Study of Anterior Segment in Emmetropic, Hypermetropic and Myopic eyes by Spectral Domain – Optical Coherence Tomography (Anterior segment module)

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ABSTRACT
Purpose: Evaluation of anterior segment in Emmetropic, Hypermetropic and Myopic eyes using a non-contact and non-invasive Spectral Domain – Optical coherence tomography (anterior segment module) and to compare the parameters among these three groups.

Anterior segment parameters evaluated are: Central corneal thickness (CCT), Lens vault(LV), Anterior chamber angle (ACA), Angle Opening Distance (AOD_{500}),Angle recess area (ARA_{500}) and Trabecular Iris space area ($TISA_{500}$).

Lens vault- The perpendicular distance between the anterior pole of the crystalline lens and the horizontal line joining the two scleral spurs

Angle Opening Distance (AOD_{500})µm - The perpendicular distance between the trabecular meshwork and the anterior surface of the iris at500µm anterior to the scleral spur.

Angle recess area (ARA_{500}) in mm² - It is the triangular area bounded by the AOD_{500} (Angle opening distance), the anterior iris surface and the inner corneoscleral wall.

Trabecular Iris space area ($TISA_{500}$) in mm² - Trapezoidal area bounded by AOD_{500}, the anterior iris surface area, the inner corneoscleral wall and the perpendicular distance between the scleral spur and the opposing iris.

Methods: An observational cross-sectional study conducted in the Department ofOphthalmology, College of Medicine and Sagore Dutta Hospital, B.T.Road, Kolkata. 30 participants (60 eyes) – 10 Emmetropia, 10 Hypermetropia, 10 Myopia between 18 – 65 years of age (mean age 41.5) were enrolled for the study and the anterior segment parameters – Central corneal thickness (CCT), Lens vault (LV) anterior chamber angle (ACA), Angle opening distance (AOD_{500}),Angle recess area (ARA_{500}) and Trabecular iris space area ($TISA_{500}$) using a non-contact and non-invasive Spectral domain – OCT were evaluated. Statistical analysis was done using Anova to compare these six parameters.

Results: CCT right eye $p<0.75$ and left eye $p<0.95$. ACA (nasal $p<.000$; temporal $p <0.009$) for right eye and (nasal $p<0.00$; temporal $p<0.00$) for left eye. ARA_{500} (nasal $p<0.00$; temporal $p<0.06$)for right eyeARA_{500} (nasal $p<0.00$; temporal $p<0.3$) for left eye. AOD for right eye (nasal $p<0.00$; temporal $p<0.01$) and left eye (nasal $p<0.03$; temporal $p<0.00$). $TISA_{500}$ for right eye (nasal $p<0.14$; temporal $p<0.03$) and left eye (nasal $p<0.804$; temporal $p<0.354$). Lens vault $p<0.184$ right eye and $p<.396$ left eye.

Conclusions:On comparison of the three groups, significant difference was found inboth eyes, nasally and temporally in ACA, AOD_{500}, ARA_{500} and $TISA_{500}$(temporal -Right eye only). It was highest in Myopia followed by Emmetropia and Hypermetropia. No significant difference was seen in CCT, Lens vault in both eyes and $TISA_{500}$ in the left eye.

Keywords: Anterior segment, Spectral Domain OCT, Emmetropia, Hypermetropia and Myopia.

I. INTRODUCTION

Anterior segment optical coherence tomography (AS-OCT) imaging is a non-contact imaging technique that produces high resolution images and quantitative measurements of the anterior segment and its anatomical structures.[1] Anterior segment OCT (ASOCT) imaging was first described in 1994 by Izatt et al. using the same wavelength of light as retinal OCT, namely 830nm. This wavelength is suboptimal for imaging the angle due to limited penetration through scattering tissue such as the sclera. OCT imaging of the anterior segment with a longer wavelength of 1310nm was developed later on and had the advantages of better penetration through sclera as well as real-time imaging at 8 frames per second.[2]

This study uses a Spectralis OCT (Heidelberg Engineering), which has an external add-on-lens for anterior segment imaging (Anterior segment module). [3]Its optical source is a Super luminescent Diode(SLD) and the technology uses both cSLO(Confocal scanning laser

ophthalmoscope) and low -coherence Interferometry with different functions creating the images with a wavelength of 820 nm. In the present study, I have done Central corneal thickness (CCT), Anterior chamber angle (ACA), Angle opening distance (AOD_{500}), Angle recess area (ARA_{500}) and Trabecular iris space area $(TISA_{500})$ and lens vaultby using the Spectralis OCT(Anterior segment Module).

Anterior chamber angle (ACA) in degreeis the amount of contact/apposition between the iris and the cornea-scleral wall, anterior to the scleral spur. In AS-OCT, Iridotrabecular contact (ITC) is defined as any contact between the iris and the angle wall. Anterior chamber angle is considered closed on AS-OCT in the presence of ITC, while on Gonioscopy, a quadrant is considered closed only if the posterior pigmented TM is not visible in the primary position without indentation[4].

Angle recess area (ARA_{500}) in mm² is the triangular area bounded by the AOD_{500} (Angle opening distance), the anterior iris surface and the inner cornea-scleral wall.[2]

Trabecular Iris space area $(TISA_{500})$ in mm² is thetrapezoidal area bounded by AOD_{500}, the anterior iris surface area, the inner cornea-scleral wall and the perpendicular distance between the scleral spur and the opposing iris.[2]

Scleral spur is identified as a point where there is change of the inner surface of the angle wall often appearing as an inward protrusion of the sclera. Sometimes it appears as a lightly reflective region.[2]

Angle Opening Distance (AOD_{500}) is the perpendicular distance between a point 500μm anterior to the scleral spur and opposing iris.[2]

Lens vault is the perpendicular distance between the anterior pole of the crystalline lens and the horizontal line joining the two scleral spurs.[5]

Xie X et al. studied the relationship of age (23-74yrs) & refractive status (-8.25 D sph to +3.5D sph) on anterior segment using a SS-ASOCT. Eight anterior chamber angle biometric endpoints were analyzed: anterior chamber angle (ACA750), scleral spur angle (SSA750), angle-opening distance (AOD750), and trabecular-iris space area (TISA750) on the temporal and nasal sides. There were no statistically significant differences comparing both sides. Univariate analyses showed a negative linear relationship between all of these end-points with increased age and more hyperopic refractive status (p<0.001–0.03).[5]

II. MATERIALS AND METHODS:
Study type and design: An observational cross-sectional study using a non-invasive and non-contact Spectral Domain- OCT to examine and compare the anterior segment structures in Emmetropic, Hypermetropic and Myopic eyes. Each subject will sign a consent form before being enrolled in the study and prior to any measurements being taken.

Study setting: The study is conducted in the Department of Ophthalmology, College of Medicine and Sagore Dutta Hospital, Kolkata, West Bengal.

Study population: Study population includes age group from 18 – 65 years reporting to the department of Ophthalmology.

Inclusion Criteria:
All adults from 18 - 65 years of age willing to take part in the study with
Hypermetropia $\geq$ 0.5D Spherical with or without cylindrical component.
Myopia ≥0.5D Spherical with or without cylindrical component.
Emmetropia

Exclusion Criteria: (i) Unwilling volunteers
(ii) Age18 years and above till 65 years (mean age 41.5)
(iii) Central corneal opacities
(iv) Patients presenting with Red eye
(v) Posterior segment pathology

Sample size: 30 healthy volunteers (60 eyes) are taken in the study - 10 Emmetropes, 10 Myopes, 10Hypermetropes.

Study duration: The data collection was carried out over a period of 1 month. August 1 – September 1 2021

Tools and Techniques:
(i)   Visual acuity using a Snellen chart
(ii)   Anterior Segment Examination with Slit Lamp Bio-microscopy
(iii)   Ultrasound A Scan for measuring Axial length
(iv)   Spectral Domain – OCT for anterior segment imaging in Emmetropia, Hypermetropia and Myopia

Method of data collection: Data will be collected through history taking, recording of best corrected visual acuity, Anterior segment examination, Axial length measurement and OCT imaging in Emmetropia, Hypermetropia and Myopia.

Parameters examined: Central corneal thickness (CCT), Anterior chamber angle (ACA), Angle opening distance (AOD_{500}), Angle recess area (ARA_{500}) and Trabecular iris space area ($TISA_{500}$) and lens vault.

Plan for data management and analysis: Data was entered in MS excel spreadsheet and Anova was applied for analysis.

III.   RESULTS:

Table 1. Demographic, ophthalmologic characteristics of the study population	
No of participants	30
No of eyes	60
Age range , median	17-66, 41.5
Gender(Male/female)	9/21
Rage of refractive error (Diopter)	-4.0D sph to +4.0D sph

Table 2. Comparing Mean of the following six parameters in emmetropic, hypermetropic and myopic eyes								
Parameters	Mean ± Standard Deviation (Emmetropic)				Mean ± Standard Deviation (Hypermetropic)				Mean ± Standard Deviation (Myopic)			
	(RE)		(LE)		(RE)		(LE)		(RE)		(LE)	
CCT μm	519.4 ± 49.3		529.6 ± 36.9		530.9 ± 37.6		530.4 ± 30.2		533.8 ± 47.3		534.3 ± 45.7	
ACA °	30.4 ± 6.4 (T)	30 ± 6.5 (N)	30.6 ± 5.8 (T)	30.2 ± 5.9 (N)	24.2 ± 7.7 (T)	19.7 ± 5.4 (N)	20.3 ± 5.9 (T)	20.5 ± 5.3 (N)	33.3 ± 3.6 (T)	33.8 ± 4.4 (N)	30.50 ± 2.8 (T)	31.3 ± 3.5 (N)
ARA (mm²)	0.60 ± 0.5	0.80 ± 0.42	7.8 ± 22.5	0.7 ± 0.48	0.40 ± 0.5	0.2 ± 0.42	0.2 ± 0.42	0.2 ± 0.42	1.10 ± 0.316	1.0 ± 0.0	1 ± 0.0	1.10 ± 0.31
TISA (mm²)	0.3 ± 0.48	0.10 ± 0.31	0.2 ± 0.42	0.2 ± 0.42	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.1 ± 0.31	0.5 ± 0.527	0.3 ± 0.48	0.10 ± 0.316	0.20 ± 0.42
AOD (μm)	579.1 ± 148.4	572.8 ± 154.3	565.4 ± 137.2	587.1 ± 215.6	433.2 ± 141	342.1 ± 131.8	392 ± 122.9	398.2 ± 127	770.8 ± 240.4	676.2 ± 135.4	642.8 ± 119.2	728.6 ± 232.7
Lens Vault (μm)	224.9 ± 79.3		268.8 ± 173		334.3 ± 185.15		376.78 ± 193.3		287.3 ± 97		290.3 ± 168.7	

CCT: Central corneal thickness   ACA: Anterior chamber angle   AOD: Angle opening distance   ARA: Angle recess area   TISA: Trabecular Iris space area

Table 3. p-value of the following six anterior segment parameters				
Parameters	p-value (RE)		p-value (LE)	
CCT	.753		.958	
ACA	.009 (T)	.00 (N)	.00 (T)	.00(N)
ARA	.006 (T)	.00 (N)	.372(T)	.00(N)
TISA	.037 (T)	.142 (N)	.354 (T)	.804(N)
AOD	.001(T)	.00 (N)	.00 (T)	.003(N)
Lens Vault	.184		.396	

CCT right eye p<0.75 and left eye p<0.95. ACA (nasal p<.000; temporal p <0.009) for right eye and (nasal p<0.00; temporal p<0.00) for left eye. ARA $_{500}$ (nasal p<0.00; temporal p<0.06)for right eyeARA$_{500}$ (nasal p<0.00; temporal p<0.3) for left eye. AOD for right eye (nasal p<0.00; temporal p<0.01) and left eye (nasal p<0.03; temporal p<0.00). TISA$_{500}$ for right eye (nasal p<0.14; temporal p<0.03) and left eye (nasal p<0.804; temporal p<0.354). Lens vault p<0.184 right eye and p<.396 left eye.
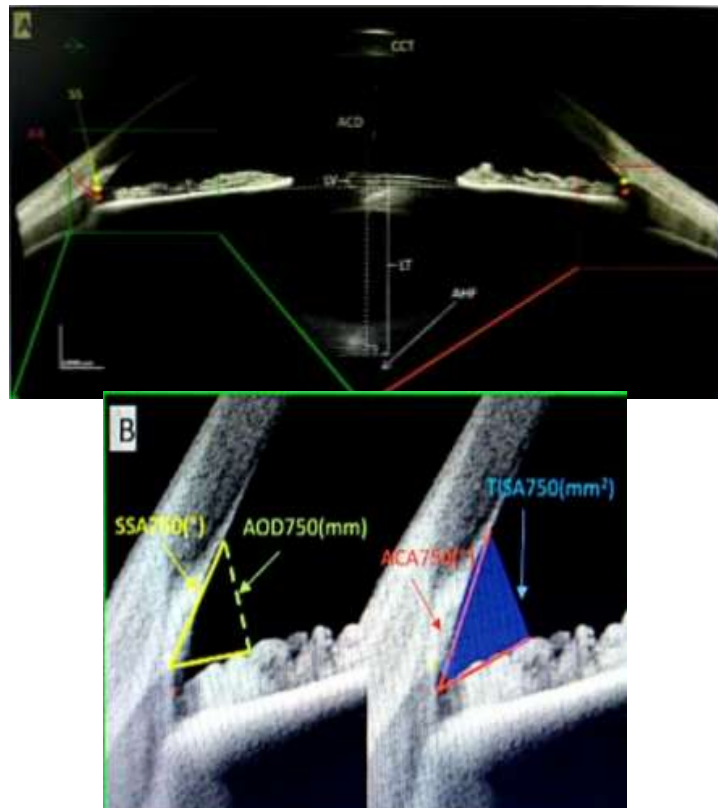

Fig 1. Anterior segment OCT endpoints.
(A) The overall anterior ocular biometry with SS, scleral spur; AR, angle recess; CCT, central cornea thickness (µm); LV, lens vault(µm).
(B) Anterior angle parameters. AOD$_{750}$(mm^2); ACA$_{750}$(°), TISA$_{750}$ (mm^2)Xie X et al.[5]
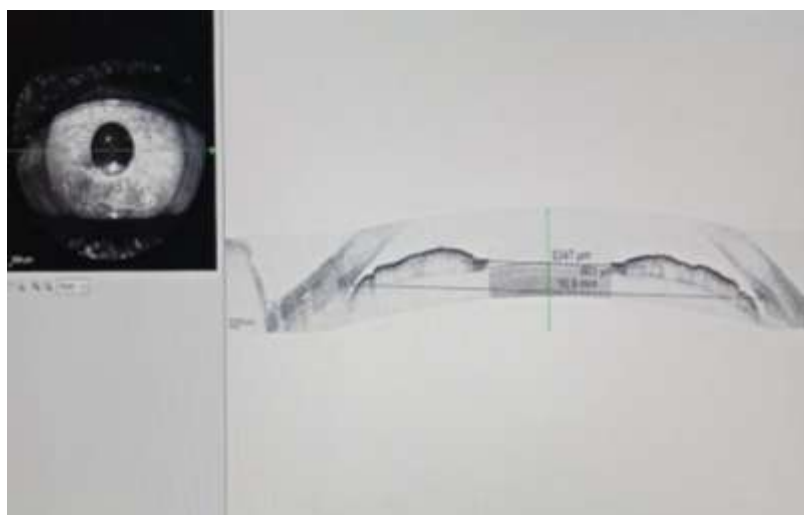

Fig 2. Assessment of lens vault

IV. DISCUSSION:

For every patient, all the six parameters - Central corneal thickness (CCT), Anterior chamber angle (ACA), Angle recess area (ARA_{500}), Trabecular Iris Space area ($TISA_{500}$), Angle opening distance (AOD_{500}) and Lens Vault are manually measured by a single observer.

The anterior chamber angle can be assessed both qualitatively and quantitatively. [2]Apposition between the iris and the inner cornea-scleral wall has been used in several studies as a qualitative method of detecting angle closure, however it must be noted that the degree of apposition may be variable and does not correlate exactly with appositional closure as defined by gonioscopy.[2]In AS-OCT, Iridotrabecular contact (ITC) is defined as any contact between the iris and the angle wall. [3]Anterior chamber angle is considered closed on AS-OCT in the presence of ITC, while on Gonioscopy, a quadrant is considered closed only if the posterior pigmented TM is not visible in the primary position without indentation.The anterior chamber angle can also be quantitatively by ARA_{500}, $TISA_{500}$ and AOD_{500}[2].Their measurements are possible only with AS-OCT.

Anterior chamber angle measurement requires the identification of the scleral spur. One arm of the triangle is at the inner corneoscleral wall while the other arm is kept at the second hump of the iris. Once the degree of angle is adjusted, [2]the perpendicular distance between a point 500μm anterior to the scleral spur and opposing iris is the AOD_{500}. ARA_{500} and $TISA_{500}$ are also measured with the scleral spur as the identification point. [2]The triangular area bounded by the AOD_{500} (Angle opening distance), the anterior iris surface and the inner cornea-scleral wall is ARA_{500} while $TISA_{500}$is the trapezoidal area bounded by AOD_{500}, the anterior iris surface area, the inner cornea-scleral wall and the perpendicular distance between the scleral spur and the opposing iris.

CCT is usually measured by Ultrasound Pachymetry (after instillation of a topical anesthetic). Gold standard for anterior chamber angle measurement is currently Gonioscopy (requires topical anesthetic agent and the procedure is uncomfortable for the patient). Measurement of ACA °, ARA_{500}, $TISA_{500}$ and AOD_{500}[2] and Lens Vault are possible only with AS-OCT.AS-OCT also offered the advantage of being non-contact and non-invasive, no requirement of topical anesthesia, examined in an upright position and requires a very short duration (4-5 minutes per person) which led to better voluntary participation of the subjects. And all the six parameters can be examined in a single sitting[6]. Therefore SD-OCT(AS- module) was used to examine these anterior segment parameters.

The cornea was first imaged and central corneal thickness was measured. Then the focus was shifted posteriorly and the anterior chamber angles (nasally and temporally) were taken simultaneously. For proper assessment of angle biometry, the identification of scleral spur is extremely important and the entire angle measurement depends on it[6].High quality Anterior segment images were obtained using a Spectral Domain OCT- AS module by simply changing the external add-on lens.

Limitation of small sample size and there is chance of observer making mistakes manually in identifying the scleral spur and angle recess. In addition, anterior chamber findings were not compared with Gonioscopy . However, there are studies in literature that have compared AS-OCT with Gonioscopy and found a fair good agreement classifying more angles as narrow than gonioscopy[6].

V. CONCLUSION:

After comparing the three groups, significant difference was found in ACA, AOD_{500}, ARA_{500}. It was highest in Myopia followed by Emmetropia and Hypermetropia. No significant difference was seen in CCT and lens vault.

On comparing with $TISA_{500}$, only $TISA_{500}$ (Right eye-temporal) showed significant difference , no significant difference was found in $TISA_{500}$ left eye and right eye –nasal

We can plan routine studies of all the anterior segment parameters of the patients with hypermetropia to detect the PACD/suspects.

REFERENCES:

[1]. Shan J, DeBeor C, Xu B Y. Anterior Segment Optical Coherence Tomography: Applications for Clinical Care and Scientific Research. Asia Pac J of Ophthalmol (Phila).2019 Feb24; 10.22608/ APO.201910.

[2]. Eye wiki.aao.org. Anterior segment optical coherence tomography.2021 May 5.

[3]. Ang M, Baskaran M, Werkmeister RM Chua J, Schmidl D, Dos Santos VA et al. Anterior segment optical coherence tomography. Progress in retinal and eye research 2018 Sep1; 66: 132-156.

[4]. Angmo D, Nongpiur ME, Sharma R, Sidhu T, Sihota R, Dada T. Clinical utility of anterior segment swept-source optical

coherence tomography in glaucoma. Oman journal of ophthalmology.2016; 9(1) 3-10.

[5]. Xie X, Corradetti G, Song A, Pardeshi A, Sultan W, Lee JY, et al. Age- and refraction-related changes in anterior segment anatomical structures measured by swept-source anterior segment OCT.PLos One. 2020; 15(10): e0240110.

[6]. Angmo D, Singh R, Chaurasia S, Yasdav S, Dada T. Evaluation of anterior segment parameters with two anterior segment optical coherence tomography systems: Visantae and Casia, in primary angle closure disease.Indian Journal Ophthalmol.2019; 67(4):500-504.