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Original Research Paper

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SPECTRUM OF OPTICAL COHERENCE TOMOGRAPHY CHANGES IN AGE-RELATED MACULAR DEGENERATION

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ABSTRACT

Background: Age-related macular degeneration is a major cause of visual impairment in the elderly, characterized by degenerative changes involving the retinal pigment epithelium, photoreceptors, and Bruch's membrane. Spectral-domain optical coherence tomography enables high-resolution visualization of retinal microstructure and plays a key role in identifying AMD-related changes.**Objective:** To evaluate the spectrum of SD-OCT findings in patients with AMD.**Methods:** This hospital-based cross-sectional study included 150 patients aged ≥50 years with clinically suspected AMD. All patients underwent a detailed ophthalmic examination followed by SD-OCT imaging of the macula. OCT features such as drusen morphology, pigment epithelial detachment, subretinal fluid, intraretinal fluid, and outer retinal layer disruption were documented and analyzed using descriptive statistics.**Results:** The mean age was 67.8 years. The most common OCT finding was hyperreflective irregular nodules between the RPE and Bruch's membrane with outer retinal tubulations (40%), followed by SRF and IRF (33.3%). PED was observed in 13.3% of cases. Wet AMD (53%) was slightly more common than dry AMD (47%).**Conclusion:** SD-OCT effectively demonstrates the structural spectrum of AMD and is essential for diagnosis, classification, and monitoring of disease progression.

KEYWORDS : Age-related macular degeneration; Spectral-domain optical coherence tomography; Drusen; Pigment epithelial detachment; Subretinal fluid.

INTRODUCTION-

Age-related macular degeneration (AMD) is a progressive degenerative disorder of the macula and represents one of the leading causes of irreversible visual impairment among the elderly population worldwide. It is characterised by a spectrum of pathological changes involving the photoreceptors, retinal pigment epithelium (RPE), Bruch's membrane, and the choriocapillaris. Clinically, AMD is identified by the presence of intermediate or large drusen (≥63 m), pigmentary abnormalities of the RPE, reticular pseudodrusen, and advanced manifestations such as geographic atrophy or choroidal neovascularisation, including polypoidal choroidal vasculopathy and retinal angiomatous proliferation. [1]

Advancements in retinal imaging have significantly enhanced the understanding of AMD pathogenesis and progression. Optical coherence tomography (OCT) has emerged as an indispensable, non-invasive imaging modality for in vivo evaluation of retinal microarchitecture. Since its introduction into clinical practice in the late 1990s, OCT has undergone remarkable technological evolution, enabling high-resolution, cross-sectional, and three-dimensional visualisation of intraocular structures with near-histological detail. [2]

OCT operates on the principle of low-coherence interferometry, utilising near-infrared light to measure the magnitude and delay of backscattered signals from retinal tissues. Initially developed as time-domain OCT (TD-OCT), this technology relied on a mechanically moving reference mirror, which limited acquisition speed, sampling density, and spatial resolution.[3,4] These limitations restricted accurate layer-by-layer analysis and longitudinal assessment of subtle retinal changes.

The advent of spectral-domain OCT (SD-OCT), also known as Fourier-domain OCT, marked a paradigm shift in retinal imaging. By employing a stationary reference arm and capturing interference data as a function of wavelength, SD-OCT achieved acquisition speeds 50–100 times faster than TD-OCT, with superior axial and transverse resolution. [5,6] This technological advancement allows dense raster scanning, precise registration with fundus landmarks, and reliable longitudinal monitoring of retinal pathology.

In the context of AMD, SD-OCT has provided critical insights into disease morphology, enabling detailed characterisation of drusen, subretinal drusenoid deposits, photoreceptor disruption, RPE irregularities, and outer retinal atrophy. It has also facilitated improved differentiation between non-exudative and exudative forms of AMD and enhanced understanding of disease progression at a microstructural level. [7-10]Consequently, SD-OCT has become an essential tool not only for diagnosis and monitoring but also for advancing research into the structural spectrum of AMD.

The present study aims to evaluate and document the range of OCT-based retinal changes observed in patients with age-related macular degeneration, thereby highlighting the role of spectral-domain OCT in delineating disease severity, patterns of retinal involvement, and potential prognostic indicators.

Material and Methods-

Study Design and Study Population

This hospital-based cross-sectional observational study was conducted in the Department of Ophthalmology of a tertiary care medical college and hospital. The study population comprised patients attending the ophthalmology outpatient department who were clinically suspected to have AMD based on history and fundus examination.

Study Duration

The study was carried out over a period of 18 months, during which eligible patients were recruited and evaluated.

Sample Size

The minimum estimated sample size for the present study was 150 patients.

Sampling Technique
A consecutive sampling method was adopted. All patients aged 50 years and above, attending the ophthalmology outpatient department during the study period, who were clinically suspected of having AMD and who fulfilled the eligibility criteria, were included until the required sample size was achieved.

Inclusion Criteria
1. Patients aged 50 years or older.

2. Patients attending the ophthalmology outpatient department with clinical features suggestive of age-related macular degeneration.

3. Participants who provided written and informed consent to participate in the study.

Exclusion Criteria
1. Patients with dense cataract or media opacities precluding adequate fundus visualization and OCT imaging.

2. Patients unable to maintain fixation due to severely reduced visual acuity.

3. Patients with other ocular diseases such as glaucoma, retinal disorders other than AMD, or significant corneal pathology that could interfere with OCT interpretation.
4. Patients below 50 years of age.

Materials Used
The following instruments and equipment were used during the study:
- Snellen's visual acuity chart and C-chart for illiterate patient
- Goldmann applanation tonometer
- Slit lamp biomicroscope (Appasamy) with +78D and +90D lenses
- Direct ophthalmoscope (Heine Beta 200 S)
- Indirect ophthalmoscope (Heine) with +20D lens
- Mydriatic agents: 1% tropicamide and 2.5% phenylephrine eye drops
- Spectral-domain Optical Coherence Tomography (OCT) machine (Zeiss)

Methodology
Clinical Evaluation and Data Collection
After obtaining written informed consent, a detailed history was elicited from each participant, including demographic details, presenting ocular complaints, duration of symptoms, and relevant systemic history. Data were recorded using a predesigned and semi-structured questionnaire.

Each patient underwent a comprehensive ophthalmic examination, which included:
1. Assessment of visual acuity using Snellen's chart for literate patients and C-chart for illiterate patients, and documentation of best-corrected visual acuity after refraction.

2. Torchlight examination to assess the anterior segment.

3. Objective and subjective refraction, following which the best-corrected visual acuity was recorded.

4. Measurement of intraocular pressure using Goldmann applanation tonometry.

5. Slit lamp biomicroscopy for detailed evaluation of the anterior segment.

6. Pharmacological pupillary dilatation using 1% tropicamide combined with 2.5% phenylephrine eye drops.

7. Dilated fundus examination using direct ophthalmoscopy, indirect ophthalmoscopy, and slit lamp biomicroscopy with +78D and +90D lenses to assess the macula and posterior pole.

OCT
SDOCT was performed in all patients with adequate pupillary dilatation. OCT imaging was used to evaluate the macular region in detail and to identify structural retinal changes associated with age-related macular degeneration.

The OCT parameters assessed included the presence and type of drusen, alterations in the retinal pigment epithelium, pigment epithelial detachment, subretinal fluid, intraretinal fluid, disruption of outer retinal layers, and other characteristic macular changes. The spectrum of OCT findings was documented and analyzed in relation to the clinical presentation.

Statistical Analysis
All collected data were coded and entered into Microsoft Excel spreadsheets and subsequently analyzed using IBM SPSS Statistics Version 25 (IBM Corporation, New York, USA).

Descriptive statistics such as mean, standard deviation, frequencies, and percentages were used to summarize continuous and categorical variables. Associations between qualitative variables were assessed using the Chi-square test. A p-value of ≤ 0.05 was considered statistically significant.

RESULTS-
TABLE 1: AGE-WISE DISTRIBUTION OF THE STUDY PARTICIPANTS-

	Frequency	Percent
50-60	21	14.0
60-70	99	66.0
70-80	15	10.0
>80	15	10.0
Total	150	100.0
Mean ± SD	67.8	RANGE (55-86)

TABLE 2: SMOKINGWISE DISTRIBUTION OF THE STUDY PARTICIPANTS

	Frequency	Percent
N (Non-smokers)	67	44.7%
Y (Smokers)	83	55.3%
Total	150	100.0

TABLE 3- DISTRIBUTION ACCORDING TO FAR VISUAL ACUITY(VA)

	Frequency	Percent
1/60	2	1.3
2/60	5	1.5
3/60	15	10.0
FCCF	7	4.7
6/60	15	10.0
6/36	17	11.3
6/24	14	9.3
6/18	22	14.7
6/12	29	19.3
6/9	24	16.0
Total	150	100.0

TABLE 4: FUNDUS EXAMINATION FINDINGS WISE DISTRIBUTION OF THE STUDY

	Frequency	Percent
An orange dome-shaped elevation with sharply delineated edges, with a pale margin of subretinal fluid, was seen	5	3.3

Drusen with pigmentary abnormality	60	40.0
Drusenoid pigment epithelial detachment with shallow Elevated pale areas were seen	5	3.3
Fibrotic sub-macular scarring with chronic sub-macular fluid was seen	5	3.3
A grey-green area and a small haemorrhage were seen	50	33.3
Specks of blood on the fovea were seen	20	13.3
Well-delineated areas of hypopigmentation and Depigmentation areas were seen	5	3.3
Total	150	100.0

TABLE 5: OCT FINDINGS WISE DISTRIBUTION OF THE STUDY

	Frequency	Percent
Pigment epithelial detachment with a multilobulated appearance was seen	20	13.3
A well-demarcated, highly hyperreflective lesion was seen	5	3.3
Homogeneous hyperreflectivity within the PED was seen	5	3.3
hyperreflective irregular nodules (bumps) were located between the RPE and Bruch's membrane, and tubulations were seen	60	40.0
Separation of RPE from Bruch's membrane by an optically empty area was seen	5	3.3
Severe disruption of the external limiting membrane of the retina was seen	5	3.3
Subretinal fluid, intraretinal thickening, and haemorrhages were seen	50	33.3
Total	150	100.0

TABLE 6: WET / DRY ARMD WISE DISTRIBUTION OF THE STUDY

	Number	Percent
Dry	70	47
Wet	80	53
Total	150	100.0

A total of 150 patients with age-related macular degeneration were included in the study. The mean age of the participants was 67.8 years (range: 55–86 years). The majority of patients belonged to the 60–70 years age group (66%), followed by the 50–60 years group (14%).

Among the study population, 55.3% were smokers, while 44.7% were non-smokers. With respect to far visual acuity, the most common presenting visual acuity was 6/12 (19.3%), followed by 6/9 (16.0%) and 6/18 (14.7%). Moderate to severe visual impairment (≤6/36) was observed in a substantial proportion of patients.

Fundus examination showed drusen with pigmentary abnormalities as the most frequent finding (40%), followed by grey-green lesions with haemorrhage suggestive of neovascular activity (33.3%). Specks of blood over the fovea were noted in 13.3% of cases.

On optical coherence tomography, the most common finding was the presence of hyperreflective irregular nodules between the retinal pigment epithelium and Bruch's membrane with tubulations (40%), followed by subretinal fluid and intraretinal changes (33.3%). Pigment epithelial detachment was observed in 13.3% of patients.

Based on clinical and OCT findings, dry age-related macular degeneration was noted in 47% of patients, while wet age-related macular degeneration was present in 53%.

DISCUSSION:

AMD is a leading cause of irreversible visual impairment in individuals above 50 years of age. In the present study, the mean age of patients was 67.8 years, with the majority clustered in the 60–70-year age group, reinforcing the well-established association between increasing age and AMD prevalence. The clinical classification system described by Ferris et al. emphasizes the significance of drusen size and pigmentary abnormalities in defining disease stages, which correlates well with the clinical and OCT-based observations in our study.[1]

A higher proportion of smokers was noted in the study population, supporting the recognized role of smoking as a modifiable risk factor in AMD. Smoking contributes to oxidative stress, vascular compromise, and retinal pigment epithelium dysfunction, thereby accelerating disease progression.

The introduction of OCT by Huang et al. marked a major advancement in retinal imaging by enabling non-invasive, cross-sectional visualization of retinal structures.[2] Early imaging systems, including time-domain OCT, were limited by slower acquisition speeds and lower resolution.[3,4] The advent of spectral-domain OCT significantly enhanced imaging quality, enabling faster acquisition and improved delineation of retinal layers.[5,6] These advancements have substantially improved the evaluation of macular pathologies.

In the present study, the most frequent OCT finding was hyperreflective irregular nodules between the retinal pigment epithelium and Bruch's membrane with associated outer retinal tubulations. These features correspond to drusen and subretinal drusenoid deposits, which are hallmarks of intermediate AMD. Similar microstructural alterations have been demonstrated using spectral-domain OCT in previous studies.[7–9] Schuman et al. highlighted photoreceptor layer thinning over drusen, emphasizing the prognostic relevance of outer retinal integrity. [9]

Subretinal fluid, intraretinal thickening, and pigment epithelial detachment were commonly observed in cases classified as wet AMD. High-resolution OCT is particularly useful in identifying such exudative changes and in differentiating them from non-exudative forms. Studies evaluating geographic atrophy have further demonstrated the value of spectral-domain OCT in delineating outer retinal and RPE loss.[10]

In our study, wet AMD was slightly more prevalent than dry AMD. OCT played a crucial role in distinguishing these subtypes by identifying fluid accumulation, RPE elevation, and structural disruption. The ability to detect subtle morphological changes enhances early diagnosis, guides therapeutic intervention, and allows longitudinal monitoring of disease progression.

Overall, the findings of this study reaffirm the indispensable role of spectral-domain OCT in characterizing the structural spectrum of AMD and improving clinical decision-making.

CONCLUSION:

The present study highlights the broad spectrum of retinal structural alterations identifiable on spectral-domain OCT in patients with age-related macular degeneration. Drusen-related changes and hyperreflective deposits were the most frequently observed features, while fluid accumulation and pigment epithelial detachments were more commonly associated with exudative disease.

SD-OCT proved invaluable in differentiating dry and wet forms of AMD and in detecting subtle microstructural disruptions not always apparent on clinical examination alone. Its high-resolution imaging capability enhances diagnostic precision, guides management decisions, and supports longitudinal monitoring of disease progression.

Early recognition of characteristic OCT patterns may facilitate timely intervention and improve visual outcomes in patients with AMD.

REFERENCES

1. Ferris FL III, Wilkinson CP, Bird A, et al. Clinical classification of age-related macular degeneration. Ophthalmology 2013;120:844-51.
2. Huang D, Swanson EA, Lin CP, Schuman JS, Stinson WG, Chang W, et al. Optical coherence tomography. Science 1991;254:1178-81.
3. Shahidi M, Ogura Y, Blair NP, Rusin MM, Zeimer R. Retinal thickness analysis for quantitative assessment of diabetic macular edema. Arch Ophthalmol 1991;109:1115e9.
4. Srinivasan VJ, Wojtkowski M, Witkin AJ, Duker JS, Ko TH, Carvalho M, et al. High-definition and 3-dimensional imaging of macular pathologies with high- speed ultrahigh-resolution optical coherence tomography. Ophthalmology. 2006;113(2054):e1e14.
5. Wojtkowski M, Srinivasan V, Fujimoto JG, Ko T, Schuman JS, Kowalczyk A, et al. Three-dimensional retinal imaging with high-speed ultrahigh-resolution optical coherence tomography. Ophthalmology. 2005;112:1734e46
6. Alam S, Zawadzki RJ, Choi S, Gerth C, Park SS, Morse L, et al. Clinical application of rapid serial Fourier-domain optical coherence tomography for macular imaging. Ophthalmology. 2006;113:1425e31
7. Nassif N, Cense B, Park B, Pierce M, Yun S, Bouma B, et al. In vivo high-resolution video-rate spectral-domain optical coherence tomography of the human retina and optic nerve. Opt Express. 2004;12:367e76.
8. Querques G, Canouı-Poitrine F, Coscas F, Massamba N, Querques L, Mimoun G, et al. Analysis of progression of reticular pseudodrusen by spectral domaineoptical coherence tomography. Invest Ophthalmol Vis Sci. 2012;53:1264e8.
9. Schuman SG, Koreishi AF, Farsiu S, Jung SH, Izatt JA, Toth CA. Photoreceptor layer thinning over drusen in eyes with age-related macular degeneration imaged in vivo with spectral-domain optical coherence tomography. Ophthalmology 2009;116. 488e496.e2.
10. Fleckenstein M, Charbel Issa P, Helb HM, Schmitz-Valckenberg S, Finger RP, Scholl HP, et al. High-resolution spectral domain-OCT imaging in geographic atrophy associated with age-related macular degeneration. Invest Ophthalmol Vis Sci 2008; 49: 4137e44