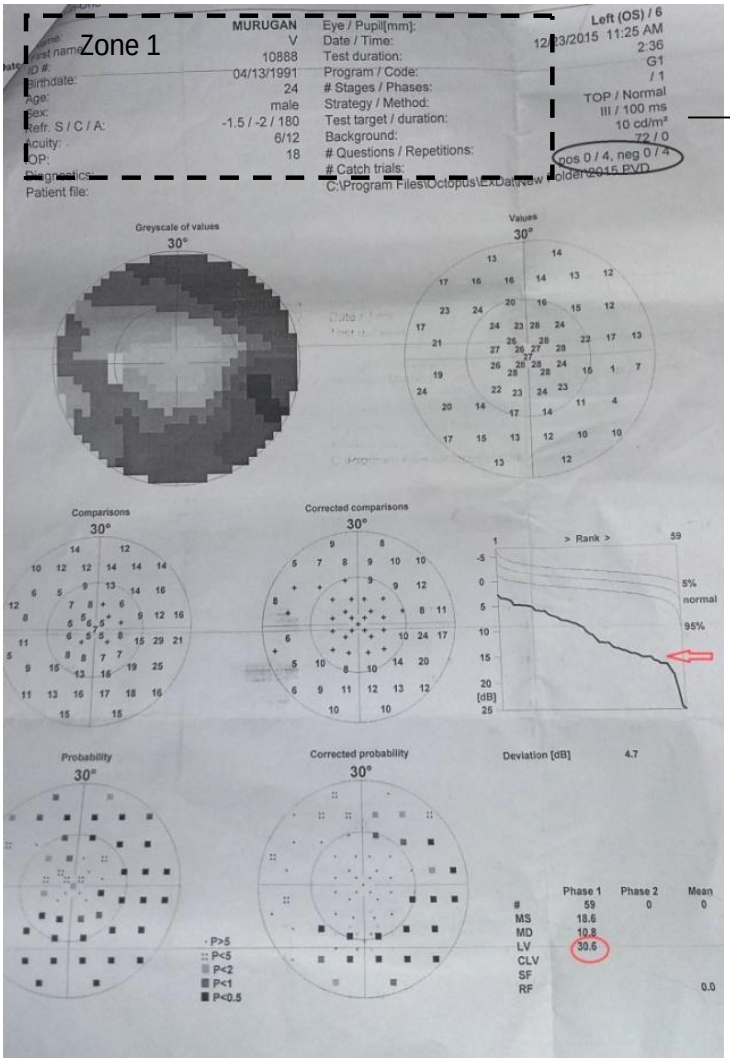
This strategy takes advantage of the correlation between the thresholds of neighbouring zones and thus reduces the testing time by 80 %. There is an excellent correlation between the visual field indices obtained with TOP and the Normal strategy.

PROGRAMS USED IN OCTOPUS PERIMETRY:

- G1: central 30° tested using 59 points.
- G2: central 30° tested using 59 points, additional 15 points are used to test between 30 °- 60°
- Macular programs (M1, M2) : central 10° is tested . It is used in advanced glaucomas.

INTERPRETATION OF VISUAL FIELDS:

There are totally 7 zones to be considered during interpretation of visual fields



Zone 2:
reliability indices

ZONE I: Patient data and examination data

Age: Age of the patient is very important since in automated perimetry subjects retinal sensitivity is compared with aged matched normative data.

Refraction:

Full refractive correction should be given during perimetry . Refractive errors can produce generalised decrease in sensitivity.

Pupil size:

Pupil size is also an important variable to be considered since very small pupil can cause generalised constriction of field.

ZONE II :

RELIABILITY INDICES:

- Positive catch trials or false positive:

Subjects respond without the stimuli being projected .

Example: trigger happy subject

- Negative catch trials or false negative :

Subjects who had once responded to a stimulus of lower intensity, but do not respond to a stimulus of higher intensity during repeated testing.

For a field testing to be reliable, positive and negative catch trails should be less than 33 %

ZONE III:

- Grey scale: In this the threshold sensitivity values are displayed as shades of grey .Grey scale gives a gross depiction of field defect

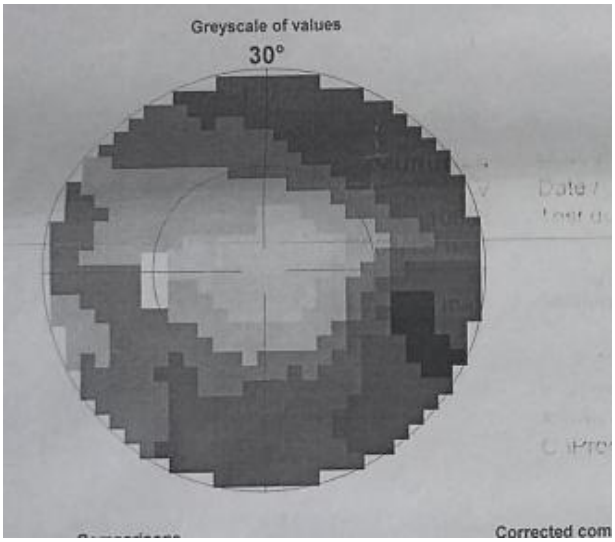
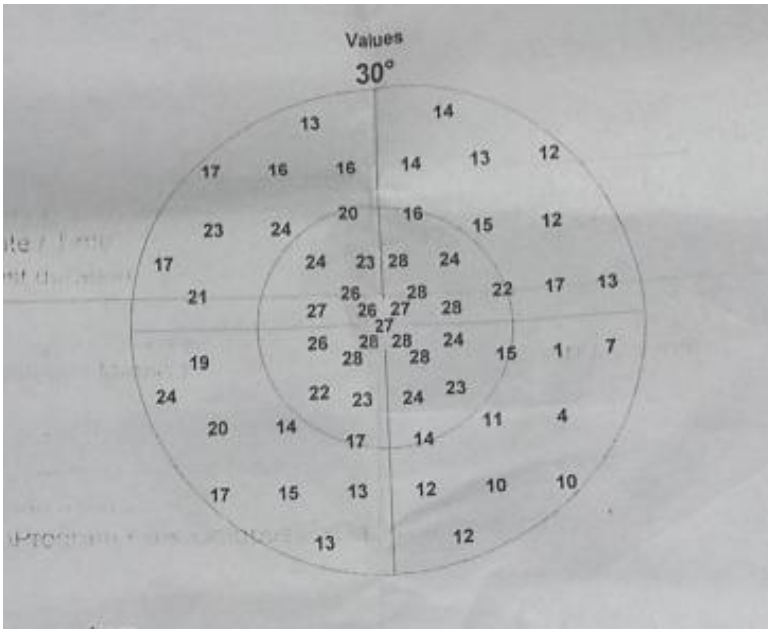


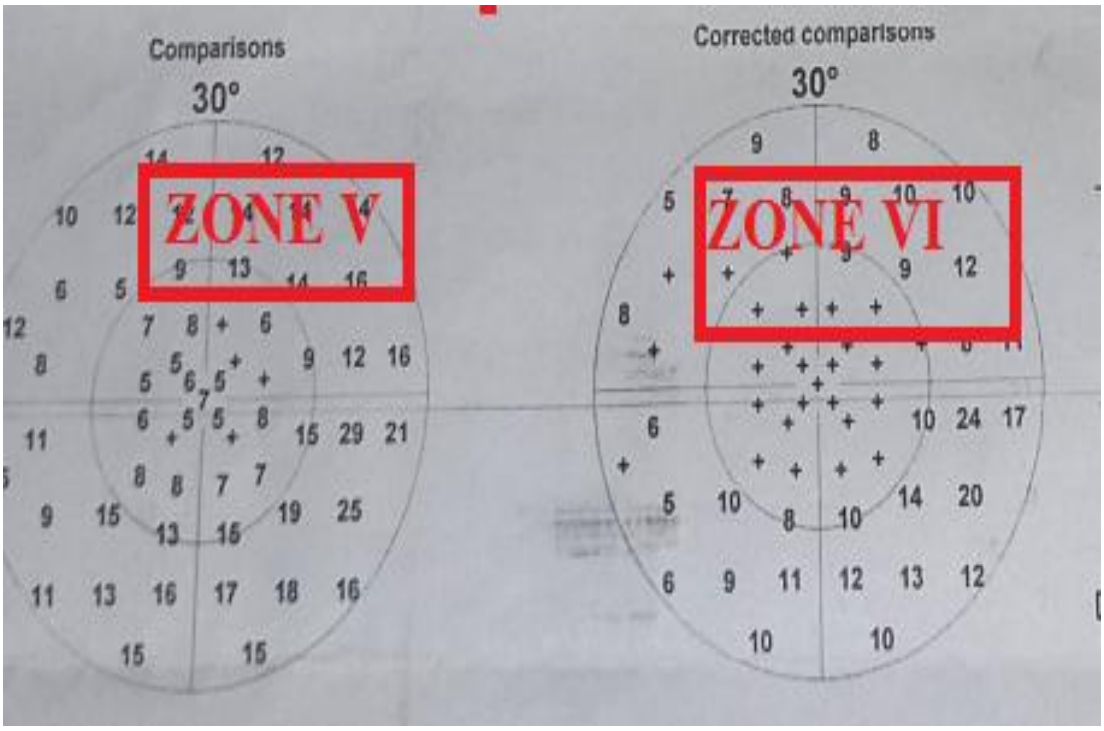
Figure showing grey scale

ZONE IV:

- Raw data : This shows the retinal sensitivity at a particular point which is being tested.



ZONE V : COMPARISON MAP OR TOTAL DEVIATION PLOT



In comparison plot, the difference between subjects threshold sensitivity and the age matched normal retinal sensitivity from the perimeters database is depicted

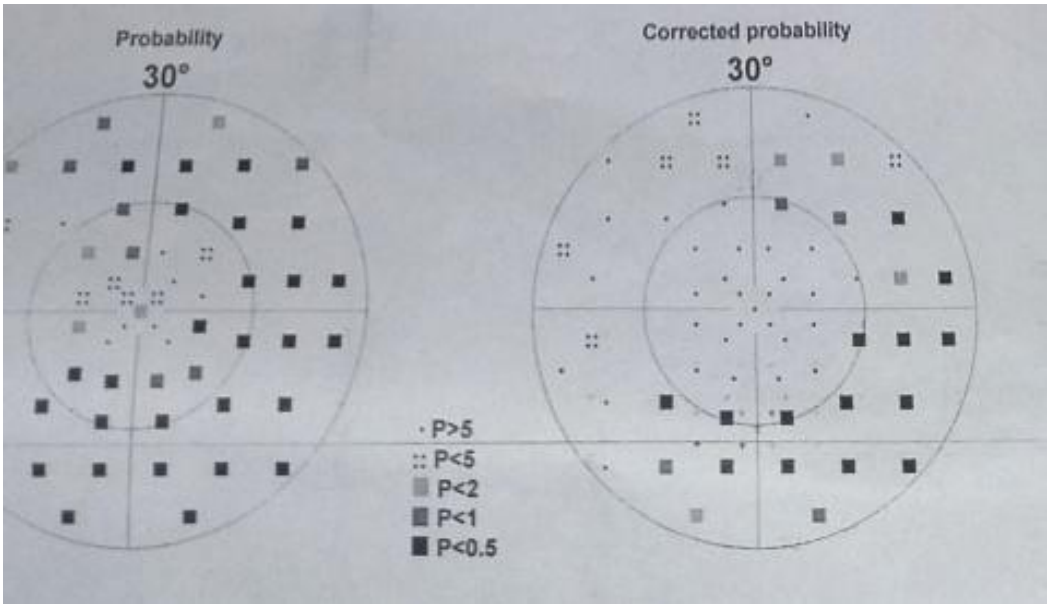
ZONE VI:

CORRECTED COMPARISON OR PATTERN DEVIATION PLOT :

This eliminates any generalised decreased sensitivity due to refractive error or media opacities and thus shows the localised loss at each tested point.

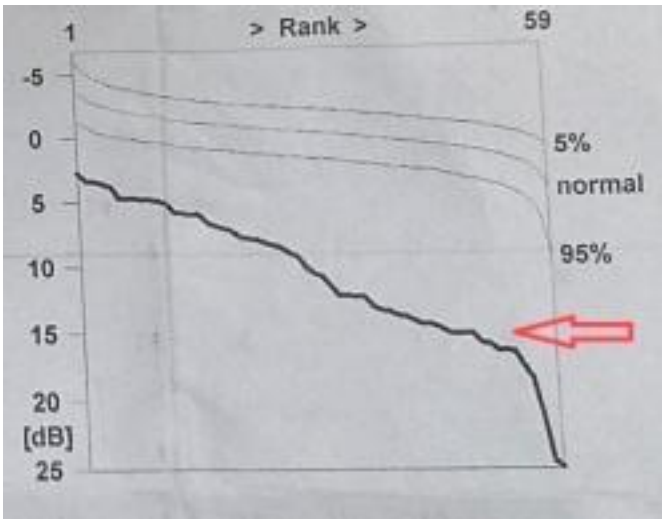
ZONE VII :

PROBABLITY PLOTS :



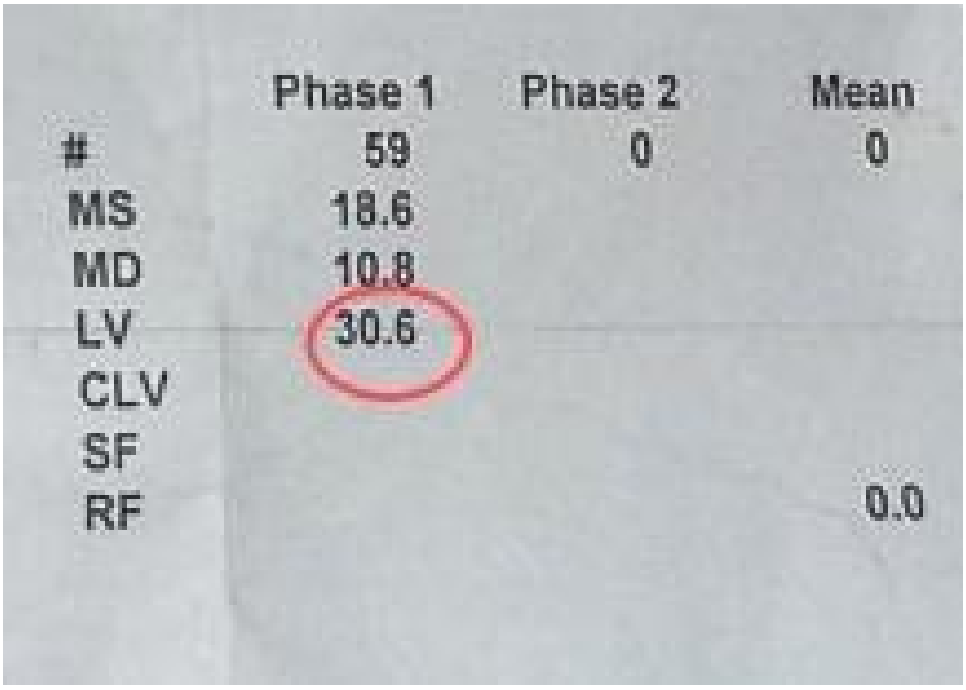
This depicts locations where the deviations are less than those found in 5 %,2%,1% , 0.5% of normal subjects.

BEBIE'S CURVE:



It is a graphical representation displaying the magnitude of depressed sensitivity in visual fields.

GLOBAL INDICES:

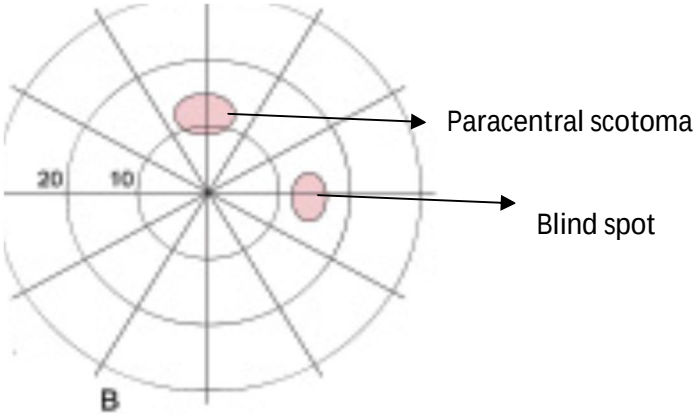


This includes Mean sensitivity MS, Mean defect MD, Loss variance LV and corrected loss variance CLV.

FIELD DEFECTS IN GLAUCOMA:

PARACENTRAL SCOTOMA:

The earliest field defect is paracentral scotoma.

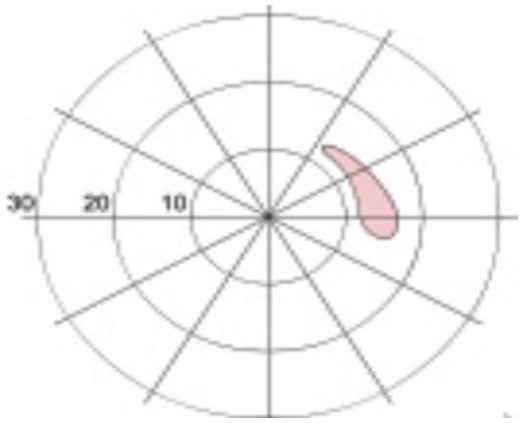


BJERRUM'S AREA:

It is an arcuate area extending above and below the blind spot between 10 -20° of the fixation.

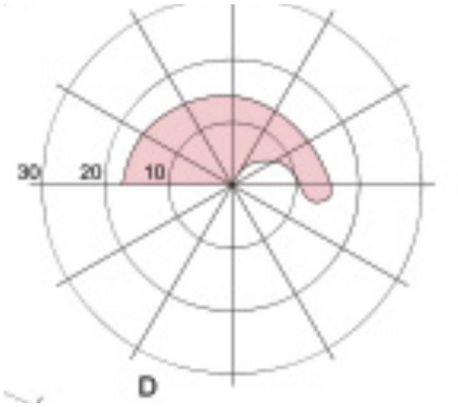
SEIDEL S SCOTOMA:

The paracentral scotoma joins the blind spot with progression of disease and is called seidel's scotoma.



ARCUATE OR BJERRUM'S SCOTOMA:

Seidel"s scotoma extends above or below the horizontal line to form arcuate scotoma.

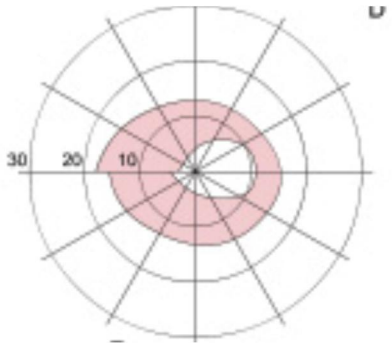


RING SCOTOMA:

This occurs when two arcuate scotoma meet along the horizontal line.

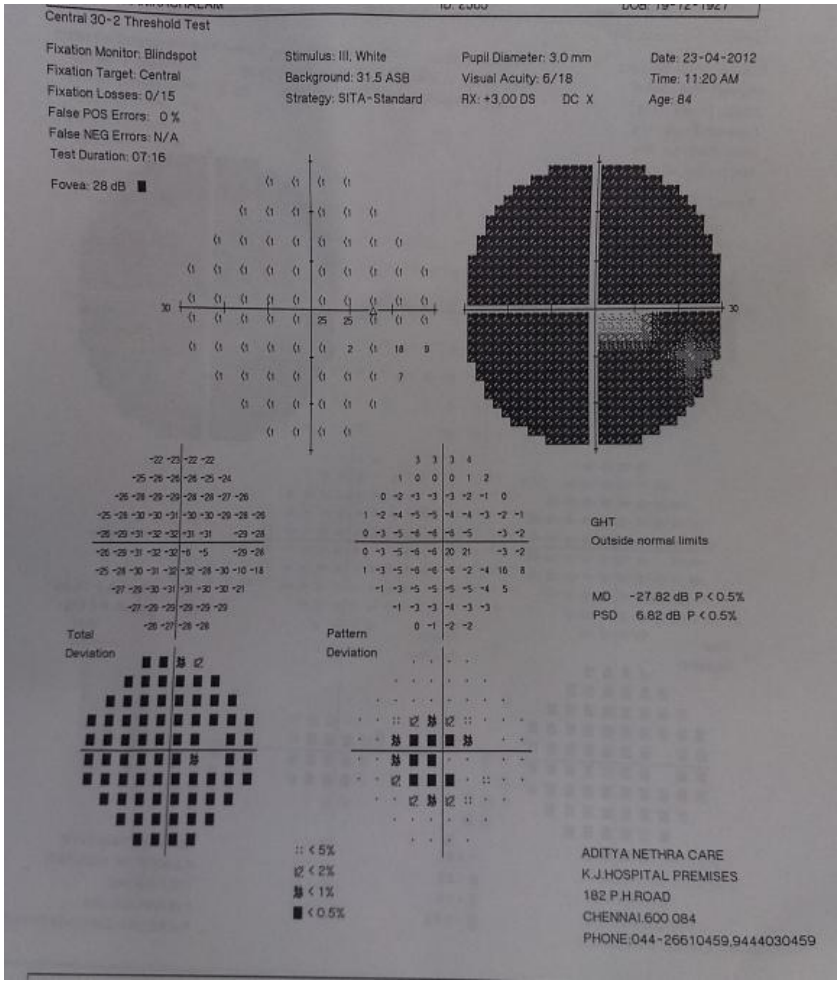
ROENNE'S NASAL STEP:

This is due to asymmetry between two arcuate scotomas thereby forming a sharp right-angled defect at the horizontal meridian



ADVANCED GLAUCOMATOUS FIELD DEFECTS.

In advanced glaucomas, only central 5° fields known as tubular vision and an accompanying temporal island are retained.



HFA showing advanced tubular field.

PRIMARY OPEN ANGLE GLAUCOMA:

DEFINITION :

Primary open angle glaucoma is a chronic progressive optic neuropathy where intraocular pressure and other factors contribute to loss of retinal ganglion cells in the absence of other identifiable causes

RISK FACTORS:

The common risk factors include

- elevated IOP
- older age
- family history of glaucoma
- African race
- thinner central corneal thickness
- low diastolic perfusion pressure,
- diabetes
- myopia
- systemic hypertension

CLINICAL FEATURES:

SYMPTOMS:

Usually asymptomatic .Patients may complain of painless progressive loss of vision, frequent change of presbyopic glasses .

EXAMINATION:

Anterior segment examination is usually normal with open angles in gonioscopy (shaffer’s grade of three or more)

Optic nerve head changes and field defects are usually present.

Intraocular pressure is usually high

PART – II

AIM

To analyse **"Disc Damage likelihood scale"** in patients with established open angle glaucoma and to correlate it with field defects and to thereby obtain an anatomical versus functional correlation . This study also evaluates the diagnostic ability of disc damage likelihood scale in glaucoma.

PRIMARY OBJECTIVE:

To calculate the "Disc Damage Likelihood Scale" in patients with established primary open angle glaucoma and to correlate the DDLS scores of the patients with visual fields.

SECONDARY OBJECTIVE:

To evaluate the diagnostic ability of disc damage likelihood scale in established glaucomas.

DDLS SCALE: The DDLS helps in quantification of the amount of damage that the optic nerve has sustained.

	DDLS STAGE	NARROWEST RIM WIDTH(RIM DISC RATIO)
AT RISK	1	0.4 or more
	2	0.3-0.39
	3	0.2-0.29
	4	0.1-0.19
GLAUCOMA DAMAGE	5	Less than 0.1
	6	0(extension less than 45°)
	7	0(extension :46° to 90°)
GLAUCOMA DISABILITY	8	0(extension :91°-180°)
	9	0(extension : 181°-270°)
	10	0(extension : more than 270°)

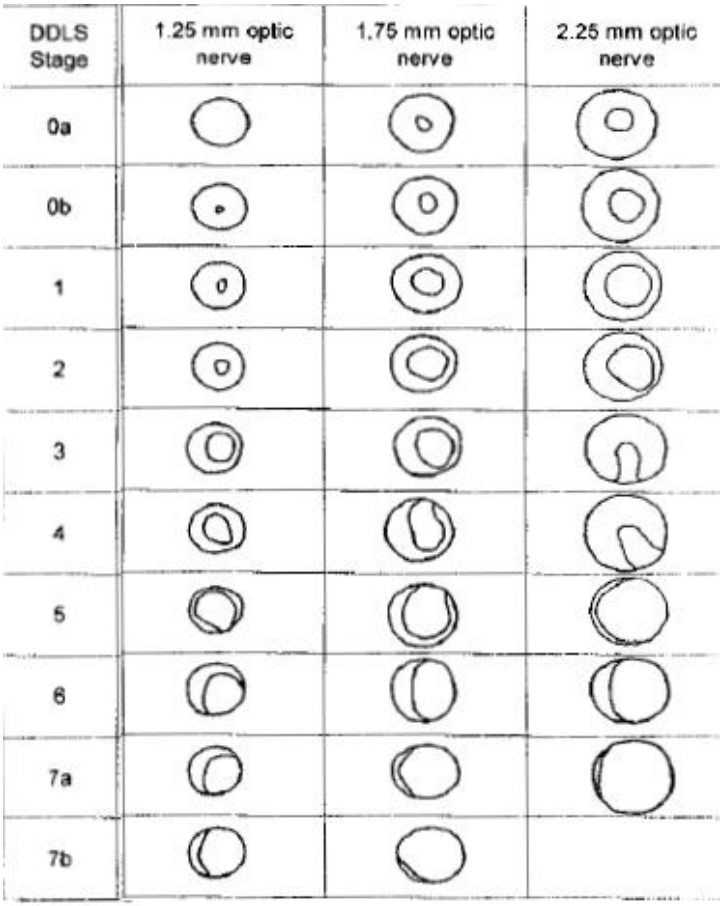


Figure showing examples of DDLS score

METHODOLOGY (MATERIALS AND METHODS):

- Study centre: Glaucoma services ,Regional Institute Of Ophthalmology and Government Ophthalmic Hospital ,Egmore, Chennai
- Study duration: 5 months(April 2016- August 2016)
- Study design: Prospective study
- Sample size: 50 patients

SUBJECT SELECTION:

50 patients with open angle glaucoma attending glaucoma services of Regional Institute of Ophthalmology And Government Ophthalmic Hospital,Chennai between April 2016 and August 2016, who satisfied the following inclusion criteria were included in the study.

INCLUSION CRITERIA:

Inclusion criteria were as follows

- Age: Patients aged 45 yrs or more were included.
- Best Corrected Visual Acuity : Patients with best corrected visual acuity of more than 6/24 were included .This is because the visual fields by automated perimetry are not very reliable in patients with low visual acuity .There is generalised decrease in retinal sensitivity in patients with low visual acuity.
- Gonioscopy: Patients with open angles by gonioscopy(shaffer's grading more than or equal 3) were included
- Fields : patients with established field defects ,atleast 2 consecutive and reliable fields by Octopus 301 automated perimetry done over a period of 6 months showing glaucomatous fields ,were included in this study.
- Post operative patients of more than a year of surgery were included.

EXCLUSION CRITERIA:

- Other causes of optic neuropathy like traumatic optic neuropathy were excluded.
- Gonioscopy : patients with narrow and occludable angles (shaffer's grade less than 2) were excluded
- Best Corrected Visual Acuity: Patients with best corrected visual acuity of less than 6/24 were excluded.
- Patients with secondary glaucomas like lens induced glaucomas ,traumatic angle recession glaucomas ,post inflammatory glaucomas, neovascular glaucomas were excluded.
- Patients operated less than a year were excluded .

METHODS:

All patients underwent the following examinations

1. Best corrected visual acuity
2. Detailed anterior segment examination by slit lamp biomicroscopy
3. Intra ocular pressure by Goldmann applanation tonometry
4. Gonioscopic examination of angle by Goldman single mirror gonioscopy

5. Automated perimetry by octopus 301 using G1 program ,TOP strategy
6. Disc damage likelihood scale calculation

Disc damage likelihood scale calculation :

- Disc damage likelihood scale was calculated after pupillary dilataion with 0.5% tropicamide .
- Using a volk 90 D lens and a slit lamp, the width of the disc and the rim width were calculated .
- A correction factor of 1.3 was used.
- The disc were classified as small,medium and large and the scale was calculated accordingly.
- Clinical diagram was made for the discs.

RESULTS

DEMOGRAPHY:

AGE DISTRIBUTION:

AGE GROUP(in years)	NO. OF PATIENTS
45-50	15
51-55	10
56-60	5
60-65	8
More than 66	12

Table 1 showing age distribution

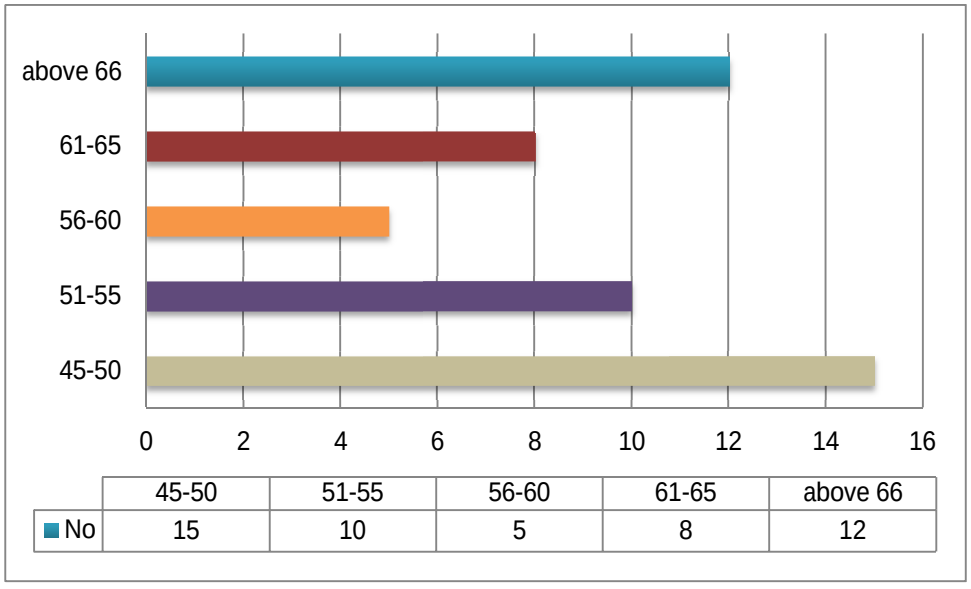


Chart 1 showing age distribution

SEX DISTRIBUTION:

Of the 50 patients included in this study, 31 were males and 19 were females.

SEX DISTRIBUTION	NO OF PATIENTS
Male	31(62%)
female	19(38%)

Table 2 showing sex distribution

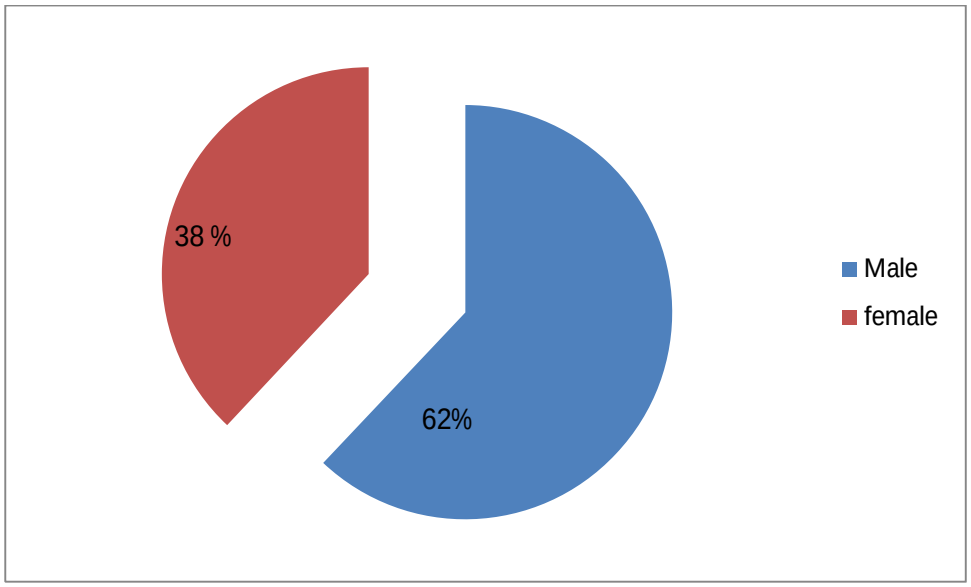


Chart 2 showing sex distribution

MODALITY OF TREATMENT:

Of the 50 patients included in this study,

- 35 patients were on medical management .They were on topical medications (which included topical beta blockers, prostaglandins , brimonidine or combination of drugs).
- 15 patients had antiglaucoma surgery done (trabeculectomy done).
- Of these 15 patients , 2 patients were on additional medical management Topical antiglaucoma medication for IOP control.

TREATMENT MODALITY	NO. OF PATIENTS
Medical (topical antiglaucoma medication)	35(70 %)
Surgical trabeculectomy	13(26%)
Both medical and surgical	2(4%)

Table 3 showing distribution according the treatment modality

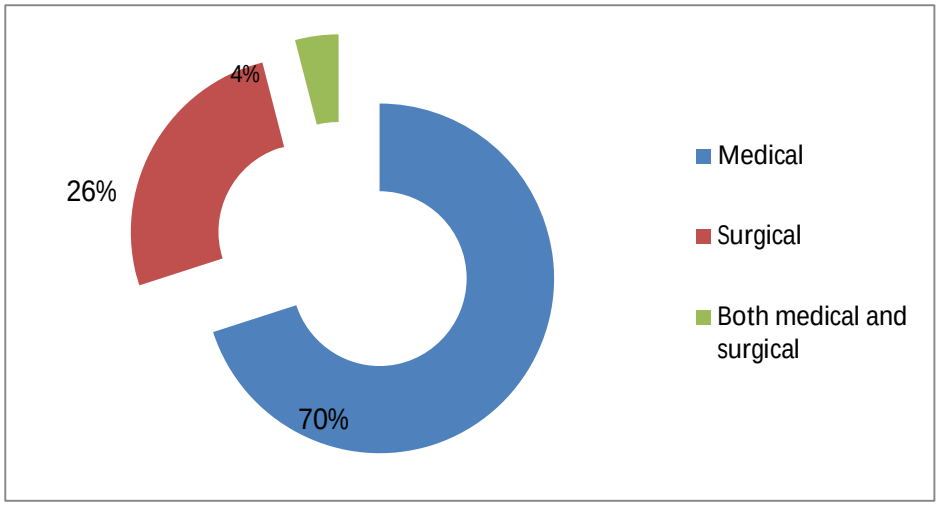


Chart 3 showing distribution according the treatment

DISC SIZE:

Of the 100 eyes of 50 patients examined ,

- None of the patients had small discs(disc diameter of less than 1.5 mm)
- 86 eyes had medium size discs (diameter between 1.5 – 2 mm)
- 14 eyes had large discs (diameter more than 2 mm)

DISC DIAMETER	NO.OF EYES
Small discs	0
Medium discs	86(86%)
Large discs	14(14%)

Table 4 showing classification according to disc diameter

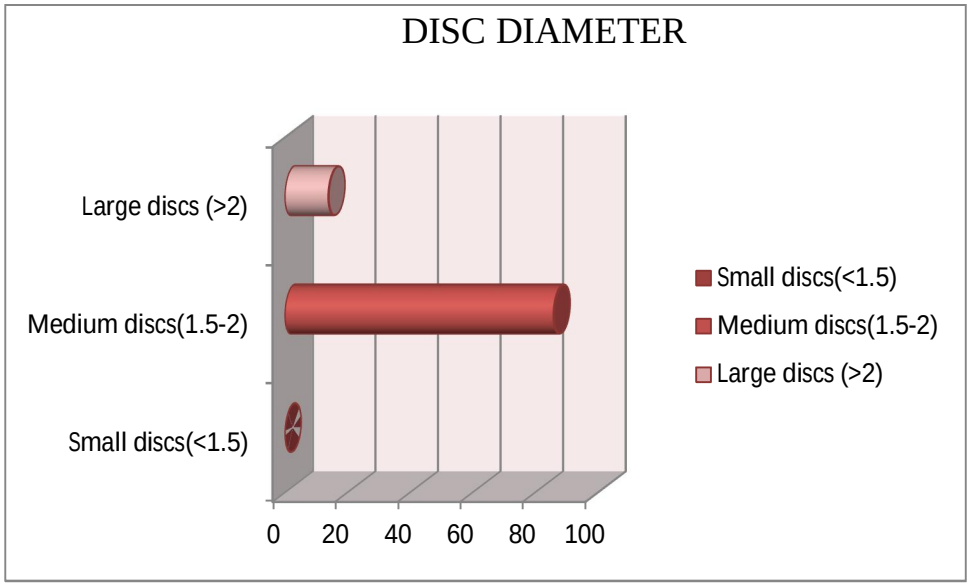


Chart 4 showing classification according to disc diameter

ASYMMETRY OF DISC DIAMETER:

Of the 50 patients examined ,4 patients had asymmetry of disc diameter.

DISC DIAMETER OF TWO EYES	NO OF PATIENTS
Symmetry of disc diameter	46
Asymmetry of disc diameter	4

Table 5 showing no. of patients with symmetrical and asymmetrical discs

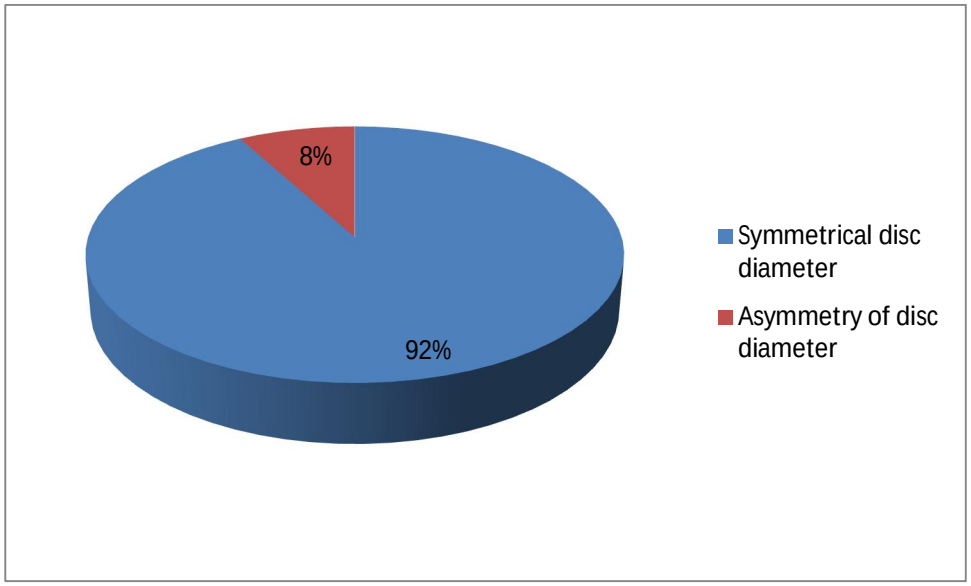


Chart 5 showing no. of patients with symmetrical and asymmetrical discs

DDLS SCORE:

The following were the DDLS score of 100 eyes

DDLS SCORE	NO. OF EYES
1	0
2	0
3	11
4	19
5	18
6	15
7	9
8	11
9	13
10	0

Table 6 showing DDLS score of 100 eyes

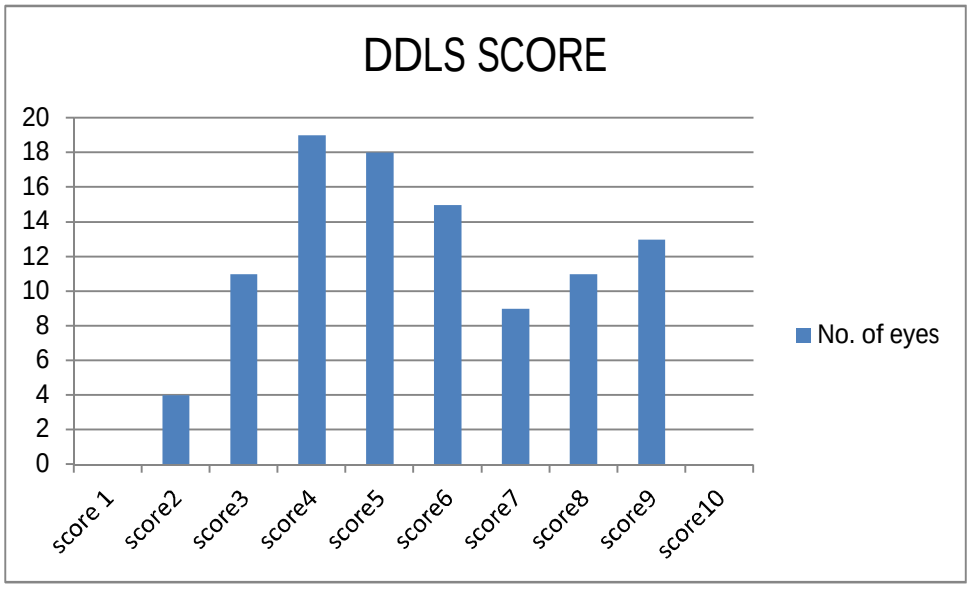


Chart 6 showing DDLS score of 100 eyes

CLASSIFICATION BASED ON DDLS SCORE:

Of the 100 eyes included in the study

- 34 eyes came under classification of " At risk of glaucoma"
- 42 eyes came under classification of "Glaucoma damage"
- 24 eyes came under classification of " Glaucoma disability"

CLASSIFICATION	NO OF EYES
At risk	34(34%)
Glaucoma damage	42(42%)
Glaucoma disability	24(24%)

Table 7 showing classification according to DDLS score

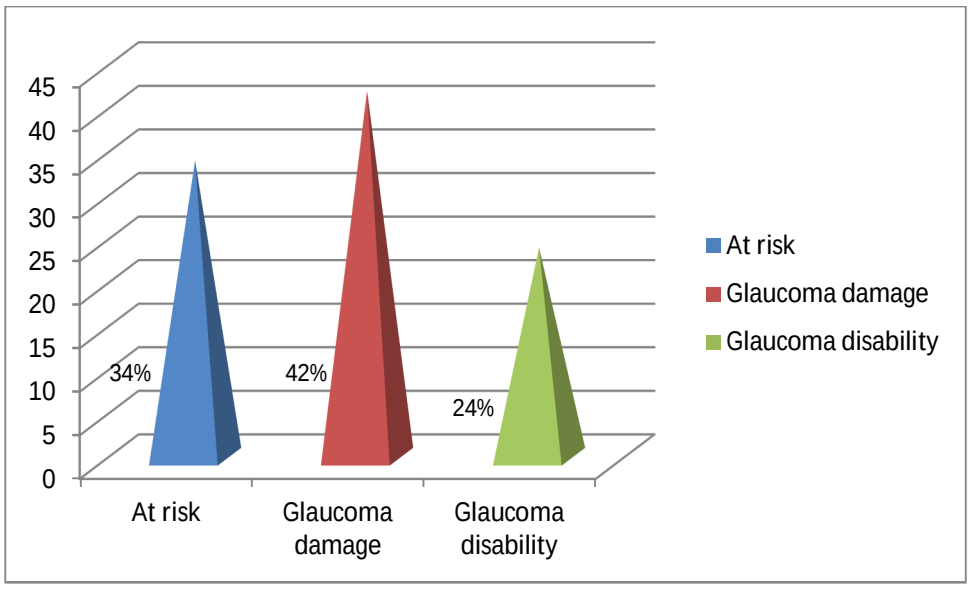


Chart 7 showing classification according to DDLS score

FIELD DEFECTS:

FIELD DEFECTS	NO OF EYES
Areas of depressed sensitivity in paracentral region	11
Paracentral scotoma	10
Relative defects in superior arcuate region	13
Relative defects in the inferior arcuate region	14
Superior arcuate scotoma	16
Inferior arcuate scotoma	8
Biarcuate scotoma with nasal step defects	13
Tubular fields	15

Table 8 showing the field defects in 100 eyes

CLASSIFICATION OF FIELD DEFECTS:

Based on field defects, glaucoma can be classified as

- **MILD:**

Disc changes without field defects on white on white perimtery(defects may be present on swap blue on yellow perimetry. In this study, pre perimteric glaucoma patients were excluded.

- **MODERATE:**

Disc changes with field defects , involving one hemifield and not involving the central 5° of fixation. In this study ,the following field defects come under this classification

  - Areas of depressed sensitivity in paracentral region
  - Paracentral scotoma
  - Relative defects in superior arcuate region
  - Relative defects in the inferior arcuate region
  - Superior arcuate scotoma
  - Inferior arcuate scotoma

- SEVERE:

Field defects in both hemifields and /or loss involving the central 5° of fixation .This includes biarcuate scotoma with step defects and tubular fields.

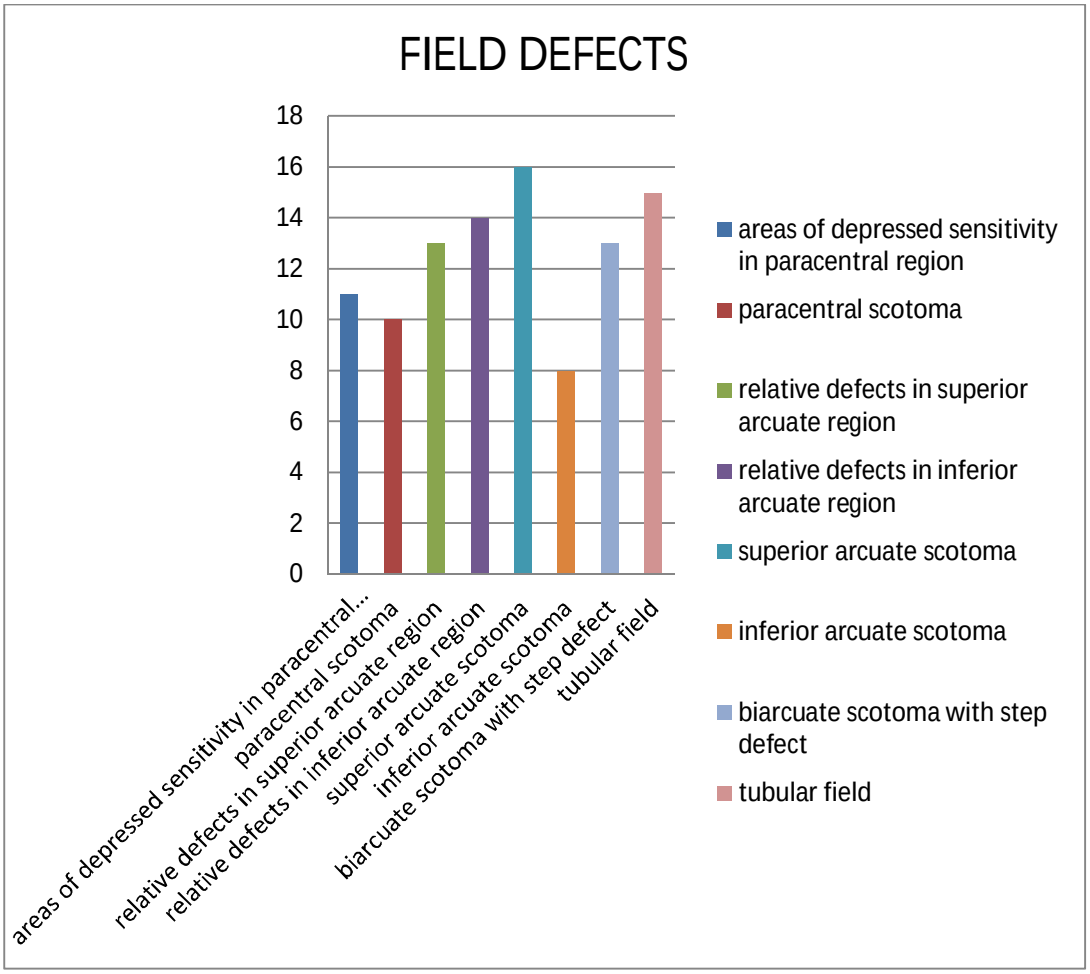


Chart 8 showing field defects in 100 eyes

GRADING ACCORDING TO FIELDS	NO OF EYES
Mild	0
Moderate	72
Severe	28

Table 9 showing classification based on severity of field defects

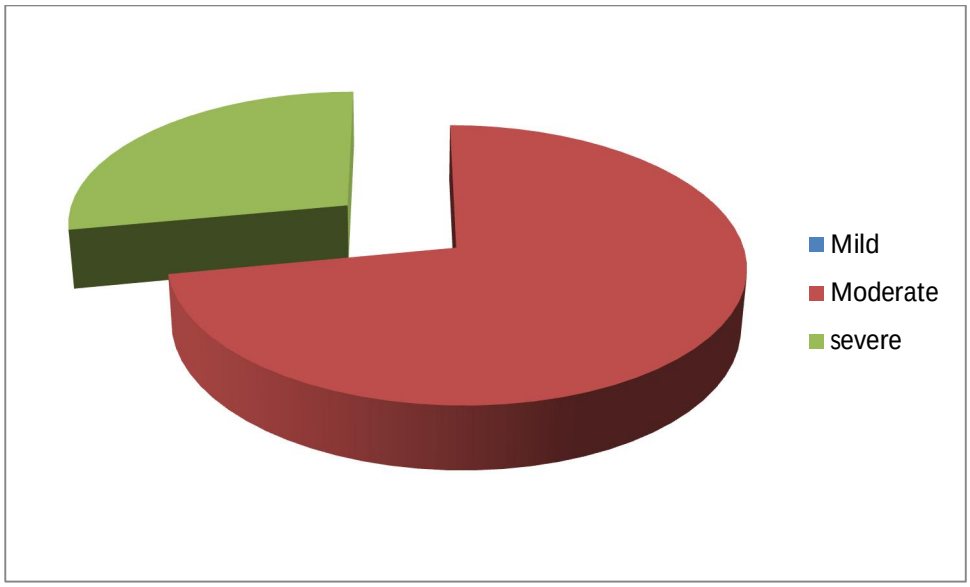


Chart 9 : Pie chart showing classification based on severity of field defects

FIELD INDICES:

MEAN SENSITIVITY:

Average mean sensitivity in different field defects are as follows:

FIELD DEFECTS	AVERAGE MEAN SENSITIVITY(db)
Defects in paracentral region and Paracentral scotoma	28.89
Relative defects in superior and inferior arcuate region	25.91
Arcuate scotoma(superior and inferior)	23.30
Biarcuate scotoma with step defects	18.95
Tubular fields	17.07

Table 10 showing average mean sensitivity in different field defects

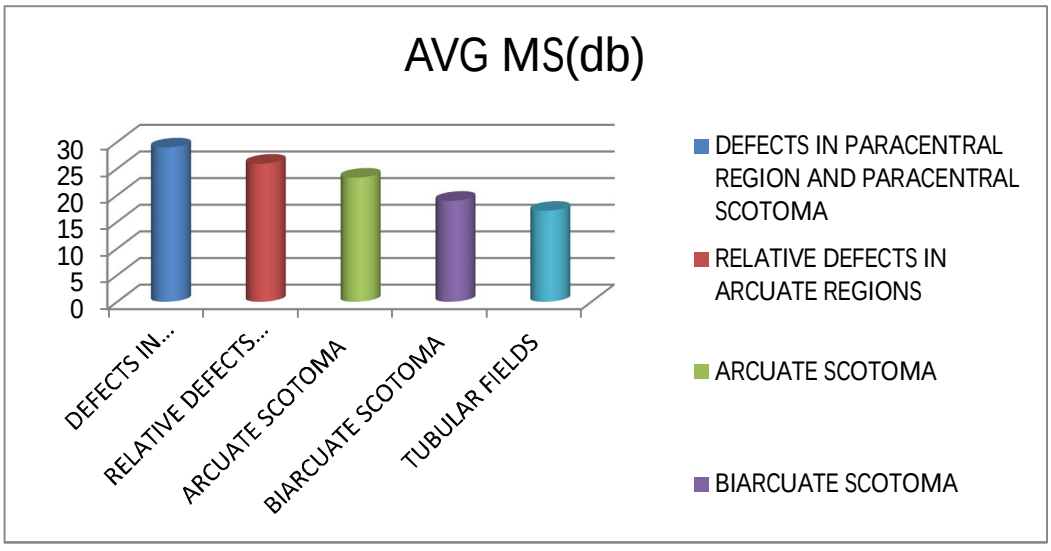


Chart 10: Bar graph showing average mean sensitivity in different field defects

MEAN DEFECT:

The average mean defect in different field defects are as follows

FIELD DEFECTS	AVERAGE MEAN DEFECT(db)
Defects in paracentral region and Paracentral scotoma	9.79
Relative defects in superior and inferior arcuate region	14.62
Arcuate scotoma(superior and inferior)	18.77
Biarcuate scotoma with step defects	26.83
Tubular fields	24.93

Table 11 showing average mean sensitivity in different field defects

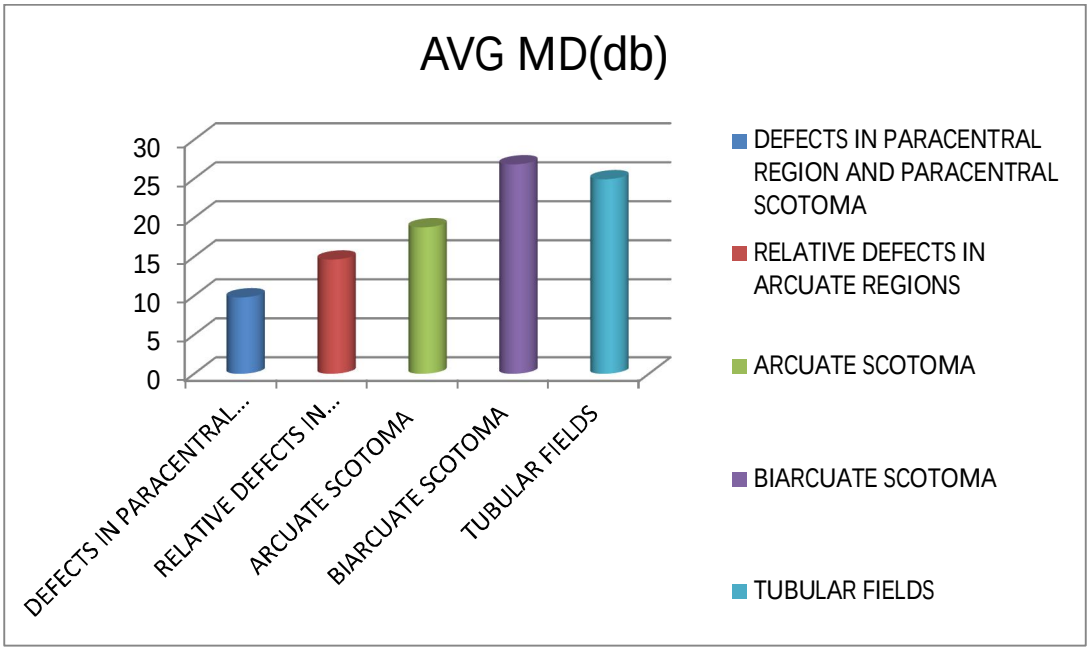


Chart 11: Bar graph showing average mean defects in different field defects

LOSS VARIANCE:

The average loss variances in different field defects are as follows

FIELD DEFECTS	AVERAGE LOSS VARIANCE:
Defects in paracentral region and Paracentral scotoma	8.66
Relative defects in superior and inferior arcuate region	14.62
Arcuate scotoma(superior and inferior)	39.30
Biarcuate scotoma with step defects	101.54
Tubular fields	106.94

Table 12 showing average loss variance in different field defects

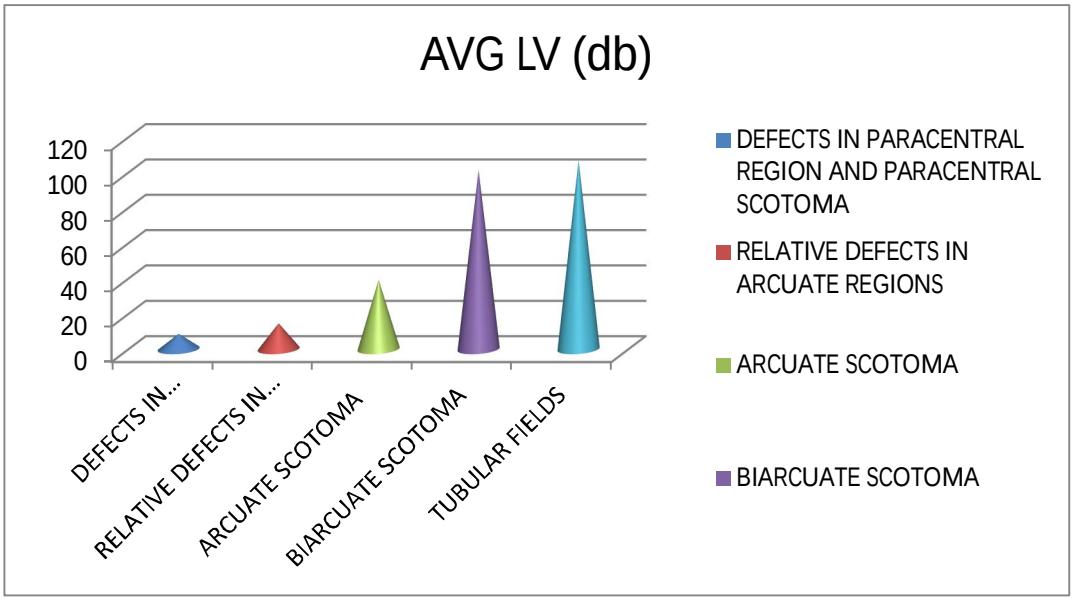


Chart 12: Graph showing average mean defects in different field defects

FIELD INDICES AND DDLS SCORE:

Average mean sensitivity in eyes with different DDLS scores are as follows

DDLS SCORE	AVERAGE MEAN SENSITIVITY(db)
2	30.15
3	28.58
4	27.35
5	26.42
6	23.26
7	20.28
8	18.56
9	16.88

Table 13 showing average mean sensitivity in various DDLS scores

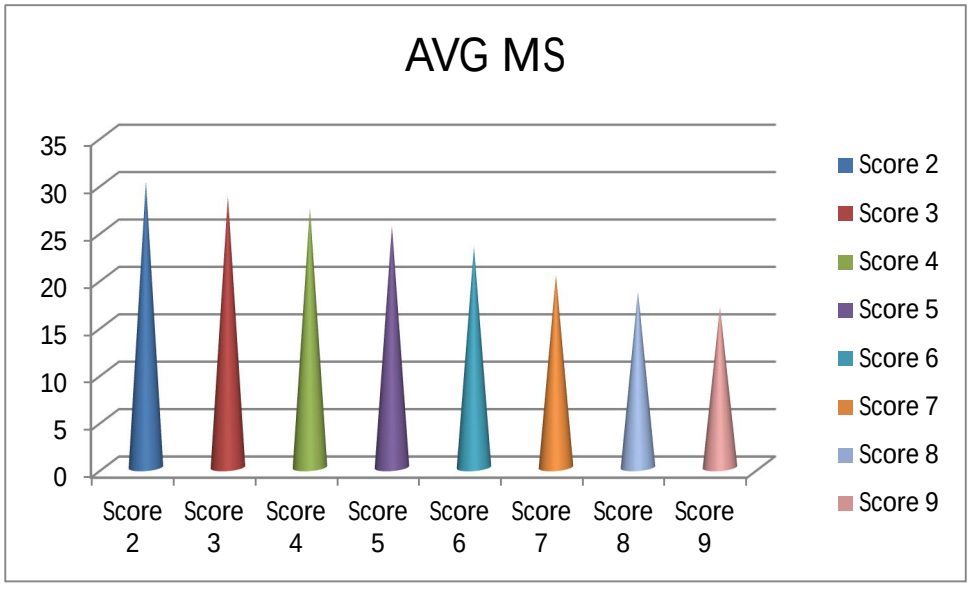


Chart 13 showing average mean sensitivity in various DDLS scores

Average mean defects (db) in eyes with different DDLS scores are as follows

DDLS SCORE	AVERAGE MEAN SENSITIVITY(db)
2	7.45
3	11.11
4	13.49
5	16.04
6	20.75
7	24.38
8	24.90
9	24.82

Table 14 showing average mean defect in various DDLS scores

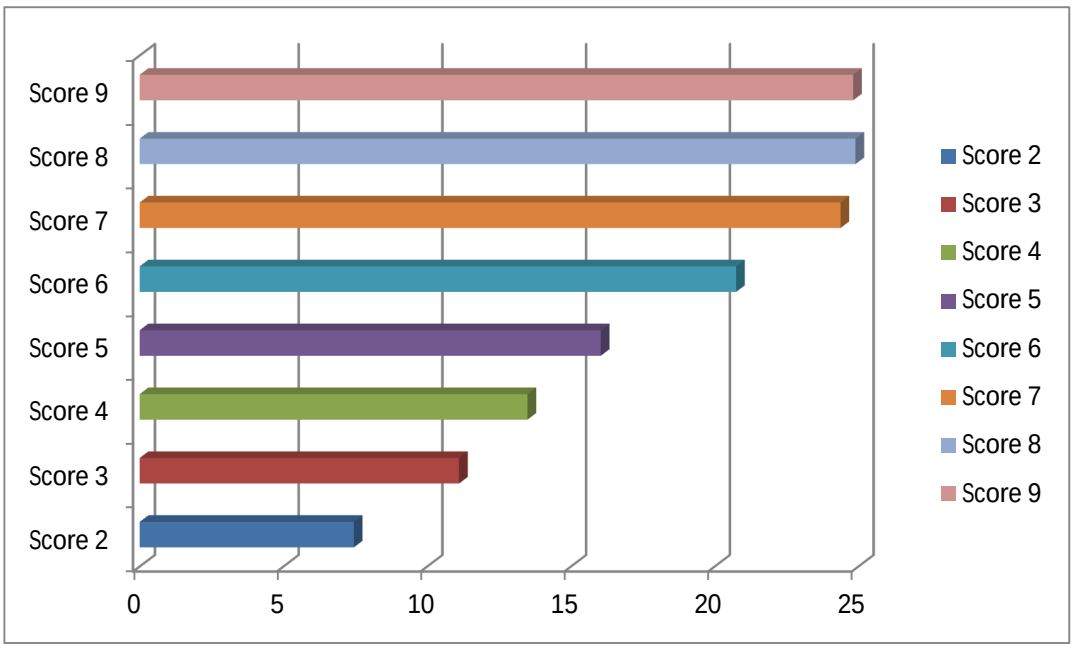


Chart 14 showing average mean defect in various DDLS scores

Average loss variance in eyes with different DDLS scores are as follows

DDLS SCORE	AVERAGE MEAN SENSITIVITY(db)
2	7.55
3	8.97
4	12.47
5	14.41
6	53.01
7	68.95
8	97.16
9	113.07

Table 15 showing average mean defect in various DDLS scores

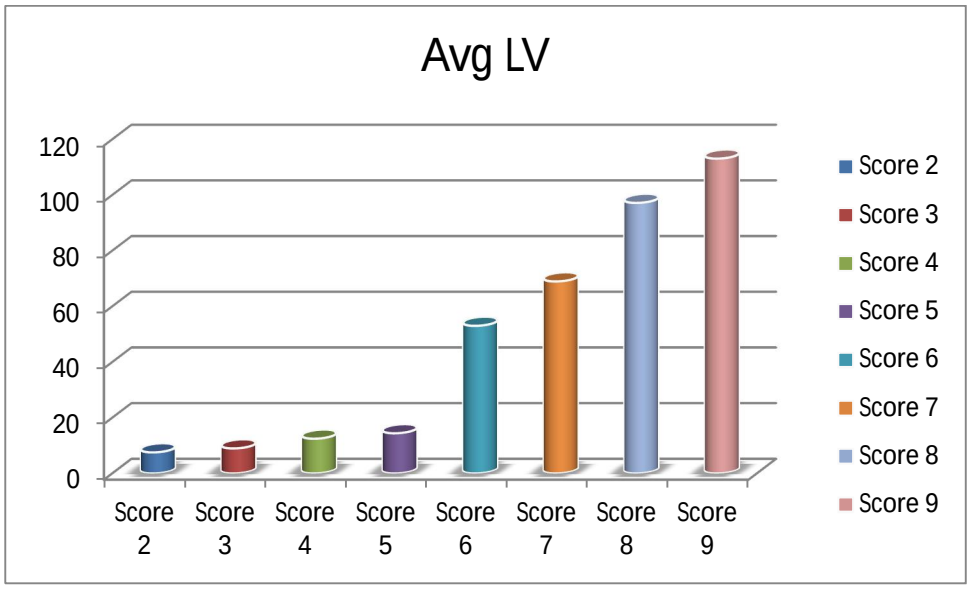


Chart 15 Showing average loss variance in various DDLS scores

CORRELATION OF DDLS SCORE WITH FIELD INDICES:

MEAN SENSITIVITY:

As the DDLS score increases , the mean sensitivity decreases.

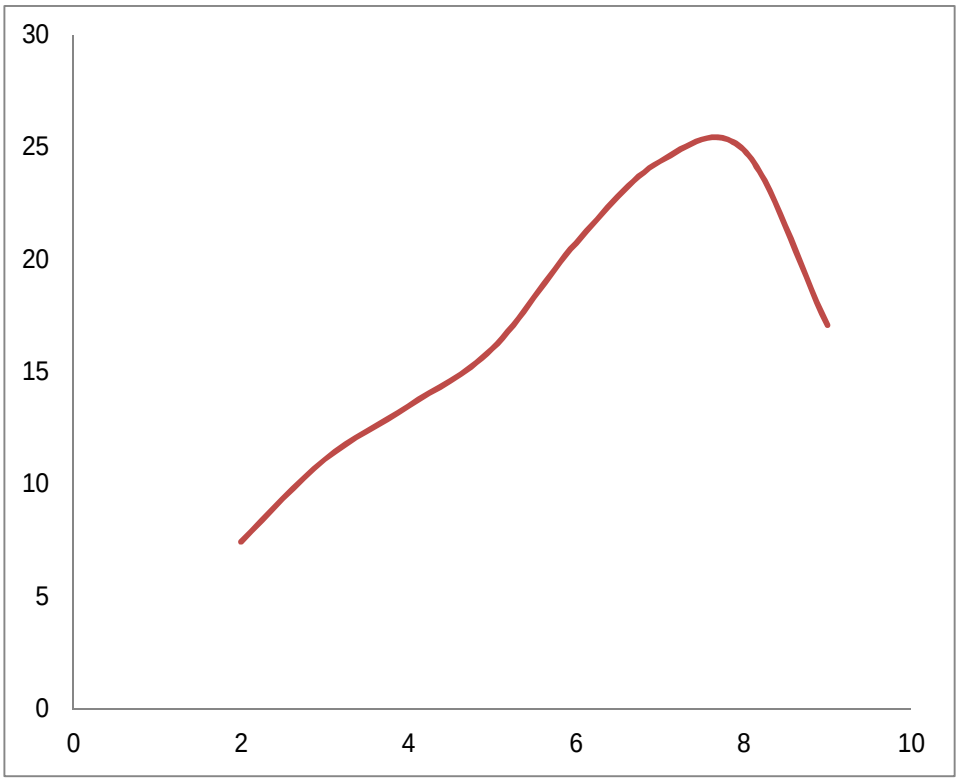


Chart 16 showing the linear relationship between DDLS score and mean sensitivity

LOSS VARIANCE :

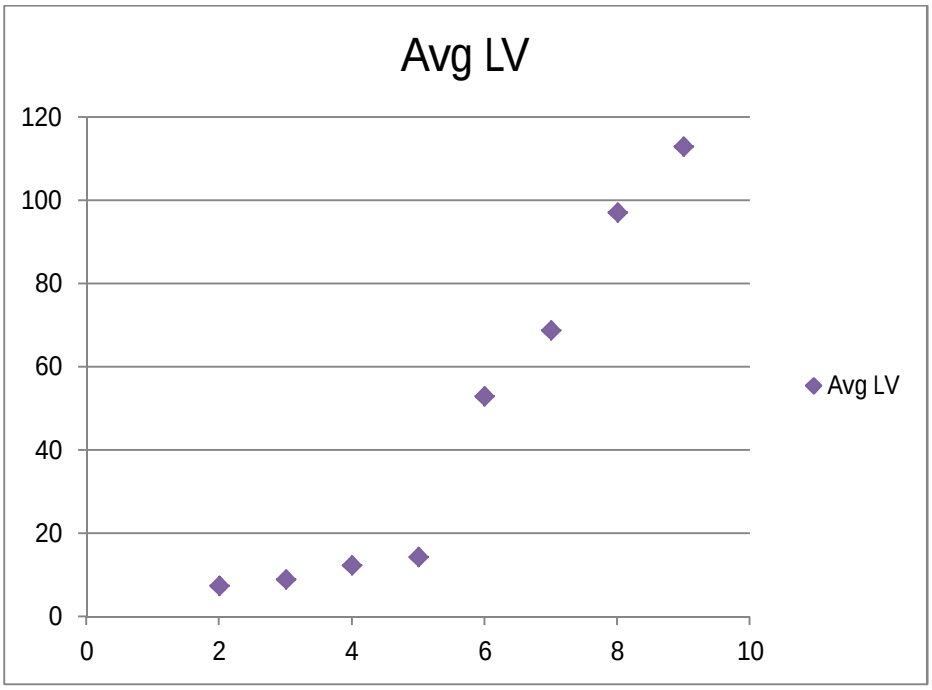


Chart 16 : Scatter plot showing correlation of DDLS score with loss variance

The **Pearson product-moment correlation coefficient r** value is **0.95 (**approximately equal to 1) showing strong positive correlation between the DDLS score and Field defect.

r = 0.95

DISCUSSION

50 cases of Primary open angle glaucoma with established field defects with visual acuity more than 6/24 were included in this study to analyse the Disc Damage Likelihood Scale and correlate with field defects.

Of the 50 patients included in this study, 30 % were in the age group of 45-50 yrs and 24 % were aged more than 66years. 62 % were male patients and 38 % were female patients.

Of the included established primary open angle glaucoma patients ,70% were on topical antiglaucoma medications and 30% had undergone trabeculectomy . Of the patients who had undergone trabeculectomy,6% (2) of patients were on further antiglaucoma medications.

According to this study, the average vertical disc diameter was 1.86 mm. Studies by Quigley et al have also shown that the average vertical disc diameter to be 1.88 and horizontal disc diameter to be 1.77 mm. Disc diameter in 50 patients ranged from 1.56 mm- 2.21 mm.

In this study, the discs were classified as small, medium and large discs based on the disc diameter. Of the 100 eyes examined, None of the patients had small discs (disc diameter of less than 1.5 mm), 86 eyes had medium size discs (diameter between 1.5 – 2 mm) and 14 eyes had large discs (diameter more than 2 mm)

Among the 50 patients , 4 patients had asymmetry of disc diameter between the right and left eye.

	DISC DIAMETER		CDR		DDLS	
PATIENT	RE	LE	RE	LE	RE	LE
Patient 1	2.08	1.69	0.7	0.4	2	2
Patient 2	1.95	2.08	0.4	0.7	4	4
Patient 3	1.56	1.82	0.4	0.6	2	2
Patient 4	1.82	1.56	0.7	0.5	4	4

This table shows that the asymmetry of the cupping is due to asymmetry of the disc diameter .The cup disc ratio in all four patients showed significant asymmetry, of more than 0.2 . But the DDLS score in these patients of both the eyes in all four patients were the same. This

highlights the importance of estimation of disc diameter in the evaluation of optic nerve head.

DDLS score was calculated and of the 100 eyes included in the study. 34 eyes came under classification of " At risk of glaucoma" having a score of 1-4, 42 eyes came under classification of "Glaucoma damage" having a score of 5-7 and 24 eyes came under classification of " Glaucoma disability" having a score of 8 -10.

The field defects which were seen in these patients include areas of depressed sensitivity in the paracentral region (11 %),paracentral scotoma (10 %) ,Relative scotomas in superior and inferior arcuate regions (27 %) , superior and inferior arcuate scotomas(24 %) , biarcuate scotoma with step defects (13 %) and tubular fields (15 %).

Based on field defects , 72 eyes were classified to have moderate glaucoma and 28 eyes were classified to have severe glaucoma. Since this study did not include preperimetric glaucoma , none of the eyes could be classified to have mild glaucoma.

FIELD INDICES :

Mean sensitivity is the average of the threshold sensitivity values in a visual field test. Patients with defects in paracentral region and paracentral scotoma had a average mean sensitivity of 28.89 db.Patients with arcuate scotoma had a mean sensitivity of 23.30 db and patients with tubular fields had a mean sensitivity of 17.07 db. This shows that the average mean sensitivity decreases as the field defect progresses.

Mean defect is the weighted average of the total deviation values in a visual field test; the more important and less variable deviations near the centre of the field are weighted more than those at the edge. In this study ,patients with defects in paracentral region and paracentral scotoma had a mean defect of 9.79 db. Patients with arcuate scotoma had a mean defect of 18.77 db and patients with tubular fields had a mean defect of 24.93 db. This study shows that the mean defect values are higher in patients with advanced field defects.

Loss variance is the local heterogeneity of a visual field defect. Loss variance is small in visual fields with generalized damage and loss variance increases with the number and depth of localized scotomas. Patients with defects in paracentral region and paracentral scotoma had

an average loss variance of 8.66 db.Patients with arcuate scotoma had a loss variance of 39.30 db and patients with tubular fields had a loss variance of 106.94 db. In this study , the loss variance values are higher in patients with advanced field defects.

FIELD INDICES IN VARIOUS DDLS SCORES:

The average mean sensitivity among the different DDLS score showed a linear relationship , that is , higher the DDLS score , lower is the sensitivity value.

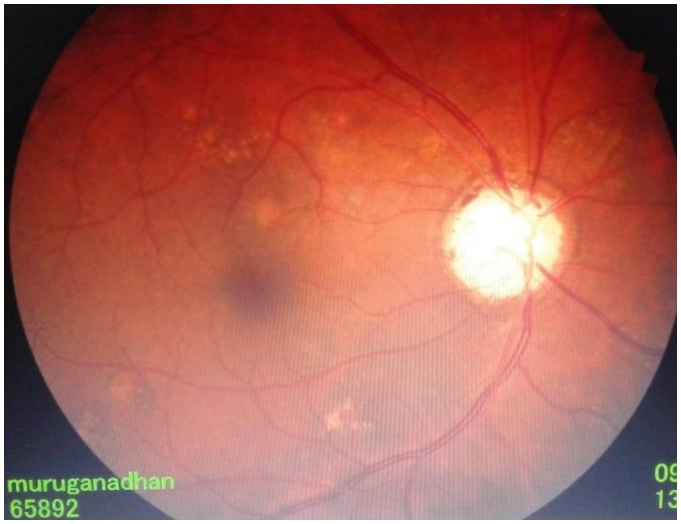
Pearson product –moment correlation coefficient (r value) is a measure of linear dependence between two variables ,giving a value between +1 and -1. +1 indicates total positive correlation ,0 indicates no correlation and -11 indicates total negative correlation. In this study, the variables compared were DDLS score and average loss variance . The variables showed a strong positive correlation as the **r value was 0.95** (approximately equal to one). Studies by James C Borrow et al also showed a similar observation with a r value of 0.68 between the DDLS score and mean deviation (field testing done by Humphrey field analyser)[13] .

CONCLUSION

- Disc diameter evaluation is an important part of optic nerve head evaluation. In cases with asymmetry of the cup disc ratio between two eyes , asymmetry of the disc size should also be considered if the neuroretinal rim is healthy.

- Disc Damage Likelihood Scale (DDLS) is a better indicator of optic nerve head status and has strong positive correlation with visual field indices.

CLINICAL PHOTOGRAPHS



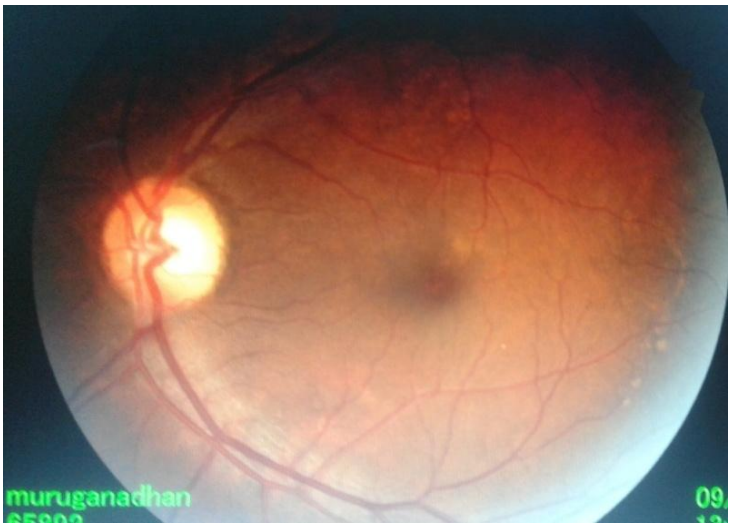
Disc photograph of RE of a patient aged 50 years showing a cup disc ratio of 0.9

DDLS Score:

Disc diameter :1.82 mm

Rim /disc ratio : 0(180 °-270°)

DDLS score : 9



Disc photograph of LE of the same patient showing a cup disc ratio of 0.5

DDLS SCORE :

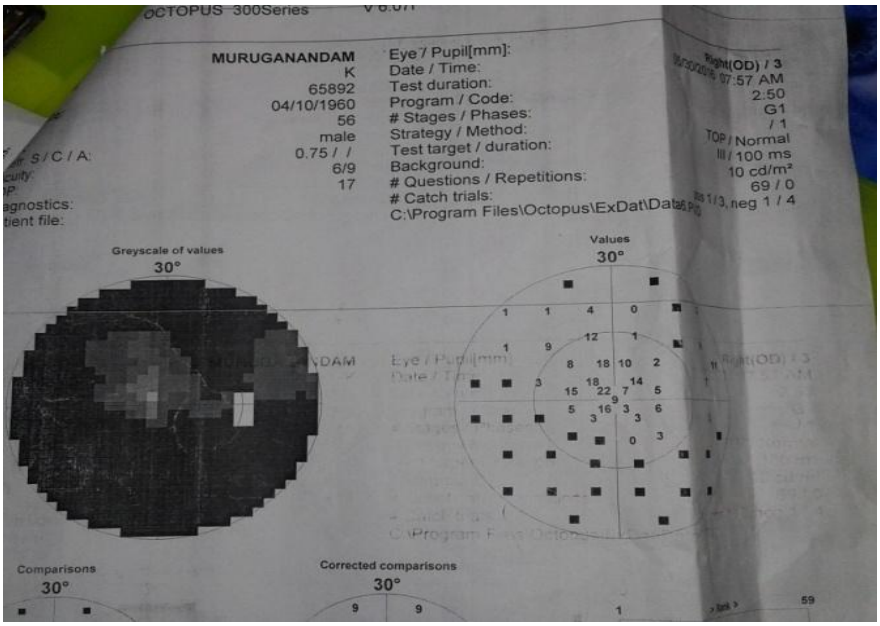
Disc diameter :1.82 mm

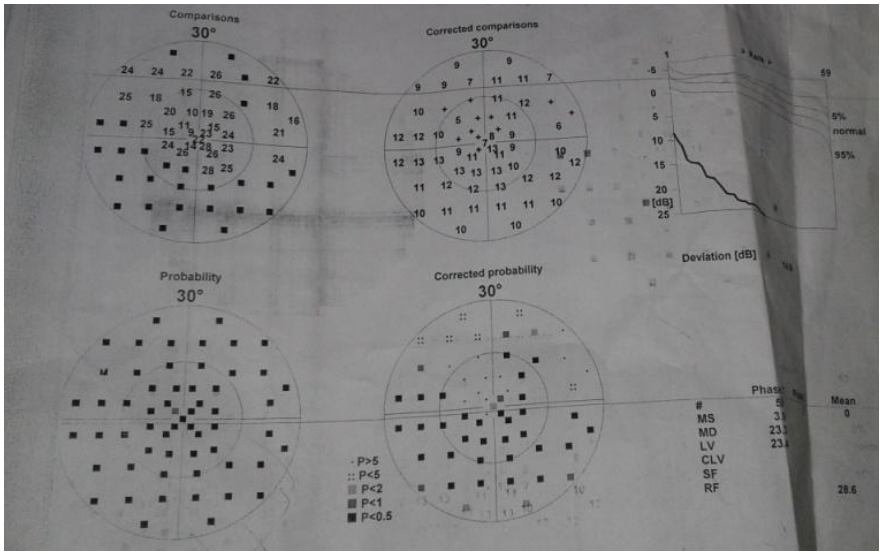
Rim/disc ratio :0.19

DDLS score: 4

FIELD DEFECTS :

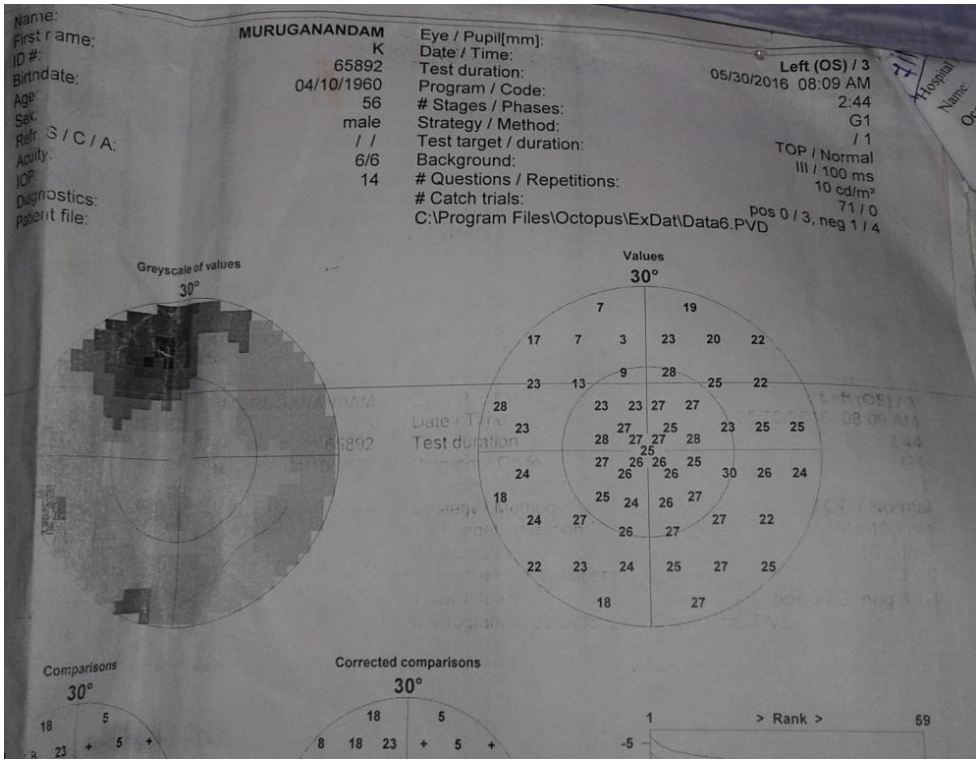
RIGHT EYE :

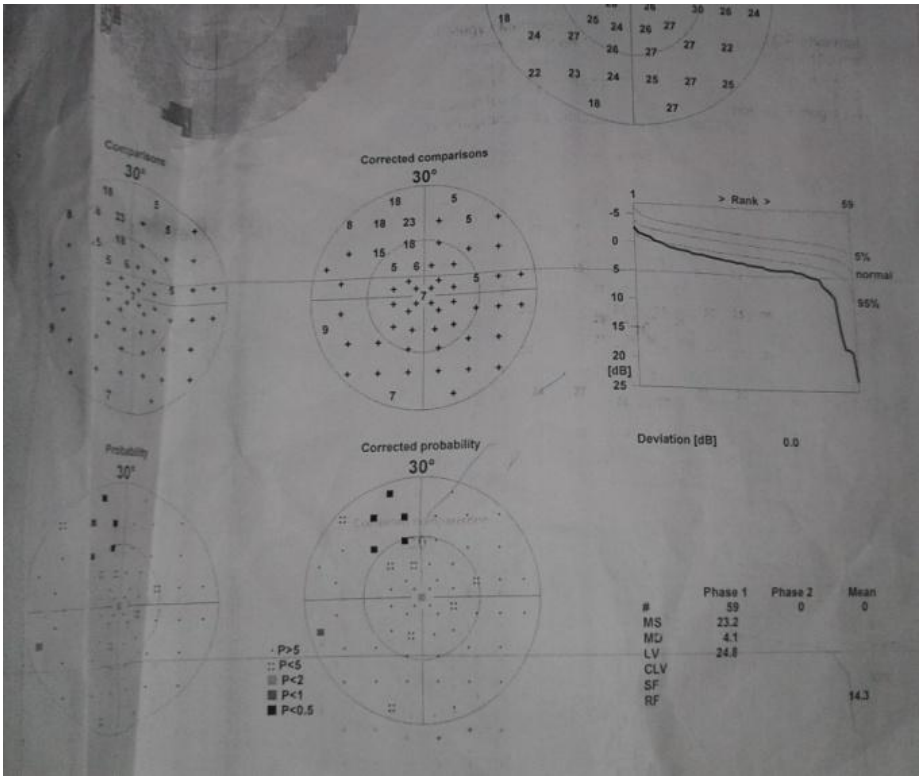




IMPRESSION : Tubular fields

LEFT EYE:

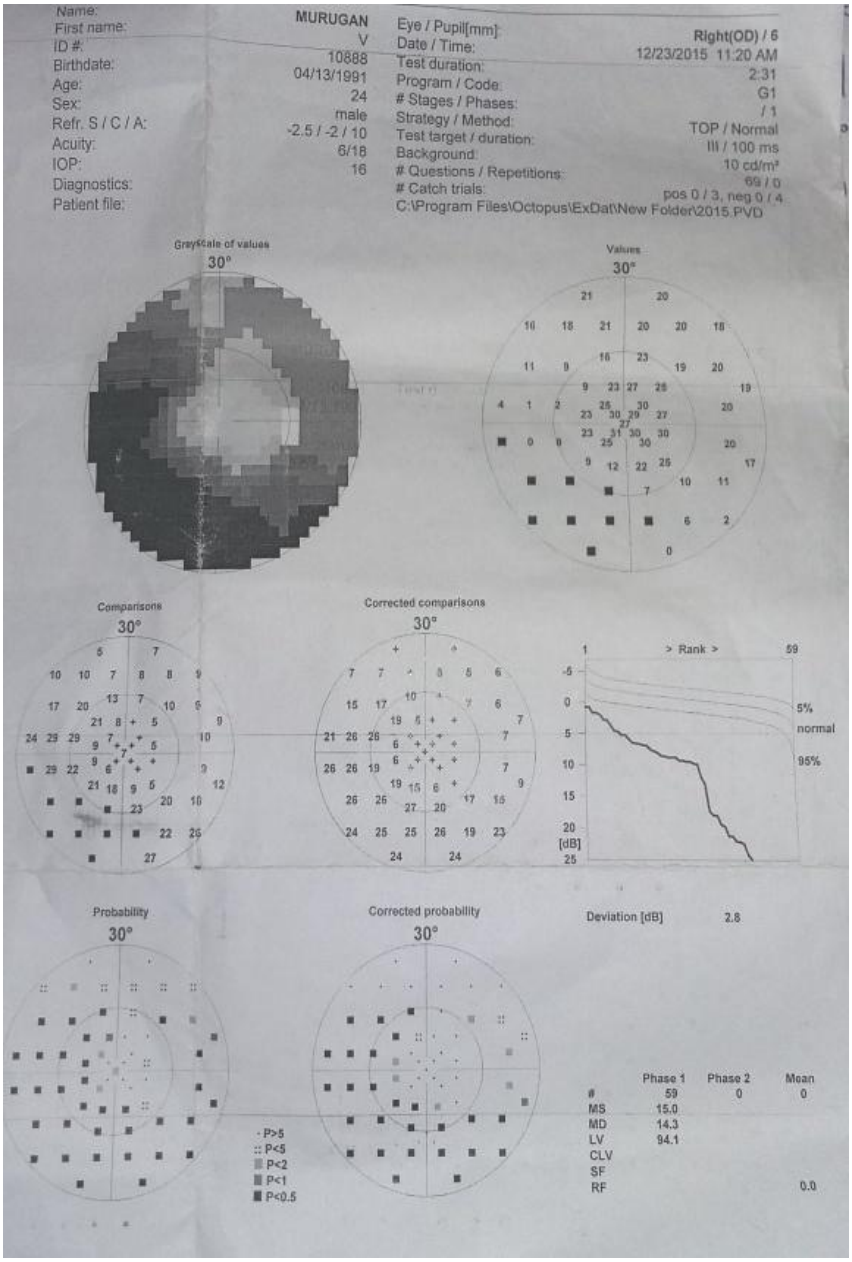




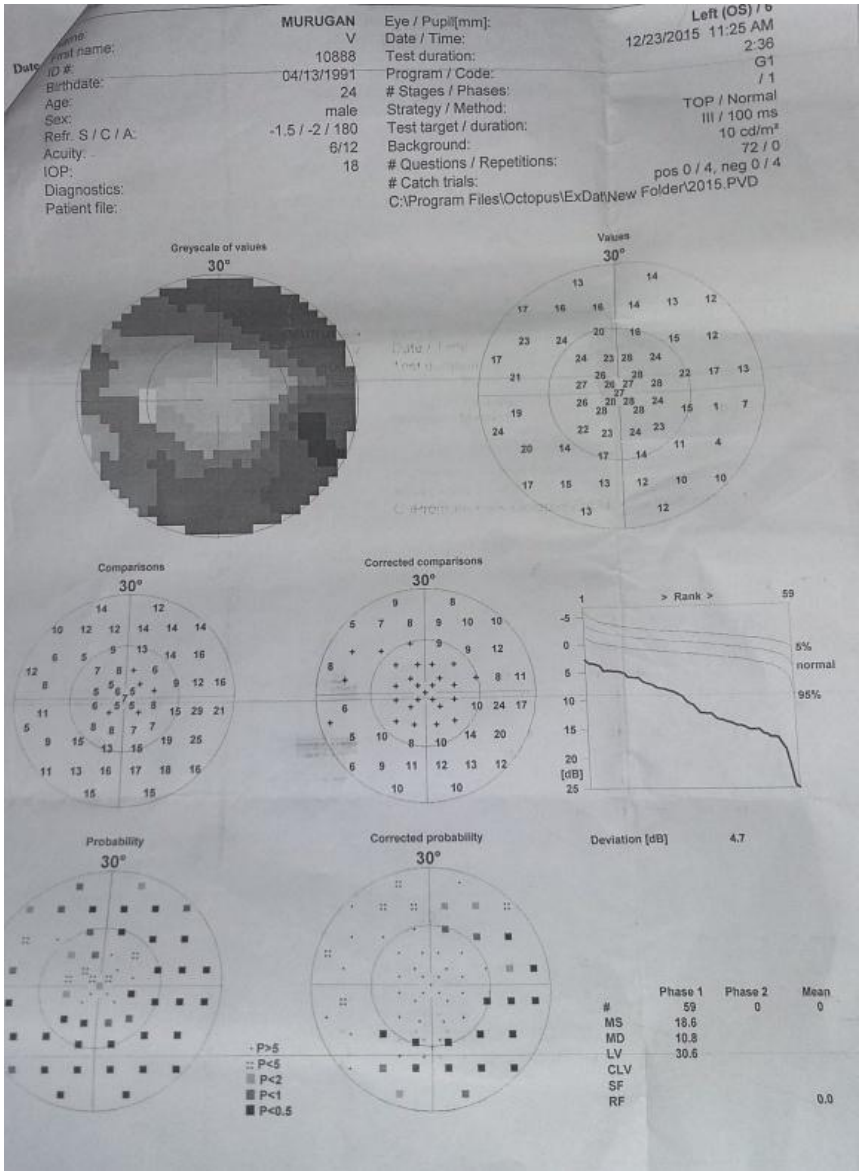
IMPRESSION: Relative defects in superior arcuate region

Field defects of a 55 yr old female :

Right eye :



Left eye:

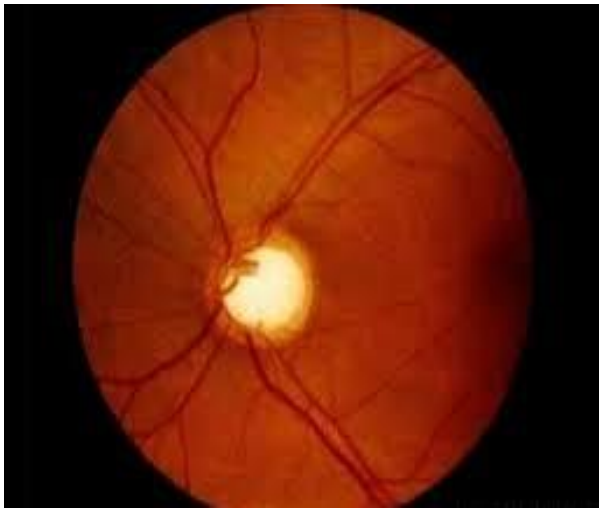


Impression:

Right eye : Inferior arcuate scotoma

Left eye : Biarcuate scotoma with step defects

Optic disc photograph of the same patient:



BE: Fundus photo showing a cup disc ratio of 0.8 with inferior notching

PART – III

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CORRELATION OF DISC DAMAGE LIKELIHOOD SCALE WITH FIELD DEFECTS – AN ANATOMICAL vs FUNCTIONAL CORRELATION

PROFORMA

Name: Age: Sex:

IP/OP no: Mobile no:

Occupation:

Symptoms :

☐ Defective vision : duration

☐ Frequent change of glasses

☐ History of drug usage(topical drugs) duration

☐ History of previous ocular surgeries /lasers

☐ Diabetic ☐ Hypertensive

☐ Bronchial asthma : On steroids

☐ History of steroid usage : (rheumatological problem)

☐ Epilesy : On anticonvulsants

☐ Ischemic heart disease : medications :

☐ Other neurological problems:

PARAMETERS	RIGHT EYE	LEFT EYE
UCVA		
BCVA		
TN BY GAT(mm hg)		
CCT(microns)		
Lids		
Conjunctiva		
Cornea		
AC		
Iris		
Pupil		
Lens		

Prelimnary fundus : RE LE

Gonio :(shaffers grade)RE LE

Fields: Octopus 301 G1 program Top strategy

Parameters	RE	LE
Reliability		
Absolute defects		
Relative defects		
Bebies curve		
Loss variance		
Impression		

DDLS

RE:

Type of disc	Narrowest rim width (rim / disc ratio)	DDLS stage	Diagram
Mm			

LE

Type of disc	Narrowest rim width (rim / disc ratio)	DDLS stage	Diagram
Mm			

	DDLS STAGE	NARROWEST RIM WIDTH(RIM DISC RATIO)
AT RISK	1	0.4 or more
	2	0.3-0.39
	3	0.2-0.29
	4	0.1-0.19
GLAUCOMA DAMAGE	5	Less than 0.1
	6	0(extension : less than 45°)
	7	0(extension :46° to 90°)
GLAUCOMA DISABILITY	8	0(extension :91°-180°)
	9	0(extension : 181°-270°)
	10	0(extension : more than 270°)

S.NO	NAME	AGE	SEX	IP/OP NO	HISTORY C	MEDICATI	DM	HYPERTEN	BRONCHIA	IHD	STEROID U	EYE	UCVA	BCVA	CONJUCTI	CORNEA	AC	IRIS	PUPIL	LENS	IOP	GONIOSCC	CD RATIO	DISC SIZE	RIM/DISC	DDLS STAG	RELIABILITY	MS	MD	LV	BEBIES CURV	FIELD DEFECT
1	RAMAN	54	m	514373	BE SICS WI	BE BRIMOI	YES	YES	NO	NO	NO	R	6/18	6/6	Bleb	Clear	nd	PI at 12 o c	3mm,RTL	Pciol	14	3	0.5	1.82	0.14	4	fair	19.1	26.7	29	focal dip	relative defects in superior arcuate region
												L	6/24	6/6	clear	clear	nd	cpn	3mm,RTL	Pciol	18	3	0.9	1.82	0	8	good	13.2	16.6	112.1	focal dip	tubular field
2	mohan	50	m	55836	nil	be lumigar	no	NO	NO	NO	NO	R	6/18	6/6	Clear	Clear	nd	cpn	3mm,RTL	lens chang	16	3	0.9	1.95	0	9	good	16.2	24.5	115.6	generalised	tubular field
												L	6/12	66	clear	Clear	nd	cpn	3mm,RTL	lens chang	14	3	0.7	1.95	0	8	good	18.6	22.3	102.5	focal dip	biarcuate scotoma with step defect
3	JOHNSON	46	M	103822	NIL	be timolol	NO	NO	NO	NO	NO	R	6/6	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	16	4	0.5	1.82	0.2	3	good	27.4	12.3	10.1	focal dip	relative defects in superior arcuate region
												L	6/6	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	18	4	0.5	1.82	0.19	4	good	27.9	11.2	9.5	focal dip	relative defects in superior arcuate region
4	geetha	53	F	31513	BE SICS WI	LE BIMAT	YES	YES	NO	YES	NO	R	6/18	6/6	Bleb	Clear	nd	PI at 12 o c	3mm,RTL	Pciol	18	3	0.9	1.82	0	9	good	18.2	27.3	119.2	focal dip	tubular field
												L	6/9	6/6	clear	Clear	nd	cpn	3mm,RTL	lens chang	18	3	0.5	1.82		4	good	28.1	8.2	8.3	focal dip	paracentral scotoma
5	shankar	60	m	25967	nil	be combig	yes	NO	NO	NO	NO	R	6/12	6/6	clear	Clear	nd	cpn	3mm,RTL	lens chang	20	3	0.6	1.82	0.05	5	good	24.5	16.3	14.2	focal dip	relative defects in superior arcuate region
												L	6/12	6/6	clear	Clear	nd	cpn	3mm,RTL	lens chang	22	3	0.7	1.82	0	6	good	22.3	20.1	65.2	focal dip	superior arcuate scotoma
6	ETHIRAJ	61	M	87337	NIL	BE DORTIN	YES	NO	NO	NO	NO	R	6/18	6/9	clear	Clear	nd	cpn	3mm,RTL	lens chang	16	4	0.7	1.95	0.1	4	good	28.4	11.2	10.5	focal dip	relative defects in superior arcuate region
												L	6/18	6/12	clear	Clear	nd	cpn	3mm,RTL	lens chang	16	3	0.8	1.95	0.05	5	good	27.5	16.4	15.6	focal dip	relative defects in superior arcuate region
7	pushpa	45	f	29444	nil	BE combig	no	NO	NO	NO	NO	R	6/12	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	12	3	0.7	1.82	0	6	good	24.4	3.2	9.6	focal dip	relative defects in superior arcuate region
												L	6/12	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	12	3	0.7	1.82	0	7	good	23.6	3.9	13.4	focal dip	superior arcuate scotoma
8	bakthavac	63	m	22320	nil	BE combig	no	NO	NO	NO	NO	R	6/36	6/6	clear	Clear	nd	cpn	3mm,RTL	lens chang	16	3	0.8	2.21	0	7	fair	20.4	23.5	71.1	focal dip	superior arcuate scotoma
												L	6/36	6/6	clear	Clear	nd	cpn	3mm,RTL	lens chang	18	3	0.7	2.21	0	7	good	22.3	21.1	68.9	focal dip	superior arcuate scotoma
9	jeshamma	65	f	49188	nil	be timolol	no	NO	NO	NO	NO	R	6/12	6/12	clear	Clear	nd	cpn	3mm,RTL	immature	14	4	0.5	1.82	0.05	5	good	25.6	16.3	11.2	focal dip	relative defects in superior arcuate region
												L	6/12	6/12	clear	Clear	nd	cpn	3mm,RTL	immature	14	4	0.5	1.82	0.05	5	good	24.3	15.6	16.6	focal dip	relative defects in superior arcuate region
10	loganayagi	53	f	777632	nil	be combig	no	NO	NO	NO	NO	R	6/60	6/9	clear	Clear	nd	cpn	3mm,RTL	lens chang	22	4	0.9	1.95	0	9	good	18.2	24.5	119.3	focal dip	tubular field
												L	6/60	6/9	clear	Clear	nd	cpn	3mm,RTL	lens chang	12	3	0.9	1.95	0	7	good	20.1	22.3	102.5	focal dip	biarcuate scotoma with step defect
11	ramani	56	f	26517	be sics wit	BE BRIMOI	YES	NO	NO	NO	NO	R	6/18	6/6	Bleb	clear	nd	PI at 12 o c	3mm,RTL	pciol	16	3	0.6	1.95	0.1	4	good	24.3	11.5	10.2	focal dip	superior arcuate scotoma
												L	6/24	6/6	Bleb	clear	nd	PI at 12 o c	3mm,RTL	pciol	16	3	0.8	1.95	0	7	good	16.6	68.3	118.3	focal dip	biarcuate scotoma with step defect
12	ramu	52	m	74559	nil	BE brimon	no	no	no	no	no	R	6/60	6/18	clear	Clear	nd	cpn	3mm,RTL	immature	18	3	0.7	1.95	0.1	4	good	28.3	12.5	14.6	generalised	relative defects in inferior arcuate region
												L	6/12	6/6	clear	Clear	nd	cpn	3mm,RTL	lens chang	14	3	0.7	1.95	0.1	4	good	27.8	15.5	15.4	focal dip	relative defects in inferior arcuate region
13	indarani	55	f	89896	be trab	nil	yes	no	no	no	no	R	6/36	6/6	blob	Clear	nd	PI at 12 o c	3mm,RTL	lens chang	12	4	0.7	1.95	0.05	5	good	24.5	16.5	16.6	focal dip	relative defects in superior arcuate region
												L	6/36	6/6	bleb	Clear	nd	PI at 12 o c	3mm,RTL	lens chang	12	4	0.5	1.95	0.2	3	good	27.6	11.2	9.3	focal dip	paracentral scotoma
14	vasantha	67	f	197895	nil	BE latanop	yes	yes	no	no	no	R	6/9	6/9	clear	Clear	nd	cpn	3mm,RTL	lens chang	14	3	0.7	1.82	0	7	good	22.5	16.5	98.5	focal dip	biarcuate scotoma with step defect
												L	6/9	6/9	clear	Clear	nd	cpn	3mm,RTL	lens chang	14	3	0.4	1.82	0.2	3	good	30.2	2.8	9.2	focal dip	areas of depressed sensitivity in paracentral region
15	krishnan	67	m	15988	be sics wit	be timolol	yes	yes	no	yes	no	R	6/9	6/6	clear	Clear	nd	cpn	3mm,RTL	Pciol	18	3	0.5	2.08	0.19	4	good	32.2	2.6	8.5	focal dip	paracentral scotoma
												L	6/12	6/6	clear	Clear	nd	cpn	3mm,RTL	Pciol	18	3	0.5	2.08	0.19	4	good	32.9	2.5	7.8	focal dip	paracentral scotoma
16	sakunthala	66	f	500304	be sics wit	be timolol	no	no	no	no	no	R	6/12	6/12	clear	Clear	nd	cpn	3mm,RTL	Pciol	14	3	0.8	1.95	0	8	good	18.6	25.6	112.3	focal dip	biarcuate scotoma with step defect
												L	6/12	6/12	clear	Clear	nd	cpn	3mm,RTL	Pciol	16	3	0.7	1.95	0	6	good	20.8	22.5	88.2	focal dip	superior arcuate scotoma
17	dharmaraj	61	m	104948	nil	be combig	no	no	no	no	no	R	6/9	6/9	clear	Clear	nd	cpn	3mm,RTL	lens chang	22	4	0.8	1.82	0.05	5	good	25.4	15.2	11.2	focal dip	inferior arcuate scotoma
												L	6/9	6/9	clear	Clear	nd	cpn	3mm,RTL	lens chang	24	4	0.5	1.82	0.2	3	good	28.6	11.2	9.6	focal dip	relative defects in superior arcuate region
18	murugan	45	m	22354	be trab	nil	no	no	no	no	no	R	6/36	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	14	4	0.8	2.08	0.04	5	good	25.4	16.8	18.2	focal dip	relative defects in inferior arcuate region
												L	6/36	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	12	4	0.8	2.08	0.04	5	good	24.5	15.6	17.2	focal dip	relative defects in inferior arcuate region
19	vani	50	f	79845	be sics wit	be timolol	yes	no	no	no	no	R	6/9	6/6	clear	Clear	nd	cpn	3mm,RTL	Pciol	16	3	0.6	2.21	0.2	3	good	28.6	11.4	9.3	focal dip	areas of depressed sensitivity in paracentral region
												L	6/9	6/6	clear	Clear	nd	cpn	3mm,RTL	Pciol	18	3	0.6	2.21	0.2	3	good	29.7	12.2	8.8	focal dip	areas of depressed sensitivity in paracentral region
20	lakshmiam	70	f	88979	be sics wit	be brimon	no	no	no	no	no	R	6/24	6/9	clear	Clear	nd	cpn	3mm,RTL	Pciol	16	4	0.6	1.82	0.14	4	good	28.6	13.6	9.8	focal dip	relative defects in inferior arcuate region
												L	6/18	6/12	clear	Clear	nd	cpn	3mm,RTL	Pciol	14	4	0.6	1.82	0.14	4	good	28.7	14.6	7.6	focal dip	relative defects in inferior arcuate region
21	muruganar	47	m	57716	nil	BE combig	no	no	no	no	no	R	6/12	6/9	clear	Clear	nd	cpn	3mm,RTL	Clear	14	3	0.8	1.82	0	9	good	17.3	24.5	112.3	focal dip	tubular field
												L	6/12	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	16	3	0.4	1.82	0.19	4	good	28.4	12.6	9.5	focal dip	paracentral scotoma
22	kanthikum	52	m	106299	nil	be timolol	yes	no	no	no	no	R	6/24	6/6	clear	clear	nd	cpn	3mm,RTL	lens chang	18	3	0.5	1.69	0.2	3	good	28.9	10.2	8.2	focal dip	relative defects in superior arcuate region
												L	6/24	6/6	clear	clear	nd	cpn	3mm,RTL	lens chang	16	3	0.5	1.69	0.2	3	good	30.2	12.4	7.9	focal dip	relative defects in superior arcuate region
23	muthuraj	45	m	12365	nil	be timolol	no	yes	no	no	no	R	6/6	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	14	3	0.5	1.69	0.15	4	good	26.4	11.2	10.2	focal dip	relative defects in inferior arcuate region
												L	6/6	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	12	3	0.5	1.69	0.15	4	good	27.5	10.5	9.6	focal dip	relative defects in inferior arcuate region
24	muthuraja	51	m	8965	nil	be betaxol	yes	yes	no	yes	no	R	6/9	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	10	4	0.6	1.82	0.05	5	good	24.5	16.4	11.2	focal dip	superior arcuate scotoma
												L	6/9	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	10	4	0.6	1.82	0.05	5	good	26.5	14.2	10.3	focal dip	relative defects in superior arcuate region
25	Savithiri	57	f	79864	Re sics wit	be dortim	no	no	no	no	no	R	6/6	6/6	clear	Clear	nd	cpn	3mm,RTL	Pciol	14	3	0.7	1.95	0	6	good	20.5	23.6	78.3	focal dip	inferior arcuate scotoma

												L	6/12	6/12	clear	Clear	nd	cpn	3mm,RTL	immature	16	3	0.8	1.95	0	8	good	18.6	25.6	112.8	focal dip	biarcuate scotoma with step defect
26	amala	45	f	66145	nil	be timolol	yes	yes	no	yes	no	R	6/6	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	10	3	0.7	1.82	0.14	4	good	27.8	10.2	9.6	focal dip	paracentral scotoma
												L	6/6	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	10	3	0.5	1.56	0.12	4	good	28.2	11.2	10.1	focal dip	paracentral scotoma
27	kuppabai	63	f	46410	nil	be timolol	yes	no	no	no	no	R	6/9	6/9	clear	Clear	nd	cpn	3mm,RTL	immature	12	3	0.9	1.95	0	9	good	17.8	26.5	116.8	focal dip	tubular field
												L	6/9	6/9	clear	Clear	nd	cpn	3mm,RTL	immature	14	3	0.8	1.95	0	8	good	19.6	22.4	107.6	focal dip	biarcuate scotoma with step defect
28	Ramani	49	m	154123	nil	BE latanop	no	no	no	no	no	R	6/6	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	16	4	0.6	1.82	0.05	5	good	23.2	18.2	16.4	focal dip	superior arcuate scotoma
												L	6/12	6/9	clear	Clear	nd	cpn	3mm,RTL	immature	20	4	0.9	1.82	0	8	good	19.4	24.5	103.2	focal dip	biarcuate scotoma with step defect
29	vijayalaksh	56	f	108660	be sics with	nil	yes	no	no	no	no	R	6/24	6/6	bleb	clear	nd	PI at 12 o c	3mm,RTL	Pciol	16	3	0.8	1.95	0	7	good	20.5	20.1	52.1	focal dip	biarcuate scotoma with step defect
												L	6/12	6/6	bleb	Clear	nd	PI at 12 o c	3mm,RTL	Pciol	14	3	0.5	1.95	0.1	4	good	28.7	15.4	11.9	focal dip	relative defects in inferior arcuate region
30	subramani	81	m	2194	be phaco v	nil	no	yes	no	no	no	R	6/24	6/6	bleb	Clear	nd	PI at 12 o c	3mm,RTL	Pciol	14	4	0.8	1.82	0	8	good	17.5	26.8	99.4	focal dip	biarcuate scotoma with step defect
												L	6/12	6/6	bleb	Clear	nd	PI at 12 o c	3mm,RTL	Pciol	14	4	0.5	1.95	0.05	5	good	24.9	16.3	11.2	focal dip	areas of depressed sensitivity in paracentral region
31	padmanab	65	m	51651	be sics with	be timolol	no	no	no	no	no	R	6/12	6/6	bleb	Clear	nd	PI at 12 o c	3mm,RTL	Pciol	10	3	0.4	1.69	0.2	3	good	26.3	14.4	7.2	focal dip	areas of depressed sensitivity in paracentral region
												L	6/6	6/6	bleb	Clear	nd	PI at 12 o c	3mm,RTL	Pciol	10	3	0.7	1.69	0	6	good	20.1	21.1	46.8	focal dip	relative defects in inferior arcuate region
32	dhandapar	48	m	108822	nil	be latanop	yes	yes	no	yes	no	R	6/9	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	12	4	0.9	1.82	0	8	good	17.6	25.5	109.3	focal dip	tubular field
												L	6/12	6/12	clear	Clear	nd	cpn	3mm, RTL	immature	14	4	0.9	1.82	0	9	good	16.5	26.3	114.9	focal dip	tubular field
33	padma	65	f	46344	be sics with	nil	no	no	no	no	no	R	6/24	6/6	clear	Clear	nd	cpn	3mm,RTL	Pciol	16	3	0.4	1.56	0.3	2	good	30.2	5.6	7.1	n	areas of depressed sensitivity in paracentral region
												L	6/24	6/6	clear	Clear	nd	cpn	3mm,RTL	Pciol	16	3	0.6	1.82	0.3	2	good	32.2	4.2	6.9	n	areas of depressed sensitivity in paracentral region
34	gopal	63	m	109180	be sics with	nil	no	no	no	no	no	R	6/24	6/6	bleb	Clear	nd	PI at 12 o c	3mm,RTL	Pciol	12	4	0.6	1.82	0.05	5	good	25.6	16.5	13.5	focal dip	relative defects in inferior arcuate region
												L	6/24	6/6	bleb	Clear	nd	PI at 12 o c	3mm,RTL	Pciol	12	4	0.8	1.82	0	7	good	20.5	20.3	50.2	focal dip	inferior arcuate scotoma
35	balaji	53	m	54613	nil	Be timolol	no	no	no	no	no	R	6/18	6/9	clear	Clear	nd	cpn	3mm,RTL	lens chang	14	3	0.7	1.69	0	6	good	24.1	22.1	60.1	focal dip	superior arcuate scotoma
												L	6/12	6/12	clear	Clear	nd	cpn	3mm,RTL	immature	12	3	0.6	1.69	0	6	good	23.5	20.2	55.4	focal dip	superior arcuate scotoma
36	shanthi	62	f	46523	be sics with	nil	yes	no	no	no	no	R	6/6	6/6	bleb	Clear	nd	PI at 12 o c	3mm,RTL	Pciol	20	4	0.6	1.95	0	6	good	21.2	17.8	39.2	focal dip	relative defects in inferior arcuate region
												L	6/9	6/6	bleb	Clear	nd	PI at 12 o c	3mm,RTL	Pciol	20	4	0.6	1.95	0	6	good	22.3	19.2	46.5	focal dip	relative defects in inferior arcuate region
37	manivanna	54	m	25267	nil	BE DORTAS	yes	yes	NO	YES	NO	R	6/18	6/6	clear	Clear	nd	cpn	3mm,RTL	lens chang	22	3	0.8	1.69	0	8	good	19.8	23.3	103.5	focal dip	biarcuate scotoma with step defect
												L	6/24	6/12	clear	Clear	nd	cpn	3mm,RTL	immature	24	3	0.9	1.69	0	9	good	15.6	26.3	50.6	focal dip	tubular field
38	anthony d	68	m	488056	nil	BE brimoni	no	no	no	no	no	R	6/18	6/12	clear	Clear	nd	cpn	3mm,RTL	immature	20	4	0.9	1.95	0	9	good	14.6	27.5	119.3	focal dip	tubular field
												L	6/12	6/6	clear	Clear	nd	cpn	3mm,RTL	immature	20	4	0.9	1.95	0	9	good	18.9	24.7	100.7	focal dip	tubular field
39	francis	68	m	486312	nil	be timolol	no	no	no	no	no	R	6/6	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	22	3	0.4	1.95	0.2	2	good	28.5	10.4	8.6	n	areas of depressed sensitivity in paracentral region
												L	6/6	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	24	4	0.5	2.08	0.2	2	good	29.6	9.6	7.6	n	areas of depressed sensitivity in paracentral region
40	kandasam	46	m	106621	BE trab	be timolol	yes	no	no	no	no	R	6/9	6/6	bleb	Clear	nd	PI at 12 o c	3mm,RTL	lens chang	12	3	0.7	1.82	0	7	good	20.4	23.4	45.5	focal dip	inferior arcuate scotoma
												L	6/24	6/12	bleb	Clear	nd	PI at 12 o c	3mm,RTL	immature	12	3	0.7	1.82	0	6	good	22.6	25.7	60.2	focal dip	inferior arcuate scotoma
41	george rich	70	m	27456	nil	BE combig	no	no	no	no	no	R	6/18	6/9	clear	Clear	nd	cpn	3mm,RTL	immature	22	3	0.9	1.69	0	9	good	19.5	24.3	113.6	focal dip	tubular field
												L	6/18	6/9	clear	Clear	nd	cpn	3mm,RTL	immature	24	3	0.8	1.69	0	8	good	20.3	22.3	96.3	focal dip	biarcuate scotoma with step defect
42	kulasekara	61	m	104068	be sics with	nil	yes	no	no	no	no	R	6/12	6/6	bleb	Clear	nd	cpn	3mm,RTL	Pciol	20	3	0.5	1.82	0.05	5	good	24.5	16.8	17.3	focal dip	superior arcuate scotoma
												L	6/12	6/6	bleb	Clear	nd	cpn	3mm,RTL	Pciol	18	3	0.9	1.82	0	9	good	16.5	26.3	117.8	focal dip	tubular field
43	govinthan	68	m	53816	nil	be brimoni	no	no	no	no	no	R	6/18	6/6	clear	Clear	nd	cpn	3mm,RTL	immature	22	3	0.6	1.82	0	5	good	24.2	19.8	16.6	focal dip	inferior arcuate scotoma
												L	6/24	6/9	clear	Clear	nd	cpn	3mm,RTL	immature	26	3	0.6	1.82	0	5	good	24.4	15.6	12.8	focal dip	inferior arcuate scotoma
44	samudhra	45	f	110744	nil	BE brimoni	no	no	no	no	no	R	6/9	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	18	4	0.4	2.08	0.2	3	good	29.6	8.2	9.6	focal dip	areas of depressed sensitivity in paracentral region
												L	6/9	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	14	4	0.4	2.08	0.2	3	good	30.2	7.8	8.4	focal dip	areas of depressed sensitivity in paracentral region
45	loganathar	50	m	51398	nil	be timolol	yes	no	no	no	no	R	6/12	6/12	clear	Clear	nd	cpn	3mm,RTL	immature	16	3	0.8	1.95	0	8	good	18.7	28.9	111.1	focal dip	biarcuate scotoma with step defect
												L	6/12	6/6	clear	Clear	nd	cpn	3mm,RTL	lens chang	14	3	0.5	1.95	0	6	good	20.6	22.6	45.7	focal dip	inferior arcuate scotoma
46	ramachanc	65	m	34128	be sics with	nil	yes	yes	no	no	no	R	6/36	6/6	bleb	Clear	nd	PI at 12 o c	3mm,RTL	Pciol	16	3	0.5	1.82	0.05	5	good	25.6	16.2	11.2	focal dip	relative defects in inferior arcuate region
												L	6/36	6/6	bleb	Clear	nd	PI at 12 o c	3mm,RTL	Pciol	12	3	0.9	1.82	0	9	fair	17.5	23.6	99.5	focal dip	tubular field
47	bl moham	55	m	525144	be sics with	nil	yes	no	yes	no	no	R	6/9	6/6	bleb	Clear	nd	PI at 12 o c	3mm,RTL	Pciol	18	3	0.7	1.95	0	6	fair	20.5	24.5	55.5	focal dip	superior arcuate scotoma
												L	6/12	6/6	bleb	Clear	nd	PI at 12 o c	3mm,RTL	Pciol	14	3	0.7	1.95	0	6	fair	22.6	24.5	56.4	focal dip	superior arcuate scotoma
48	devagi	48	f	875455	nil	be timolol	no	no	no	no	no	R	6/6	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	16	3	0.4	1.95	0.19	4	good	29.6	12.5	9.6	focal dip	paracentral scotoma
												L	6/6	6/6	clear	Clear	nd	cpn	3mm,RTL	Clear	12	3	0.7	2.08	0.19	4	good	28.5	8.9	11.4	focal dip	paracentral scotoma
49	nagalaksh	56	f	211456	nil	be combig	yes	no	yes	no	no	R	6/18	6/12	clear	Clear	nd	cpn	3mm,RTL	immature	12	3	0.6	1.69	0.05	5	good	25.6	16.5	15.5	focal dip	superior arcuate scotoma
												L	6/24	6/18	clear	Clear	nd	cpn	3mm,RTL	immature	14	3	0.9	1.69	0	9	fair	18.5	25.6	83.2	generalised	tubular field
50	aravindhar	50	m	984568	be sics with	nil	no	no	no	no	no	R	6/6	6/6	bleb	Clear	nd	PI at 12 o c	3mm,RTL	Pciol	20	3	0.7	2.08	0	6	good	28.6	10.2	9.5	focal dip	superior arcuate scotoma
												L	6/9	6/6	bleb	Clear	nd	PI at 12 o c	3mm,RTL	Pciol	20	3	0.8	2.08	0	6	good	29.8	12.3	8.6	focal dip	superior arcuate scotoma

KEY TO MASTER CHART

M – Male

F – Female

IHD – Ischemic heart disease

R – Right eye

L- Left eye

UCVA- Uncorrected visual acuity

BCVA-best corrected visual acuity

ND-normal depth

CPN – colour pattern normal

RTL –reacting to light

PCIOL- POSTERIOR CHAMBER INTRA OCULAR LENS

CD RATIO – cup disc ratio

MS-mean sensitivity

MD-mean defect

LV-loss variance