Cross-sectional, Observational Study of Anterior Segment Parameters Using Anterior Segment Optical Coherence Tomography in North Indian Population

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Abstract

Purpose: To study the anterior segment (AS) parameters using AS optical coherence tomography (AS-OCT) in the North Indian population.

Methods: A hospital-based, observational, cross-sectional study was conducted over a period of 1 year. It included 251 normal individuals aged 20–70 years. Participants underwent imaging with AS-OCT. Ocular parameters included anterior chamber angle (ACA), iris cross-sectional area (ICSA), iris thickness (IT), and iris curvature (IC). The parameters were measured nasally and temporally for both sexes and different age groups.

Results: The mean age of participants was 48.3 ± 13.9 years and 50.6% were men. The ACA decreased with age whereas ICSA, IT, and IC increased with age. The ACA (P = 0.0001 nasally and temporally), ICSA (P = 0.011 nasally, P = 0.027 temporally), IT750 (P = 0.001 nasally, P = 0.011 temporally), IT1500 (P = 0.002 nasally, P = 0.002 temporally), and IC (P = 0.059 nasally, P = 0.128 temporally) underwent statistically significant changes with increasing age. No significant difference was seen in parameters of different sex.

Conclusion: In this subset of the Indian population, the change in the AC parameters with age influences the AC dimensions predisposing the eye to glaucomatous conditions. These data are applicable clinically for the assessment and surgical management of patients requiring AS surgery.

Keywords: Anterior chamber angle, anterior segment optical coherence tomography, iris cross-sectional area, iris thickness, iris curvature

Résumé

Objectif: Étudier les paramètres du segment antérieur (AS) en utilisant la tomodensitométrie optique AS (AS-OCT) dans la population du nord de l’Inde. Méthodes: Une étude axée sur l’hôpital, observationnelle et transversale a été menée sur une période de 1 an. Il comprenait 251 individus normaux âgés de 20 à 70 ans. Les participants ont subi une imagerie avec AS-OCT. Les paramètres oculaires comprenaient l’angle de la chambre antérieure (ACA), la surface transversale de l’iris (ICSA), l’épaisseur de l’iris (IT) et la courbure de l’iris (IC). Les paramètres ont été mesurés par voie nasale et temporelle pour les deux sexes et différents groupes d’âge. Résultats: l’âge moyen des participants était de 48,3 ± 13,9 ans et 50,6% des hommes. L’ACA a diminué avec l’âge alors que ICSA, IT et IC ont augmenté avec l’âge. L’ACA (P = 0,0001 par voie nasale et temporelle), ICSA (P = 0,011 nasale, P = 0,027 temporellement), IT750 (P = 0,001 par voie nasale, P = 0,011 temporellement), IT1500 (P = 0,002 par voie nasale, P = 0,002 temporellement) Et IC (P = 0,059 nasal, P = 0,128 temporellement) ont subi des changements statistiquement significatifs avec l’âge. Aucune différence significative n’a été observée dans les paramètres du sexe différent. Conclusion: Dans ce sous-ensemble de la population indienne, la variation des paramètres CA avec l’âge influence les dimensions AC prédisposant l’oeil aux conditions glaucomateuses. Ces données sont applicables cliniquement pour l’évaluation et la gestion chirurgicale des patients nécessitant une chirurgie AS.

Mots-clés: Angle de la chambre antérieure, tomographie de cohérence optique du segment antérieur, section transversale de l’iris, épaisseur de l’iris, courbure de l’iris

Access this article online

Quick Response Code:  
Website: www.annalsafrmed.org  
DOI: 10.4103/aam.aam_40_16

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How to cite this article: Dalal LK, Dhasmana R, Maitreya A. Cross-sectional, observational study of anterior segment parameters using anterior segment optical coherence tomography in North Indian Population. Ann Afr Med 2017;16:131-5.
INTRODUCTION

Asia is the world’s largest and most populous continent hosting more than half of the world’s population. Ocular biometric parameters are known to vary considerably across racial groups and populations.[1] The development of the anterior segment optical coherence tomography (AS-OCT) has allowed a fast, noncontact method of imaging the cornea and anterior chamber (AC) for objective quantification and evaluation.[2-4] With a single AS image, the cornea, both angles on one meridian including scleral spur, anterior portion of the lens, and iris surface are imaged.[2] It has been shown to be highly reproducible even with repeated imaging and has excellent interobserver and intraobserver reliability.[5]

Since its introduction to ophthalmic use in 1995, AS-OCT has provided rapid, objective, and quantitative imaging of the cornea, AS, and angle configuration.[2,6] OCT technology was initially used to produce images of retina, using a wavelength of 820 nm.[7-9] Later, 1310 nm wavelength was used to allow better penetration through structures such as the sclera and limbus and to improve visualization of the AS.[10]

It has been shown that compared with normal eyes, eyes with occludable angles and with primary angle closure glaucoma have smaller AC depth (ACD), thicker lenses, and shorter axial length. However, many of these studies have used A-scan ultrasound biometry or ultrasound biomicroscopy (UBM). UBM and A-scan biometry are both contact techniques. UBM further requires use of a water bath with the patient supine position.

There is little literature investigating the distribution of angle parameters in the Indian population, using AS-OCT. A very limited study has been conducted in different regions of India offering a complete biometric description of the anterior ocular segment. The present study was designed to determine the AS parameters such as AC angle (ACA), iris cross-sectional area (ICSA), iris thickness (IT), and iris curvature (IC) using AS-OCT in the North Indian population.

METHODS

The current study was a hospital-based, observational, cross-sectional study of adults aged 20–70 years, conducted over a period of 1 year (October 2013 to September 2014). The current study protocol was approved by the Ethics Committee of the Institute. All the participants attending outpatient department (OPD) of ophthalmology at a tertiary care hospital in North India for routine ophthalmic checkup having normal AS findings were included in the study. More than 95% participants attending hospital were of North India origin. A hospital-based cross-sectional study has its own limitations. Informed and written consent was taken from each patient before including them in the study. An age-stratified random sampling strategy was used to select participants from normal individuals attending eye OPD in the tertiary care hospital. The study included 502 eyes of 251 normal individuals of different age groups. A detail ocular history was taken and slit lamp examination was done. Individuals with history of ocular trauma, prior intraocular or refractive surgery, any intraocular inflammation, opaque media preventing AS-OCT, any ocular disease, inability to fixate for an OCT examination, and uncooperative individuals were excluded from the study. Furthermore, participants with abnormal AS slit lamp findings and known history of glaucoma, diabetes, and hypertension were excluded from the study. Participants with refractory error more than 3 spherical diopters and astigmatism more than 2 diopters were also excluded. The participants were divided into three groups according to their age and the number of participants in each group was taken in such a manner that the number of male and female in each group remains comparable. This was done to improve the comparability between the various parameters measured in the study. The three age groups were Group A (20–39 years), Group B (40–59 years), and Group C (≥60 years).

All patients underwent detail ophthalmological examination and observations were recorded in the preset pro forma. The ocular examination included best-corrected visual acuity, AS evaluation using slit-lamp biomicroscopy, intraocular pressure, corneal curvature, lens thickness, axial length, and AS assessment using a Fourier domain Optovue OCT. Keratometric power was obtained using a manual keratometer (Bausch and Lomb, Rochester, NY, USA). Lens thickness and ACD were measured using an ultrasonic A-Scan (Alcon Laboratories).

Anterior segment optical coherence tomography imaging

Optovue (RTVue) three-dimensional Fourier domain OCT was used for the measurement of AS parameters in all participants. All participants were imaged in terms of the nasal and temporal angle (0°–180°) using OCT operating in the enhanced AS single mode. This spectral OCT has a depth resolution of 5 μm and a transverse resolution of 15 μm. The OCT scan has a range of 2–2.3 mm in depth and 2–12 mm in transverse direction. The wavelength used in this OCT is 840 nm, and the exposure power at the pupil is 750 μW. The cornea-anterior module is additional software on the device, which helps in AS imaging. All scans were performed by a single experienced observer who was masked to the clinical data and was not the part of the study. Poor-quality images with artifacts were repeated. Several AS-OCT images were obtained for each participant and images deemed to have best quality with fewest image artifacts were selected for analysis.

The AS parameters were studied according to the Zhongshan Angle Assessment Program (ZAP, Guangzhou, China) described elsewhere.[11-13] The program extracts the gray-scale images from the AS-OCT images, and the measurements are made from the scleral spur as point of reference. Scans were performed in undilated pupil of both eyes of the participants [Figures 1 and 2].

The scleral spur was identified as the inward protrusion of sclera where a change in curvature of the inner surface of the angle wall became apparent. After determination of scleral spur...
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Statistical analysis
The data obtained from the participants were entered and analyzed using the Microsoft Office Excel (2010) and SPSS version 19.0 (Microsoft, Chicago, Illinois, USA). These results have been presented in the form of mean and standard deviation using descriptive statistical methods. The statistical relationship between the variables was established by one-way ANOVA and Pearson’s correlation of coefficient, used for comparison between various groups. A \( P < 0.05 \) was considered statistically significant.

RESULTS
In the present study, 251 patients (502 eyes) were enrolled out of which 127 (50.6%) were males and 124 (49.4%) were females. The mean age of the patients was 48.3 ± 13.9 years.

The study groups were divided on the basis of their age. Out of total patients, 81 (32.3%) patients (162 eyes) belonged to Group A (20–39 years), 87 (34.7%) patients (174 eyes) to Group B (40–59 years), and 83 (33%) patients (166 eyes) to Group C (≥60 years). Table 1 shows the AS parameters in different age groups while Table 2 shows the AS parameters according to sex.

It is noted that the ACA decreases with increasing age \( (P = 0.0001, \ r = -0.419 \text{ nasally and } r = -0.417 \text{ temporally}) \) while the ICSA increased with age both nasally \( (P = 0.011, \ r = 0.267) \) and temporally \( (P = 0.027, \ r = 0.242) \). IT750 and IT1500 also increased with increasing age both nasally and temporally. IC increased with age, but the increase was not statistically significant [Table 1].

DISCUSSION
Eyes with certain anatomical structure are at increased risk of developing primary angle closure glaucoma. The prevalence of primary angle closure glaucoma increases with age. The ACA changes over time from a translucent membrane at birth, which gradually widens over the 1st year of life. With time, the ACA shows changes namely narrowing of angle with an increase in the S-type of iris configuration. There are also a decrease in the number of iris processes and an increase in pigmentation of the trabecular meshwork.\(^\text{[14]}\) These probable changes may contribute to decrease in the ACA with age. Factors that have

| Table 1: Anterior segment parameters in different age groups (mean±standard deviation) |
|---------------------------------|-----------------|-----------------|-----------------|-----|-----|
| Anterior segment parameters     | Group A \( (n=162) \) | Group B \( (n=174) \) | Group C \( (n=166) \) | \( P \) | \( R \) |
| ACA \( (^\circ) \)             |                  |                  |                  |     |     |
| Nasal                           | 42.26±8.430      | 38.54±7.251      | 34.73±7.099      | 0.0001 | -0.419 |
| Temporal                        | 42.31±8.831      | 39.51±7.111      | 33.45±6.307      | 0.0001 | -0.417 |
| ICSA \( (\text{mm}^2) \)        |                  |                  |                  |     |     |
| Nasal                           | 1.71±0.393       | 1.84±0.276       | 1.99±0.403       | 0.011 | 0.267 |
| Temporal                        | 1.74±0.416       | 1.83±0.335       | 1.98±0.351       | 0.027 | 0.242 |
| IT \( (\mu m) \)                |                  |                  |                  |     |     |
| 750 nasal                       | 388.70±102.01    | 446.57±75.78     | 486.19±93.09     | 0.001 | 0.519 |
| 750 temporal                    | 407.53±71.04     | 433.00±74.52     | 487.44±83.63     | 0.011 | 0.411 |
| 1500 nasal                      | 412.51±98.35     | 457.57±67.78     | 468.19±89.15     | 0.002 | 0.402 |
| 1500 temporal                   | 411.33±70.10     | 459.13±83.73     | 472.38±77.42     | 0.002 | 0.343 |
| IC \( (\mu m) \)                |                  |                  |                  |     |     |
| Nasal                           | 103.67±16.81     | 109.99±25.29     | 112.88±31.16     | 0.059 | 0.212 |
| Temporal                        | 105.1±15.10      | 107.2±16.98      | 110.06±15.83     | 0.128 | 0.199 |

ACA=Anterior chamber angle, ICSA=Iris cross-sectional area, IT=Iris thickness, IC=Iris curvature
been recognized as affecting the angle width include age, race, iris color, eye dominance, corneal curvature, refraction, and illumination. These factors can predispose to iridotrabecular contact, a common feature to the various mechanisms of angle closure. Therefore, decrease in the ACA with age may attribute to the risk of development of primary angle closure glaucoma in elderly patients. In the present study, the decrease of ACA with increasing age is statistically significant in both nasal and temporal quadrants. Similar results were reported by the study conducted by Cheon et al.

In the current study, the nasal and temporal ICSA was studied. The increase of nasal and temporal ICSA with age was statistically significant. Similar to the current study, Sun et al. observed that ICSA significantly increased with age. This increase in ICSA with age may be one of the many contributing factors for reduction of AC dimensions. Changes in iris and its ICSA may explain the increasing risk of primary angle closure glaucoma with age.

Sun et al. had demonstrated a significantly increment for both IT at 750 µm and 1500 µm from sclera spur with $P < 0.05$. Study on rhesus monkey shows that the fibrillar material within the trabeculum ciliare (which connects the uveal portion of trabecular meshwork with the iris root) and the intermuscular spaces at the ciliary muscle tips increases with aging. The elastic fibers in tuberculum ciliare also gain a homogeneous appearing electron-light sheath that increases with age linearly. It has been postulated that similar changes occur in the human eye and these changes in the IT with age influence the AC dimensions predisposing the eye to glaucomatous conditions.

In the present study, the increase in IC was noted with increasing age. This was however not statistically significant with age ($P > 0.05$). This result is consistent to the study conducted by Sun et al., which had demonstrated an increase in the IC with increasing age. Iris and lens are closely associated structures, and the changes in iris and its parameters may be correlated to lens position. For example, the forward movement of the lens may increase area of iridolenticular contact. At the same time, this movement can cause lens vault and IC to increase simultaneously. However, according to a multivariate analysis studied by Sun et al., lens vault and IC are associated independently with ACA narrowing. Thus, change in IC with age may be an independent risk factor related to ACA narrowing.

In the present study, there is no statistically significant difference in AC parameters between males and females. Previous studies have shown that women are more likely to have angle closure. The Liwan Eye Study, a population-based study in China, found that women had narrower iridotrabecular angles as measured by a gonioscopy.

Limitations of this study should be discussed. The cross-sectional design limits causal inferences. In this study, the superior and inferior angle quadrants were not accounted for due to poor images due to lids. This may result in an unrepresentative assessment of AC parameters, and the results of this study may thus not applicable to vertical quadrants. Furthermore, this study involved a relatively small sample size, consisting of 251 patients. In addition, lens parameter could not be studied due to limitation of the Fourier domain OCT machine. These issues should be evaluated in further studies with a larger sample size.

**Conclusion**

Our study served to provide the baseline normative data of AS parameters in an adult North Indian population. We believe that these data will be applicable clinically for assessment of patients AS parameters. The changes in the AC parameters, particularly iris with age, influence the AC dimensions predisposing the eye to glaucomatous conditions. Further studies with comparisons to other ethnic populations would be useful.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

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