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A Clinical Study On Role Of Optical Coherence Tomography (OCT) In Diagnosing Macular Lesions Among The Patients Attending O.P.D. In A Tertiary Care Hospital In Assam.

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Abstract:*OBJECTIVES :To study the role of Optical Coherence Tomography (OCT) in diagnosing macular lesions among the patients attending O.P.D.(Out Patient Department) of theAssam Medical College& Hospital,Dibrugarh.MATERIALS&METHODS:This is a prospective hospital based study conducted on 50 patients having macular lesions attending O.P.D. of the Department of Ophthalmologyin the Assam Medical College & Hospital, Dibrugarh, Assam. The study was conducted based on thecomplete ophthalmic examination includingbest corrected visual acuity, Slit Lamp Examination, IOP recording and detailed fundus examination by indirect ophthalmoscopy with +20D lens. Routine blood examination and urine examination were done. Then, patients were underwent posterior segment examination by OCT. RESULTS : A total number of 50 cases were enrolled in the study, out of which 31(62%) were male, 19(38%) were female, of the 50 cases on whom OTC was done, majority of cases 18(36%) were found to have diabetic macularedema, followed by Age Related Macular Degeneration in 10(20%), central serous retinopathy in 7(14%) cases. Epiretinal membrane was seen in 3(6%) cases, macular hole was seen in 5(10%) cases, of which 2(4%) had full thickness macular holes and 3(6%) cases had partial thickness macular hole. Retinal thinning or foveal atrophy was seen in 5(10%) of cases. CONCLUSION: OCT helps in diagnosis of macular lesions when clinical diagnosis is in doubt and also gives additional information about the pathological presentation and subtle changes so it helps in early diagnosis and better management.*

Keywords:Optical Coherence Tomography, Macular lesions, Assam

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I. Introduction

Optical coherence tomography (OCT) is a new medical diagnostic imaging technology which can perform micrometer resolution cross-sectional or tomographic imaging in biologic tissues.[1] Traditional methods of evaluating macular thickening, including slit lamp biomicroscopy and stereo fundus photography, are relatively insensitive to small changes in retinal thickness. Thus, several new techniques for quantitatively measuring retinal thickness have been explored.[2] Recent imaging techniques can provide tomographic or cross-sectional images of intraocular structures and can yield powerful diagnostic information, which is complementary to conventional fundus photography and fluorescein angiography.[3]

OCT was developed through a collaborative effort between the New England Eye Centre, Tufts University School of Medicine, the Department of Electrical Engineering and Computer Science at MIT, and Lincoln Laboratory, MIT. It is new, non-invasive, noncontact, trans pupillary imaging technology for in vivo evaluation of retinal structures. It has a resolution of 10 to 17 microns. Similar to B-scan, it produces cross-sectional images of the tissue, the difference being that it utilizes the optical backscattering of light unlike the sound waves, which are used in B-scan. Therefore, it utilizes the optical properties, rather than acoustic properties of the tissue and therefore obtains a much higher resolution up to 5 microns. The anatomic layers of the retina can be differentiated and retinal thickness can be measured. It can also be used for anterior segment imaging to visualize the cornea, iris, lens and angle.[4]

Retinal imaging is performed using infrared light at approximately 800 nm wavelength. The image is displayed using a false color map that corresponds to detected backscattered light levels ranging between $4x10^{-10}$ to 10^{-6} of the incident light. OCT can be applied in a wide variety of fields other than ophthalmology.[5,6,7] The ability of OCT to perform a non-excisional optical biopsy in real time giving detailed qualitative and quantitative information is its main advantage. Another advantage is its axial resolution of about 10 microns,

which is 10-20 times more than standard ultrasound B mode imaging. [8] The axial resolution of OCT is determined by the physical properties of light source whereas transverse resolution is determined by the focused spot size of the optical beam and is generally around 20-25 microns. The absolute minimum spot size is limited by the optical aberrations of that particular eye, unlike in other imaging applications. [9] Image resolution also depends on the speed of acquisition, pixels in the image and the basic resolution of the system.

PRINCIPLE OF OCT: [7, 10, 11]

Sir Isaac Newton first established the technique of low coherence or white light interferometry. OCT performs cross- sectional imaging based on low –coherence interferometry by using a continuous beam of low coherence light and is very sensitive to small changes in the refractive index of the sample. This light is back reflected from different tissue boundaries and the machine measures the echo-time delay and intensity of backscattered or backrefleted light from the microstructured inside the tissues. Serial axial measurements are taken at different transverse positions. These signal intensities are processed by the computer and displayed as grey-scale or as a false color-coded image. Maximum intensity signal (50dB) is displayed as white in grey scale and red in false color scale. Weakest intensity signal (95dB) is displayed as black and blue. Cross-sectional images can be reconstructed by collecting depth scans at different adjacent positions [11]. Post –processing of the image is possible to obtain measurements or reconstruct topography maps. Softwares are available for different scan patterns and different image processing protocols.

OCT SCAN PROTOCOLS IN MACULAR DISEASES:[10, 12]

The protocols that are helpful in macular diseases are the following:

1. Line scan: The line scan gives an option of acquiring multiple line scan without retaining to main window. Both the length and angle can be changed according to resolution.
2. Radial lines
3. Macular thickness map
4. Fast macular thickness map
5. Raster line
6. Repeat

VARIOUS TYPES OF OCT: [10, 11]

1. Time domain OCT
2. Frequency Domain OCT (FD-OCT)
3. Spatially Encoded Frequency Domain OCT (Spectral Domain or Fourier Domain OCT)
4. Time encoded frequency domain OCT (also swept source OCT)

Anatomy Of The Macula:

The macula lutea is an oval, yellowish area of the center of the posterior part of the retina. It measures about 5.5 mm in diameter and lies about 3mm lateral side of the optic disc. The yellowish coloration of the macula is caused by a yellow carotenoid pigment, xanthophylls, which is present in the retinal layers from the outer nuclear layer inward.

Parts of the macula: [4, 13, 14, 15]

- Umbo
- Foveola
- Foveal avascular zone
- Fovea
- Parafoveal area
- Peri foveal area

Umbo: It is a tiny depression in the centre of the Foveola which corresponds to the ophthalmoscopically visible foveolar reflex.

Foveola (350 microns): It is the small central region in which the thickness of the retina is reduced so as to contain only photoreceptors, glial cells and muller cells.

Foveal avascular zone (800 microns): It is located inside the fovea but outside the foveola.

Fovea(1500 microns): It is a small depression where the retina is reduced to about half its normal thickness moving towards the centre of the retina. The inner nuclear layer is reduced to a double row of cells at the edge

of the fovea. The foveal sides of the depression are called the clivus; the floor of the depression is the foveola. There are no blood vessels overlying the fovea and no rod cells in the floor of the fovea. It is here that there is the highest concentration of cones is found.

Parafovealarea(500 microns): It is characterized by the densest accumulation of the nerve cells in the entire retina especially ganglion cells and the inner nuclear layer. The outer boundary is the point where the ganglion cell layer has four rows of the nuclei. [4, 13]

Peri foveal area(1500microns): It ends where the ganglion cells are reduced to a single layer. [4, 16]

Histology of the macula:
The centre of the macula is the fovea containing the following layers
- Internal limiting membrane
- Outer plexiform layer
- Outer nuclear layer
- Layer of cones
- Retinal pigment epithelium

High-resolution cross-sectional imaging of the retina may be useful for identifying, monitoring, and quantitatively assessing macular diseases. OCT application has been demonstrated in the normal human anterior eye and retina in patients with selected macular abnormalities and glaucoma. [3, 17, 18] Optical Coherence Tomography (OCT) allows characterization of the profile and the intra-retinal structural changes of many macular disorders. [19]

OCT IN DIFFERENT MACULAR LESIONS:
Diabetic macular edema[19, 20]

OCT is of great importance in diagnosing diabetic macular edema, deciding upon management and evaluating the response to various modalities of management. Fibrovascular proliferations are seen as hyper-reflective pre-retinal bands. The presence of vitreo-retinal traction at the interface can also be appreciated as well as any secondary retinal changes. This has five distinct patterns on OCT :-
- Sponge-like retinal thickness
- Cystoid macular edema
- Subfoveal serous detachment
- Vitreomacular traction
- Taut posterior hyaloid

Cystoid macular edema – loss of foveal countour is seen when there is retinal edema, with thickening and fluid accumulation in the form of cystic spaces predominantly in the outer plexiform and inner nuclear layers.

Macular hole[12]
OCT is extremely used for assessing the following:
- Early macular holes
- Presence of PVD
- Size of macular holes
- Closure pattern following Vitrectomy

Various stages of macular hole can be identified by OCT as follows:

Stage IA of the macular hole is seen as foveal pseudo cyst in the retinal layers.

Stage IB is seen as partial disruption of the outer retinal layers. The posterior vitreous seen attached to its edges. It may develop to a lamellar macular hole.

Stage II reveals as a full thickness macular dehiscence with attached posterior vitreous. The surrounding retina may show thickening and cystic changes.

StageIII reveals a large macular hole with attached posterior vitreous.

StageIV reveals a macular hole larger than 400 µ in diameter, with a detached posterior hyaloid. There may be an associated optically empty space below the neurosensory retina at the edges of the dehiscence suggestive of sub retinal fluid, along with thickening and cystic changes in the retinal layer [12].

ARMD

OCT has become very popular in ARMD because of early disease detection, monitoring of therapy and early evidence of reactivation[7,10,21].Also called senile macular degeneration, is a bilateral disease and is a leading cause of blindness in developed countries, in population above the age of 65 years.

It is of two types:-

- Non-neovascular (Dry)
- Neovascular (Wet or exudative)

Drusen: Drusen can be hard drusen or soft drusen.

Hard drusen in OCT: On OCT they are seen as focal elevation of the RPE with mildly thinned overlying retina. The elevated RPE does not shadow the reflection.

Soft drusen in OCT: Images show small modulation in the contour of the retinal pigment epithelium with lack of shadowing below the contour changes, similar to serous RPE detachment. However, unlike a PED, soft drusen have shallow margins and mild back scatter into the choroid.

Geographic atrophy: OCT shows a thinned out overlying retina and decreased reflectivity of RPE with enhanced choroidal layer.

Neovascular ARMD (exudative): OCT shows retinal thickening with mild back scattering from outer retinal layers, with disruption in the RPE in an area of moderate reflectivity with fusiform thickening of the reflective band corresponding to the CNVM. The lesions merge with RPE choriocapillaries layer [12,13].

Occult CNVM: OCT shows an enhanced optical scatter signal at the choroidal level extending into sub-RPE space which is thicker than the adjacent reflection from the pigmented epithelium and choriocapillaries, consistent with a neovascular membrane. The retina overlying the lesion appears thickened and elevated, with reduced reflectivity, suggesting fluid accumulation.

ERM (Epiretinal Membrane)[12, 22]

These are clearly visible on the vitreoretinal interface on OCT [11-13]. OCT is very useful tool in grading the ERM and providing information about the underlying retinal traction and secondary changes in the retina. OCT reveals a hyper-reflective membrane at the vitreoretinal interface, adherent to the underlying retina, with distortion of the inner retinal layer. The traction on the underlying retina is seen as folds in the inner retinal layer. On OCT, ERMs are seen as clearly separable where clear space is visible between the epiretinal membrane and inner retinal surface and global ERM where no area of separation is seen between the ERM and inner retinal surface. An increased thickness of retina with optically empty spaces in retinal layers along with reduced back scattering from outer retinal layers will indicate Cystoid macular edema, a lamellar macular hole may be associated with ERM. A macular pseudo hole formed by the ERM needs to be differentiated from a true macular hole. A macular pseudo hole will show an abnormally steep foveal contour resembling a partial thickness macular hole, but the outer retinal layer is seen intact throughout the image ruling out a full thickness macular hole. It is important to distinguish an ERM from a detached posterior hyaloid as both appear as a reflective band anterior to the retina on OCT. The posterior hyaloid has a weak, patchy reflection that is inner than an ERM.

CSR(Central Serous Retinopathy)[16,23]

OCT allows detection of early CSR [19, 22]. OCT shows on elevated neurosensory retina with an optically clear space underneath and a reflective layer corresponding to the RPE and choriocapillaries underneath it, corresponding to the CSR. With the advent of OCT the existence of PED with CSR has been shown to be much more than thought previously. In cases of associated PED, below the elevated neurosensory retina lies optically clear space below which highly reflective dome shaped elevation with attenuated shadows below it suggest the presence of PED. There may be hyper reflective spots in the optically clear space below the neurosensory retina corresponding with the sub retinal exudation and fibrin seen in resolving or chronic CSCR. CSCR may also have associated Choroidal Neovascular Membrane (CNVM). In such situations, there will be a delineated hyper fluorescence on angiogram corresponding with the CNVM. OCT will show high reflectivity at the level of RPE choriocapillaries suggestive of a CNVM. Longitudinal follow-up of the patient can be done to aid in management (observation versus laser).

Retinal pigment epithelium detachment (PED)[11, 22]
PED can be differentiated into the following types:

Serous PED: Serous PED-clinically seen as an area of RPE detachment.

Fibro vascular PED: OCT shows elevated RPE, along with mild to moderate back scatter persisting beneath the RPE, consistent with the Fibro vascular PED. It may have associated overlying neurosensory detachment or overlying cystoid macular edema.

Hemorrhagic PED: OCT through the hemorrhagic PED shows elevated RPE with moderate back scatter, which attenuates quickly with depth below the RPE. This back scatter, appearing immediately below the raised RPE is consistent with the hemorrhagic. The RPE band may be indistinguishable from hemorrhagic. There may be associated neurosensory elevation and cystoid changes in the overlying retina.
Drusenoid PED: OCT defines a RPE elevation with optical back scatter below the RPE, with small modulations in the RPE contour with moderate optical reflectivity below the lesion.

II. Materials And Methods

AIMS AND OBJECTIVES:
- To study role of Optical Coherence tomography in diagnosing macular lesions among the patients attending with uncorrected decreased vision.
- Early detection of macular lesions and their management.
- To find out the different pattern of macular lesions based on OCT among the study groups.

III. Methodology

50 patients were selected with macular pathology who underwent OCT examination attending Out Patient Clinic of the Department of Ophthalmology; Assam Medical College & Hospitals, Dibrugarh; Assam.

TYPE OF STUDY:A Hospital-Based Prospective Study.

PLACE OF STUDY: Department Of Ophthalmology, Assam Medical College & Hospital; Dibrugarh, Assam.

PATIENT POPULATION : Patients attending O.P.D.(Out Patient Department) or Out-Door of the Ophthalmology Department of the Assam Medical College & Hospital, Dibrugarh; Assam.

SCREENING OF PATIENTS:Patients with macular lesions on funduscopic examination and underwent OCT examination were selected.

INCLUSION CRITERIA:
- Patients with macular lesions.
- Patients of all ages.
- Both the sexes.
- Informed consent.

EXCLUSION CRITERIA:
- Media opacity where OCT cannot be done.

EXAMINATION procedures:
1. External Examination.
2. Snellen's Vision Box.
3. Biomicroscopic examination.
4. Detailed fundoscopic examination with indirect and direct ophthalmoscopy was done.
5. OCT examination.

IV. Results

Among the maximum percentage 30%, (15 out of 50) of patients were in the age group 51 to 60 years; followed by 26%, (13 out of 50) in the age group 61 to 70 years; 18%, (9 out of 50) in the age group 41 to 50

years; 14%, (7 out of 50) in the age group 31 to 40 years and 10% (5 out of 50) were in age group of above 70 years.

Table-1. Age Distribution.

AGE GROUPS	AFFECTED SAMPLES	%AGE AFFECTED
>20 -30 years	1	2%
31 – 40 years	7	14%
41 - 50 years	9	18%
51– 60 years	15	30%
61- 70 years	13	26%
71->80 years	5	10%
TOTAL	50	100%

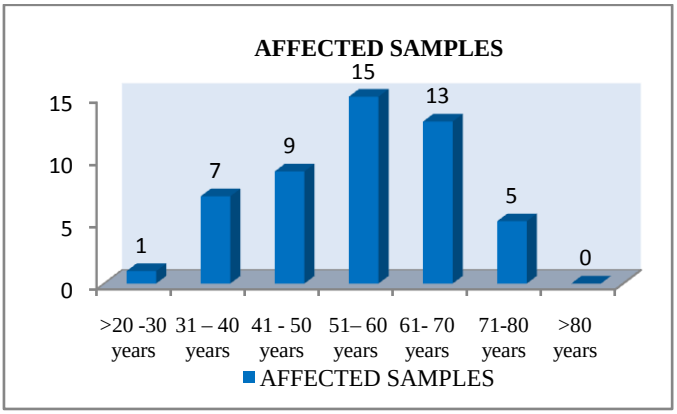


Fig. 1. Age wise distribution of Affected Patients.

Among the total patients, 31 (62%) patients were male and 19 (38%) patients were female (M : F = 1.63: 1).

Table 2. Sex Distribution.

SEX	AFFECTED SAMPLES	% AGE (Percentage) AFFECTED	RATIO M : F
MALE	31	62%	
FEMALES	19	38%	1.63 : 1

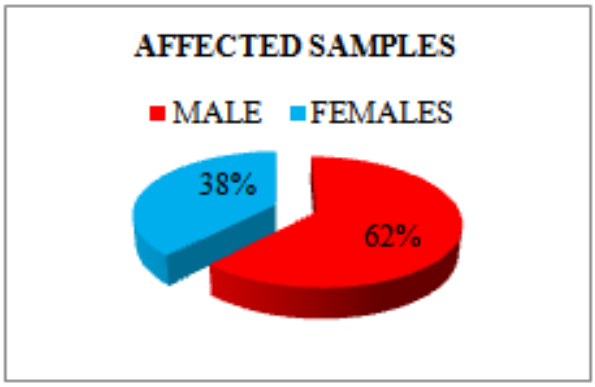


Fig. 2. Sex distribution of Affected Patients.

Among the total patients, **31**cases (62 %) patients presented were unilateral cases and 21 (42%) cases were bilateral.

Table 3. laterality

Laterality	AFFECTED SAMPLES	% AGE (Percentage) AFFECTED
Unilateral	31	62%
Bilateral	21	42%

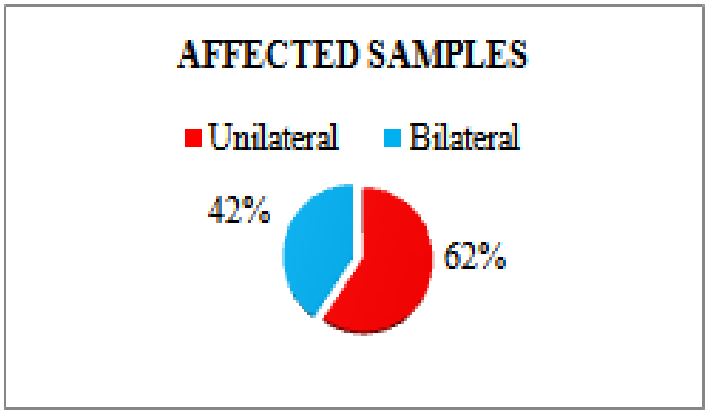


Fig.3. Laterity of the affected samples

Among the maximum percentage 46%, (23 out of 50) of patients were having visual acuity at presentation in range of 6/60-6/36; followed by 38% (19 out of 50) in the range of HM-FC; 28% (14 out of 50) in the range of 6/24-6/18; 22%, (11 out of 50) in the range of 1/60-5/60 and 10% (5 out of 50) were having 6/12-6/9 visual acuity.

Table 4. Presented visual acuity of the patients

VISUAL ACUITY	TOTAL NUMBERS	% AGE PERCENTAGE
HM-FC	19	38%
1/60-5/60	11	22%
6/60-6/36	23	46%
6/24-6/18	14	28%
6/12-6/9	5	10%
6/6	0	0%

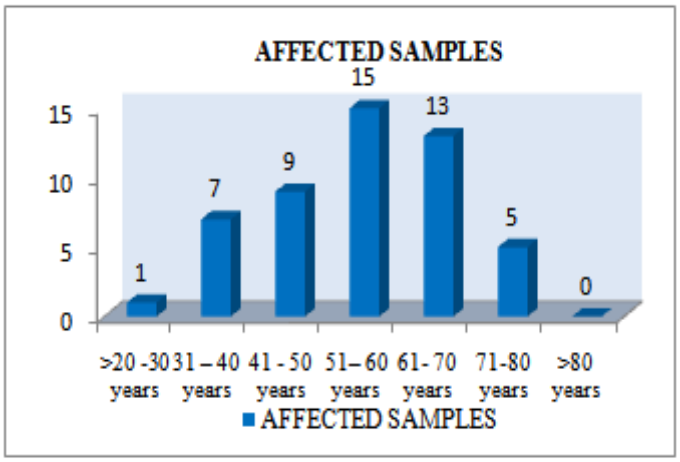


Fig. 4. Visual acuity at presentation among the Affected Patients.

Among the maximum percentage 36%, (18 out of 50) cases were found to have diabetic macular edema, followed by 20% (10 out of 50) cases having Age Related macular degeneration, 14% (7 out of 50) cases having central serous retinopathy, 2 cases (4%) had PED along with CSR. Epiretinal membrane was seen in 6% (3 out of 50 cases), macular hole was seen in 5 cases, out of which full thickness was seen 2 (4%) cases and 3 cases had lamellar macular hole, 10 %(5 cases) had macular thinning.

Table 5. Distribution macular lesions.

DISTRIBUTION OF MACULAR LESIONS		SAMPLES	TOTAL% AGE (PERCENTAGE)
Diabetic Macular Edema	Spongiform macular edema	9	18%
	Cystoid macular edema	7	14%
	Serous retinal detachment	2	4%
Central Serous Retinopathy		7	14%
Epiretinal Membrane		3	6%
Age Related Macular Degeneration		10	20%
Macular hole	Full thickness macular hole	2	4%
	Lamellar macular holes	3	6%
Macular thinning		5	10%
PED		2	4%

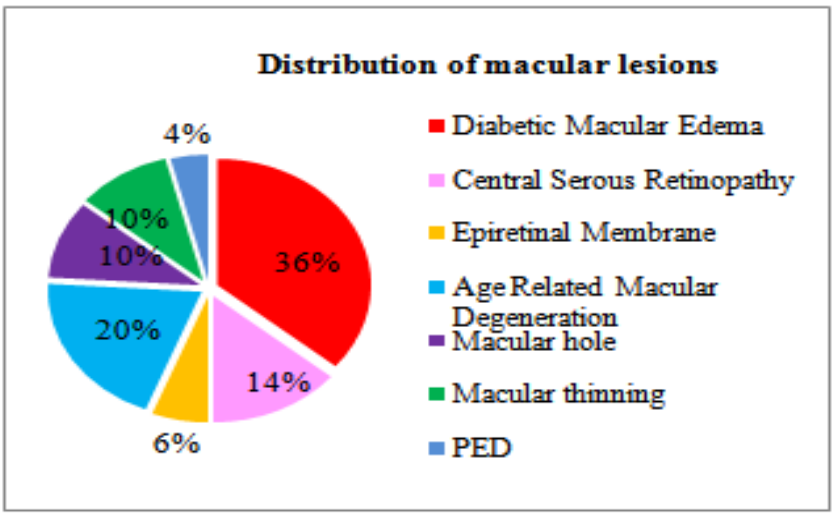
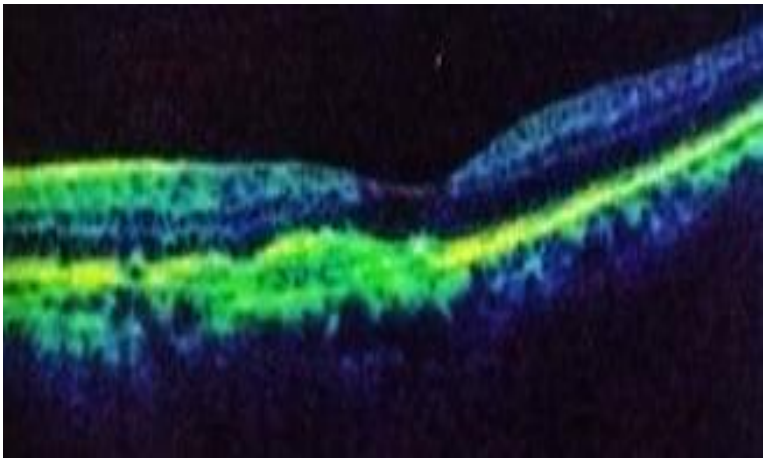
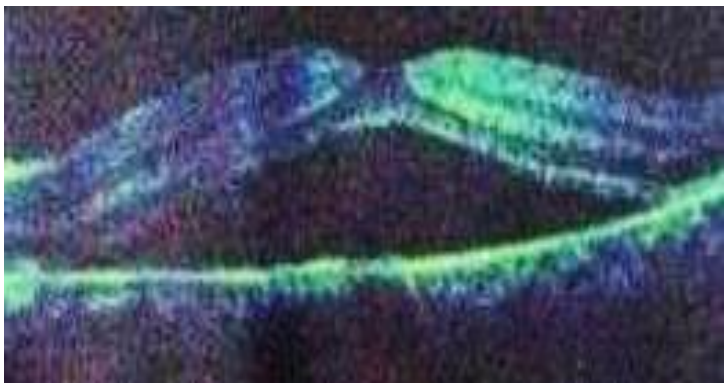


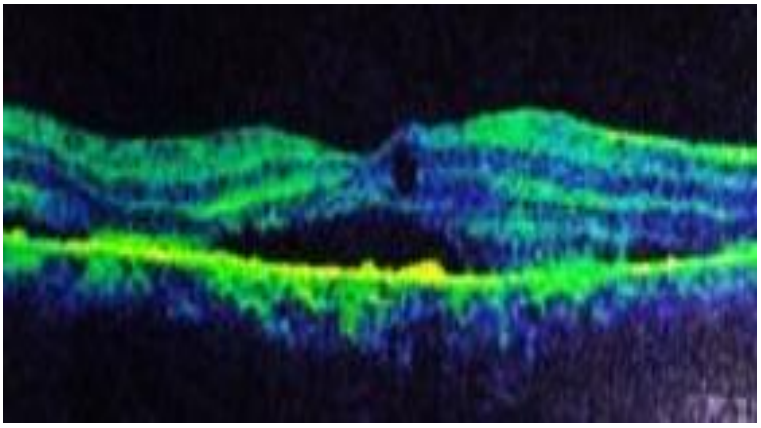
Fig. 5. Distribution of macular lesions among the Affected Patients



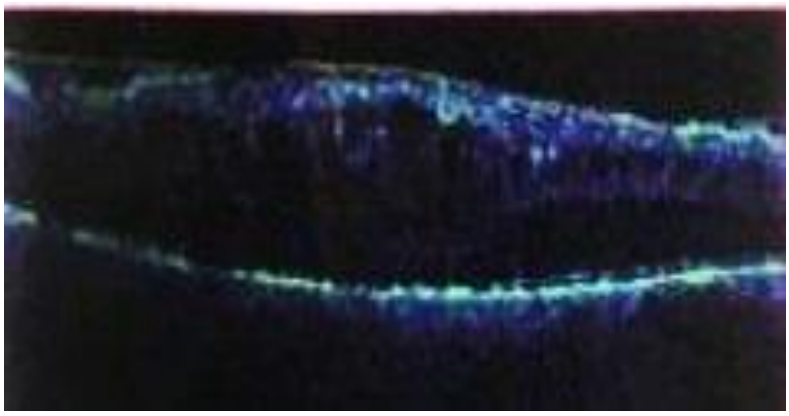
Dry age-related macular degeneration



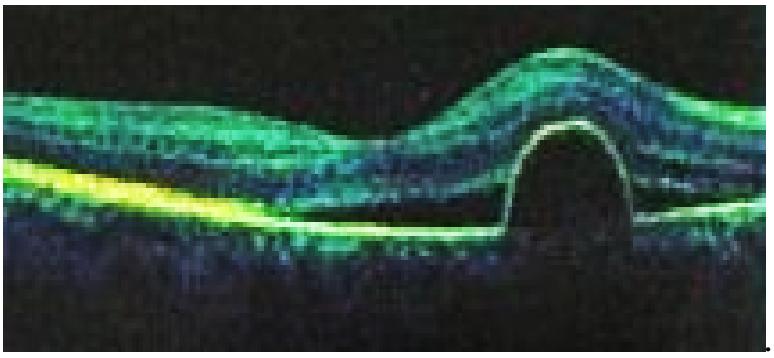
Central serous chorioretinopathy



Diaibetic macular edema



Epiretinal membrane



Pigment epithelium detachment

Fig. 6. Common macular lesions on OCT

V. Discussion

In our study 50 cases were included out of which 31 were males and 19 were females. Age distribution of study population were ranged from 28-75 years with mean age of 59 years. Out of 50 cases on whom OCT was done after clinical evaluation, majority of cases (36%) were found to have Diabetic macular edema. Among the diabetic macular edema cases, 3 structural changes were identified, which was corresponds with the findings of Otaniet et al[24],where they also observed similar patterns i.e. spongiform, cystoid form and serous retinal detachment. Whereas in contrast to Kim et al detected 5 morphological patterns of diabetic macular edema. OCT helps in identifying different patterns of macular edema and decisions regarding management strategy depends on OCT findings. Studies have compared OCT and FA with regards to detection of macular edema and macular thickening has shown to correlate better with visual acuity. OCT seems to be a very promising tool in early detection of macular thickening.

In our study 10 patients had ARMD, of which 7 had dry and 3 cases had wet form of ARMD.

Out of 50 cases, In our study CSR was seen in 7 cases with male preponderance in ratio of 9:1. OCT showed serous retinal detachments in all the cases, out of 7 cases 2 cases had PED associated with it. OCT identifies sub foveal fluid accumulation which was not detected clinically. Hee MR et al[3] in their study stated that OCT was useful in evaluating sub retinal and intra retinal fluid.Masahiro Miura et al[25] stated that OCT assists in rapid non invasiveassessement of CSR.

Among the cases, 5 cases presented with macular holes with female preponderence. 2 patients had full thickness macular holes and 3 cases had lamellar holes in inner retinal layers and both the lamellar holes are in stage 2. OCT detected all the patients with macular holes and tomographic information provided by OCT lead to better understanding of pathogenesis of macular hole formation. Similarly Hee MR et al[3] stated that OCT was useful in visualizing macular holes.

Epiretinal membrane was diagnosed clinically in 3 cases and OCT confirmed all the cases of ERM. In our study macular thinning was seen in 5 cases leading to foveal atrophy without other significant changes.

VI. Conclusion

OCT is a new technique for the clinical evaluation of a variety of macular diseases.Optical coherence tomography is potentially a powerful tool for detecting and monitoring a variety of macular diseases, including macular edema, macular holes, and detachments of the neurosensory retina and pigment epithelium. It not only confirms the diagnosis but also gives additional information regarding disease morphology and pathological presentations of macular diseases for better understanding and management of diseases.

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