Ultrasound Biomicroscopy Study of Anterior Segment Measurements in Normal Eyes in a Tertiary Care Rural Hospital of SPRR Nellore District

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Abstract

Because many of the structures imaged by ultrasound biomicroscopy cannot be clearly observed by any other method, it is helpful to define a system of measurement to be used in future assessment of normal and abnormal patients. The normal eye has much variability in the position and configuration of internal structures. We attempted to define these measurement positions in a way that would allow reproducibility in the future. By this study we can in detail know the anatomy of various anterior segment structures like cornea, ciliary body and iris etc and can measure Corneal thickness, Iris thickness (Iris thickness on TCPD, 2mm away from root of iris, and maximum iris thickness at the pupillary margin), Anterior Chamber Depth, Angle and other parameters like Angle Opening Distance (AOD), Trabecular Ciliary Process Distance, Iris Ciliary Process Distance. By measuring all these 9 parameters in normal subjects, in 100 subjects, the normative data is derived for the Indian eyes in the age group of 18 to 28 years by the technique of Ultrasound Biomicroscopy for the temporal anterior segment. i.e. at 9° clock position for right eye and 3° clock position for the left eye (temporal meridian). The measurements are calculated by calipers, which is in built in the system software. Visual acuity, slit lamp examination and fundus examination with direct ophthalmoscope were done in all subjects. Ultrasound biomicroscopy examination was conducted for both eyes under topical anaesthesia. The average value of Angle Opening Distance for the Right eye is 368.64+/-

32.824 microns and for the Left eye is 375.30+/- 28.672 microns. The average value of Trabecular Ciliary Process Distance for the Right eye is 1114.00+/-98.144 microns and for the Left eye is 1100.50+/-101.169 microns. The average value of Iris Thickness 1 (ID1) for the Right eye is 416.16+/-54.281 microns and for the Left eye is 408.02+/- 54.049 microns. The average value of Iris Ciliary Process Distance for the Right eye is 306.51+/- 58.409 microns and for the Left eye is 305.60+/- 51.115 microns. The average value of Trabecular Iris Angle for the Right eye is 38.02+/ - 3.20 and for the Left eye is 37.71+/- 4.00. The average value of Iris Thickness 2 (ID2) for the Right eye is 480.00+/-48.596 microns and for the Left eye is 478.80+/- 56.466 microns. The average value of Iris Thickness 3 (ID3) for the Right eye is 518.80+/-42.221 microns and for the Left eye is 578.70+/- 36.753 microns. The average value of Central Corneal Thickness for the Right eye is 529.80 +/- 25.819 microns and for the Left eye is 530.90 +/- 20.005 microns. The average value of AC Depth for the Right eye is 3031.60 +/- 280.806 microns and for the Left eye is 3036.40 +/-229.635 microns.

Objective: *To compare the normal measurements of anterior segment of the study with other studies and to derive normal values of anterior segment measurements for the defined age group.*

INTRODUCTION

Ultrasound Biomicroscopy (UBM) is a new method of producing high resolution images of the anterior segment with high frequency ultrasound. In other words, it is imaging the eye at microscopic resolution. This instrument is useful to scan the anterior segment of the eye. Ultrasound biomicroscopy (UBM) is a recent technique to visualize anterior segment with the help of high frequency ultrasound transducer. This method allows detailed observation of anterior and posterior chamber anatomy in the living eye and is thus a useful tool in both clinical assessment of anterior segment anomalies especially glaucoma.

High-frequency ultrasound biomicroscopy (UBM) provides high-resolution in vivo imaging of the anterior segment in a non invasive fashion. In addition to the tissues easily seen using conventional methods (ie, slit lamp biomicroscopy), which are used to see the cornea, iris, and sclera, and structures such as the ciliary body and zonules, which are previously hidden from clinical observation, can be imaged and their morphology assessed.

UBM has contributed to elucidation of the mechanisms of the diseases, particularly for plateau iris syndrome, pigment dispersion syndrome,[14] pupillary block glaucoma,[15] and malignant glaucoma clinically. UBM can accurately distinguish many of the various forms of glaucoma and is useful in guiding treatment of difficult cases. [15]

UBM can be helpful in patients with opaque corneas prior to transplantation.[18] Anterior segment details such as the depth of the anterior chamber, state of the angle, presence of anterior

synechiae, and intraocular lens positioning can be determined pre-operatively. Intracorneal abnormalities can also be imaged. Corneal oedema can be assessed and measured.[21]

UBM can easily assess the position of intraocular lens haptics. This is very useful in assessing malpositioned lenses, assessing the source of intraocular bleeding and determining haptic freedom if removal or repositioning is required.[22]

MATERIALS & METHODS

Study design: This observational study was carried out in Narayana General Hospital, Nellore, Andhra Pradesh. A Total of 100 normal subjects aged between 18 and 28 were taken in to the study. Study period from November 2012 to September 2014.

Study Methods and Instruments: Detailed clinical examination including visual acuity (snellens chart), slit-lamp biomicroscopy (for anterior chamber depth measured by Van Herick's method and anterior segment assessment) pupillary activity noted for all patients. EOM movements were noted to all the patients clinically. Detailed examination of fundus is carried out by direct ophthalmoscopy with Beta Heine200S Ophthalmoscope. UBM examination was performed with the commercial model of the instrument MORVEL UBM SCAN (Optiplex[TM] 780 Series) device, the probe is small and light enough not to require a suspension arm and a sector scanning method is used with the help of 50 MHz transducer.

INCLUSION CRITERIA: AGE: 18 to 28 years; Visual acuity: 6/6, Normal anterior segment; evaluated by slit lamp, and subjects with; PACD (>1/3 to ½ PCT) are included in the study; Pupils should be active with normal fundus; Normal posterior segment

EXCLUSUION CRITERIA: AGE < 18 & >28 Years; PACD < I/2 CT; Any ocular pathology; Myopes and Hypermetropes; One eyed patients.

PROCEDURE

UBM was performed in undilated state and under standard lighting conditions, with the patient in supine position. After instillation of 4% lignocaine eye drops in the eye, a plastic eye cup is used to gently separate the eye lids. Distilled water or methylcellulose 2.5% solution is used as immersion medium of the transducer. The transducer carefully introduced in to the cup containing distilled water and care is taken to avoid touching cornea. The subjects were asked to fixate on a ceiling target using the contra lateral eye. The probe is kept perpendicular to the structure scanned. The measurements were made in the temporal meridian, through a typical ciliary process, and as vertically as possible at 500microns anterior to sclera spur, as determined by observing the screen image. Multiple images are obtained per eye at temporal meridian and images are scanned from the centre of the cornea for corneal thickness and A/C depth. The images were exported from the UBM machine and transferred to a computer for further analysis.

After the procedure for both eyes the cup is washed with soap and water.

A drop of antibiotic solution is given to the subject eyes.

We used a technique to quantify angle measurements on the basis of ultrasound biomicroscopy. This consisted of taking a point 500microns from the scleral spur (which would consistently fall on the anterior trabecular meshwork) and extending a line from this point, perpendicular to the plane of the trabecular meshwork, to the opposing iris. The length of this line would then be measured which gives angle opening distance.

We measured the angle formed with the apex at the iris recess, and the arms passing through the point on the meshwork 500 microns from the scleral spur and the point on the iris perpendicularly opposite, and termed this the trabecular-iris angle. We ran a line from the point on the trabecular meshwork 500 microns from the scleral spur, and extended it perpendicularly through the iris to the ciliary process. We termed this distance the trabecular ciliary process distance. The iris epithelium forms a constant highly reflective layer on the posterior iris surface. Iris thickness along this line was designated iris thickness I (ID 1).Measurement of the iris was also performed at a point 2 mm from the iris root and was termed iris thickness 2 (ID 2) and its thickest point near the pupil and was termed iris thickness 3 (ID 3). The central corneal thickness is measured from epithelium to endothelium.

Measured from the posterior surface of the cornea (endothelial surface) to the anterior capsule of the lens. The measurements were done using the calipers provided in the instrument.

Statistic analysis:

Values expressed in mean and standard deviation and analysis done by Student's unpaired T test.

Results

Out of 100 subjects 57 are male and 43 are female

AOD (The angle opening distance) ranges from 300 microns to 440 microns for the right eye and 200 microns to 500 microns for the left eye and the average value for the Right eye is 368.64+/-32.824 microns and for the Left eye is 375.30+/-28.672 microns. **TCPD** (Trabecular Ciliary Process Distance) ranges from 890 microns to 1270 microns for the Right eye and 800 microns to 1300 microns for the Left eye and the average value for the Right eye is 1114.00+/-98.144 microns and for the Left eye is 1100.50+/-101.169 microns. **ID1** (Iris thickness on TCPD) ranges from 270 microns to 490 microns for the Right eye and 300 microns to 490 microns for the Left eye and the average value for the Right eye is 416.16+/-54.281 microns and for the Left eye is 408.02+/- 54.049 microns. **ICPD** (Iris Ciliary Process Distance) ranges from 240 microns to 480 microns for the Right eye and 220 microns to 500 microns for the Left eye and the average value for the Right eye is 306.51+/- 58.409 microns and for the Left eye is 305.60+/- 51.115 microns. **TIA** (Trabecular Iris Angle) ranges from 28.2 degrees to 44.1 degrees for the right eye and

25.7 degrees to 42.1 degrees for the Left eye and the average value for the Right eye is 38.02+ - 3.20 and for the Left eye is 37.71+/- 4.00.(Figure 1)

ID2: Iris thickness at 2mm from root of Iris ranges from 370 microns to 580 microns for the Right eye and 330 microns to 600 microns for the Left eye and the average value for the Right eye is 480.00+/- 48.596 microns and for the Left eye is 478.80+/- 56.466 microns.

ID3: The Maximum Iris thickness at near the papillary margin ranges from 490 microns to 670 microns for the Right eye and 400 microns to 700 microns for the Left eye and the average value for

the Right eye is 581.80 +/- 42.221 microns and for the Left eye is 578.70 +/- 36.753 microns.

CCT (Central Corneal Thickness) ranges from 490 microns to 600 microns for the Right eye and 490 microns to 600 microns for the Left eye and the average value for the Right eye is 529.80 +/- 25.819 microns and for the Left eye is 530.90 +/- 20.005 microns.

AC DEPTH (Anterior Chamber depth) ranges from 2540 microns to 3650 microns for the Right eye and 2500 microns to 3550 microns for the Left eye and the average value for the Right eye is 3031.60 +/- 280.806 microns and for the Left eye is 3036.40 +/-229.635 microns.

Figure 1: Comparison of average values for Right and Left eyes
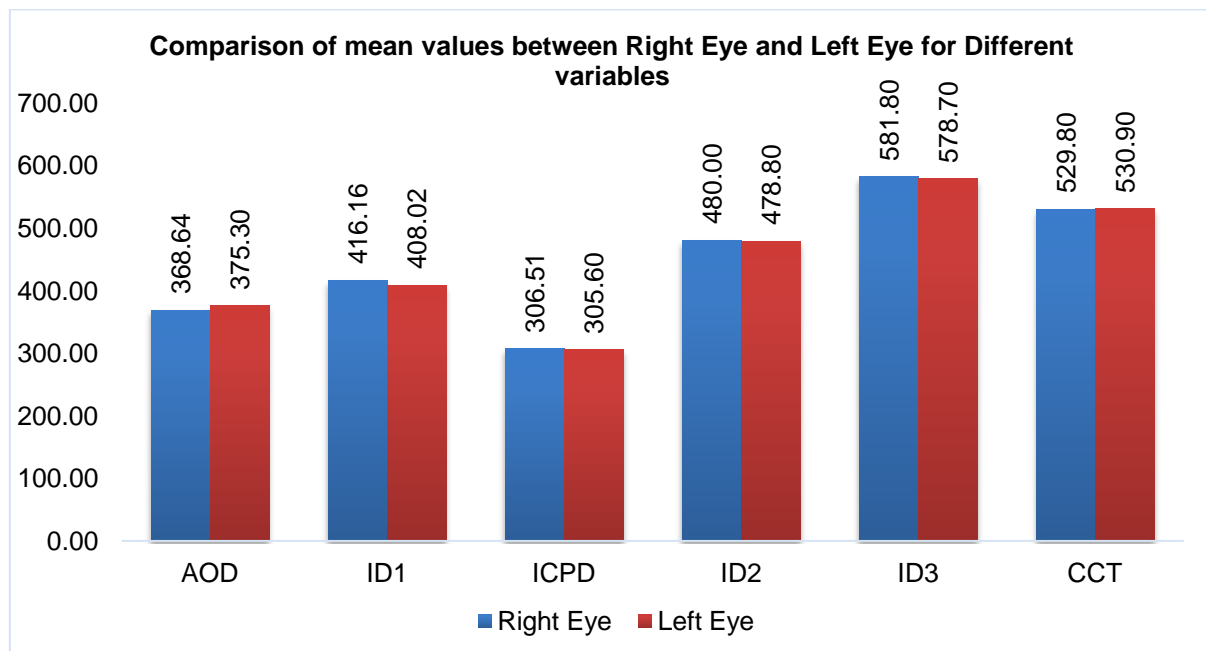
Measurements in Male sample population:

The average value of Angle Opening Distance in males for the Right Eye is 361.75 ± 31.911 and for Left Eye is 367.19 ± 28.505 microns. The average value of Trabecular Ciliary Process Distance in males for the Right Eye is 1106.84 ± 97.416 and for Left Eye is 1092.46± 105.632 microns.

The average value of Iris Thickness at Root of iris in males for the Right Eye is 422.11 ± 47.349 and for Left Eye is 410.18± 51.634 microns (**ID1).** The average value of Iris Ciliary Process Distance in males for the Right Eye is 302.79± 61.655 and for Left Eye is 297.02± 47.733 microns.The average value of Trabecular Iris Angle in males

for the Right Eye is 37.587719 ± 3.3402347 and for Left Eye is 37.356140 ± 4.1621602 degrees. The average value of Iris Thickness at 2 mm from root of iris in males for the Right Eye is 468.42 ±49.345 and for Left Eye is 479.82±52.491microns(ID2). The average value of Maximum Iris Thickness at pupillary margin in males for the Right Eye is 576.67 ± 41.072and for Left Eye is 579.47 ± 33.081 microns(ID3).The average value of Central Corneal Thickness for the Right eye is 531.05 ± 22.094 microns and for the Left eye is 530.00 ± 18.028 microns.(Table 1)

The average value of Anterior Chamber depth for the Right eye is 3039.82 ± 263.950 microns and for the Left eye is 3040.18 ± 209.101 microns.

Table 1: The measurements in Male sample population

STRUCTURE MEASURED	RIGHT EYE	LEFT EYE
AOD	361.75 ± 31.911	367.19 ± 28.505
TCPD	1106.84 ± 97.416	1092.46± 105.632
ID 1	422.11 ± 47.349	410.18± 51.634
ICPD	302.79± 61.655	297.02± 47.733
TIA	37.587719 ± 3.3402347	37.356140 ± 4.1621602
ID 2	468.42 ±49.345	479.82±52.491
ID 3	576.67 ± 41.072	579.47 ± 33.081
CCT	531.05 ± 22.094	530.00 ± 18.028
A C DEPTH	3039.82 ± 263.950	3040.18 ± 209.101

TRABECULAR IRIS ANGLE IN DEGREES; ALL OTHER VALUES IN MICRONS

The measurements in female sample population:

The average value of Angle Opening Distance in Females for the Right Eye is 377.77±32.128 and for Left Eye is 386.05 ± 25.435 microns. The

average value of Trabecular Ciliary Process Distance in Females for the Right Eye is 1123.49 ±99.448 and for Left Eye is 1111.16± 95.099 microns. The average value of Iris Thickness on trabecular ciliary process distance in Females for

the Right Eye is 408.28± 62.004 and for Left Eye is 405.16 ±57.590 microns (ID1). The average value of Iris Ciliary Process Distance in Females for the Right Eye is 311.44±54.124 and for Left Eye is 316.98± 53.743 microns. The average value of Trabecular Iris Angle in Females for the Right Eye is 38.586047±2.9578452 degrees and for Left Eye is 38.167442±3.7810128 degrees. The average value of Iris Thickness 2 mm from root of Iris in Females for the Right Eye is 495.35±43.553 and for Left Eye is 477.44±61.956 microns(ID2). The average value of Maximum Iris Thickness near the papillary margin in Females for the Right Eye is 588.60±43.237 and for Left Eye is 577.67±41.509 microns (ID3). The average value of Central Corneal Thickness Iris in Females for the Right Eye is 528.14±30.257 and for Left Eye is 532.09±22.526 microns. The average value of Anterior Chamber Depth in Females for the Right Eye is 3020.70±304.564 and for Left Eye is 3031.40±256.817microns.(Table 2)

Table 2: The measurements in female sample population

STRUCTURE MEASURED	RIGHT EYE	LEFT EYE
AOD	377.77±32.128	386.05 ± 25.435
TCPD	1123.49 ±99.448	1111.16± 95.099
ID 1	408.28± 62.004	405.16 ±57.590
ICPD	311.44±54.124	316.98± 53.743
TIA	38.586047±2.9578452	38.167442±3.7810128
ID 2	495.35±43.553	477.44±61.956
ID 3	588.60±43.237	577.67±41.509
CCT	528.14±30.257	532.09±22.526
A C DEPTH	3020.70±304.564	3031.40±256.817

TRABECULAR IRIS ANGLE IN DEGREES; ALL OTHER VALUES IN MICRONS

DISCUSSION

AOD:

According to Pavlin[1], it is 320 ± 100. According to the present study right eye measurements are 368.64+/- 32.824 microns and for the Left eye is 375.30+/- 28.672 microns. According to study [29], it is 347 ±181. These values are not comparable as the average values are low compared to the present study.

According to An UBM study of the anterior segment in Indian eyes with PACG j glaucoma 11:502-507, it is 199 ± 89. These values are not comparable as the average values are low compared to the present study.

According to Ultrasound biomicroscopic measurement of development of anterior chamber angle by Hiroshi Kobayashi, Hisako Ono, Junichii Kiryu, Kaori Kobayashi, Takehisa Kondo,

AOD250, AOD500=116–367μm (247.4 (65.9)μm), 166–509μm (349.5 (87.1) μm). AOD250, and AOD500 showed a significant increase in relation to logarithm of age.[2] These values are not correlated with the present study because anterior segments were measured in 46 normal infants and children(21 males and 25 females, aged from 1 to 60 months (mean 17.09 (SD 16.99) months)), by use of ultrasound biomicroscopy. According to UBM in the subtypes of PACG j glaucoma 2005:14:387-391, it is 199 ± 89. These values are not comparable as the average values are low compared to the present study.

Pavlin's classical method of assessing the angle opening, which treats the iris surface as a straight line. Nevertheless, it is obvious that the angle on the right is gonioscopically narrower and more likely to be occludable than the angle on the left; therefore, irregularities of iris contour and curvature need to be taken into account. Ishikawa et al[35] defined the angle recess area (ARA) as the triangular area bordered by the anterior iris surface, corneal endothelium, and a line perpendicular to the corneal endothelium drawn to the iris surface from a point 750μm anterior to the scleral spur. In this way, the iris irregularity is properly accounted for in the measurement.

TCPD:

According to the present study right eye measurements are 1114.00+/-98.144 and in left eye 1100.50+/-101.169. According to pavlin it is 1122 ± 23. These values are comparable as p =

0.09[24]. According to study[29], it is 910 ± 130. These values are not comparable as the average values are low compared to the present study. According to An UBM study of the anterior segment in Indian eyes with PACG j glaucoma 11 502-507, it is 912 ± 200. These values are not comparable as the average values are low compared to the present study. According to UBM in the subtypes of PACG j glaucoma 2005 :14:387-391 it is 1000 ± 114These values are not comparable as the average values are low compared to the present study.

ID 1:

According to the present study right eye measurements are 416.16+/-54.281and in left eye 408.02+/- 54.049. According to Pavlin it is 404.62± 52.51. These values are comparable. According to study[29], it is 460 ± 70. These values are not comparable, as the values are higher compared to the present study. According to An UBM study of the anterior segment in Indian eyes with PACG j glaucoma 11 502-507 it is 410 ± 104. These values are comparable. According to UBM in the subtypes of PACG j glaucoma 2005:14:387-391, it is 491± 86. These values are not comparable as the average values are higher compared to the present study. There were many proven studies showed that increased iris thickness is a significant risk factor for future development of angle closure glaucoma.[29]

ICPD:

According to the present study right eye measurements are 306.51+/- 58.409 and in left

eye 305.60+/- 51.115. According to study,[29] it is 150 ± 130. These values are not comparable, as the values are lower compared to the present study.

According to UBM in the subtypes of PACG j glaucoma 2005:14:387 – 391, it is 398 ± 210. These values are not comparable as the average values are higher compared to the present study.

TIA:

According to the present study right eye measurements are 38.02+ - 3.20 and in left eye 37.71+/- 4.00. According to Pavlin it is 30±11. These values are comparable. According to study[29,] it is 32.09 ± 13.34. These values are not comparable as the average values are low compared to the present study. According to UBM in the subtypes of PACG j glaucoma 2005:14:387-391, it is 27.94 ± 7.41. These values are not comparable as the average values are low compared to the present study.

ID 2:

According to the present study right eye measurements are 480.00+/- 48.596 and in left eye 478.80+/- 56.466. According to Pavlin it is 457 ± 58. These values are comparable. According to UBM in the subtypes of PACG j glaucoma 2005:14:387-391, it is 529 ± 92. These values are not comparable as the average values are higher compared to the present study.

ID 3:

According to the present study right eye measurements are 581.80 +/- 42.221 and in left eye 578.70 +/- 36.753. According to Pavlin it is 645 ± 103. These values are not comparable as the present study was done in the age group of 18 - 28 years population where as Pavlin's study was conducted in infants and children below 8 years of age in normal developing eyes. According to UBM in the subtypes of PACG j glaucoma 2005:14:387-391 it is 647 ± 122 These values are not comparable as the average values are higher compared to the present study.

CCT:

According to the present study right eye measurements are 529.80 +/- 25.819 and in left eye 530.90 +/- 20.005. According to study[29], it is 500 ± 30. These values are not comparable as the average values are low compared to the present study.

Urbak et al[11] and Tam and Rootman[36] both reported that the intraobserver reproducibility was high for all measurements of CCT. In addition, Dada et al[37] reported that there was no statistically significant difference between the mean CCT measured with the anterior segment optical coherence tomograph (AS-OCT) and the UBM. Tello et al[9] showed that intraobserver reproducibility was high with the UBM. They also reported that the interobserver reproducibility for the measured parameters varied considerably and was affected by the subjective interpretation of visualized anatomic landmarks. According to

André Omgbwa Eballe et al[31], the average CCT was 529.29 ± 35.9 μm in the right eye (95% confidence interval [CI]: 526.09–532.49), 528.19 ± 35.9 μm in the left eye (95% CI: 524.99–531.40) and 528.74 ± 35.89 μm in both eyes (95% CI: 526.48–531.00), range 440 to 670 μm. These values are comparable with the present study. According to André Omgbwa Eballe et al[31], the average IOP was 13.01 ± 2.97 mmHg in both eyes (95% CI: 12.82–13.19). A rise in CCT by 100 μm was followed by an increase in IOP of about 2.8 mmHg (95% CI: 2.3–3.6) for both eyes taken together. Linear regression analysis showed that corneal thickness was negatively correlated with age and IOP was positively correlated with age.

ACDEPTH:

According to the present study right eye measurements are 3031.60 +/- 280.806 and in left eye 3036.40 +/-229.635. According to pavlin it is 3128 ± 372. These values are comparable. According to study[29] , it is 2740 ± 300. These values are not comparable as the average values are low compared to the present study. According to An UBM study of the anterior segment in Indian eyes with PACG   j glaucoma 11 502-507 it is 2700 ± 410. These values are not comparable as the average values are low compared to the present study. According to Ramanjit sihota MD, Tanuj Dada MD, Rajkumar Gupta MD ultrasound biomicroscopy in the subtypes of Primary Angle Closure Glaucoma. J Glaucoma 2005; 14:387-391 the mean CACD in 122 normal subjects (218 eyes) was 2.8 0.4mm, ranging from 1.8 to 4.0mm. CACD accorded with normal distribution.

According to the present study, central anterior chamber depth in males is slightly more than in females. Normal women in Ramanjit sihota MD et al[13] study has a lower mean anterior chamber parameters than men, but not statistically significant.[13] With each additional year of aging, CACD was decreased by an average of 0.015mm.[13&26]

CONCLUSIONS

Ultrasound biomicroscopy technology has become an indispensable tool in qualitative and quantitative assessment of the anterior segment. UBM technology is high image resolution allowing accurate identification of structural landmarks in the anterior segment. We could define normative data of all the anterior segment measurements by Ultrasound biomicroscopy in Indian population for the age group of 18 to 28 years. No significant difference is present in the anterior segment measurements by UBM for the Right eye and for the Left eye for the age group of 18 to 28 years. No significant difference is present in the anterior segment measurements by UBM for Male and Female populations for the age group of 18 to 28 years. Advances in software design and algorithms will improve theoretical understanding of the pathophysiology of anterior segment disorders. Future applications of quantitative techniques will yield important information regarding mechanisms of angle closure, improving understanding of the dynamic functions of the iris, accommodation, presbyopia, and other aspects of anterior segment physiology and pathophysiology.

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