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Original article

Morphologic Changes in the Anterior Segment Using Ultrasound Biomicroscopy after Cataract Surgery and Intraocular Lens Implantation

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Abstract

Background: Ultrasound biomicroscopy (UBM), is a non-invasive technique used to visualize the anterior segment. The purpose of this study was to evaluate morphological changes in the anterior segment using UBM after phacoemulsification and IOL implantation. **Methods**: This was a prospective case series clinical study which was conducted on twenty eyes with senile or presenile visually significant cataract visiting the outpatient clinic of Ophthalmology Department, Benha university hospitals. Surgical technique consisted of phacoemulsification and foldable IOL implantation in the capsular bag. UBM was performed before and two months after surgery with (Sonomed Vumax II) device with a 35-MHz probe. the parameters measured were: Axial aqueous depth (AQD), Trabecular meshwork-iris angle (TIA) ,The angle opening distance at 500µm (AOD500), Iris thickness (IT),Trabecular meshwork-ciliary process distance (T-CPD) . **Results**: There was statistically significant difference between the mean of preoperative and postoperative IOP, also between the mean pre and postoperative BCVA. The current study showed that there was high statistically significant difference between pre and postoperative values of AQD ; with 1.0563mm mean difference (P<0.001),there was high statistically significant difference between pre and postoperative values of TIA ;with 6.1440 degree mean difference (P<0.001)., There was statistically significant difference between pre and postoperative values of IT3,TCPD and AOD500micron ;with 0.0069 ,0.0165 and -0.068mean difference (P<0.001)respectively. **Conclusion**: These findings confirmed that by extracting the lens, the iris shifts backwards resulting in significant change in AC depth and IOP, The quantitative changes in anterior chamber depth and angle may be determined by UBM.

Key words: Anterior segment changes –phacoemulsification –IOL implantation – significant cataract-Ultrasound biomicroscopy.

Introduction

A cataract is a disease of the eye in which the normally clear lens has opacified which obscures the passage of light. It is a gradually progressive disease and a significant cause of blindness around the world. Cataract may be congenital, traumatic, senile or secondary to other ocular or systemic disease. [(1)]

When significant cataract makes it difficult for the patient to carry on with routine activities; surgical intervention should be carried out for cataract extraction and replacing it by an artificial lens to improve patient's vision [(2)].

Phacoemulsification is a surgery used to restore vision in people with cataracts. This type of cataract surgery uses ultrasonic waves to break the lens into tiny pieces, which are then suctioned out of the eye with a vacuum. The procedure is completed by replacing the damaged lens with an artificial one. [(3)]

Phacoemulsification and intraocular lens (IOL) implantation has been used routinely for cataract surgery in millions of people worldwide for many years, it is anatomically better-wound strength, and less incidence of complications. This also gave way for the concept of foldable IOL, which can be implanted in the capsular bag through the smaller incision. [(2)]

Several preoperative factors including IOL power, anterior segment parameters, and topographic parameters are important for optimal refractive and visual outcomes [(4)]. Ultrasound biomicroscopy (UBM), is a non-invasive technique used to visualize the anterior segment with the help of high frequency ultrasound transducer. The anterior segment has a depth of 4-5 mm and the structures are close to each other so we require a higher frequency probe [(5)].

UBM is performed with a 35 and 50 MHz probe. The resolution of 50 MHz probe is 40 microns and the depth of penetration is 4 mm which uses high frequency ultrasound to produce images of the anterior segment in high resolution with high reproducibility, providing substantial information on the anterior segment structures including crystalline lens, ciliary body, and lens zonules [(6)].

In addition to morphologic assessment of those structures, this noninvasive imaging technique enables quantitation of the measurements and allows the clinician to visualize the structure of surrounding posterior chamber that may be hidden from clinical observation.

There have been several studies showing the usage of UBM in cornea, lens surgery and pathophysiology of glaucoma [(7)]

The purpose of this research was to use UBM imaging before and after phacoemulsification surgery to evaluate anterior segment changes in patients with significant cataract.

Patients and Methods

Subjects:

Twenty eyes of 20 participants (11 men and 9 women) patients aged from 45 to 73 years with clinically significant senile cataract were included in this prospective case series clinical trial.

Approval for the study was obtained from the local ethics committee (Benha Faculty of Medicine Research Ethics Committee) and informed consent forms, which were in compliance with the requirements of the Declaration of Helsinki, were signed by all participants. Full ophthalmological clinical examination and UBM imaging were used to evaluate anterior segment. Phacoemulsification surgery was performed to the patients. Axial aqueous depth (AQD), Trabecular meshwork-iris angle (TIA), The angle opening distance at 500µm (AOD500), Iris thickness (IT), Trabecular meshwork-ciliary process distance (T-CPD) were all assessed by UBM prior to the surgery and two months after surgery.

All investigations were carried out at Benha University ophthalmology hospitals from August 2022 to January 2023
Inclusion criteria:

Senile or presenile visually significant cataract (BCVA< 6/12), and no other ocular illness.

. Shaffer grade >or=3, with open angle status.

.refractive error <5D spherical and/or <3D cylinder

Exclusion criteria:

. Ocular trauma

.Previous laser surgery to the anterior segment

.Intraoperative complications such as incomplete capulorhexis, vitrous loss

.Posterior capsular rupture or requiring corneal sutures

.Ocular pathology such as optic nerve pathology or vitreous hemorrhage

Methods:

All patients were subjected to the following:

I- Preoperative workup:

-Detailed history taking including:

- Age
- Sex
- Visual complains
- Medical history
- Surgical history

-Full ophthalmological examination was done with emphasis on:

1. Best corrected visual acuity (BCVA) was measured using Snellen chart with conversion to log MAR notation for statistical analysis

2. Refraction was done to all patients by (Topcon Auto-refractometer RM 8900) to exclude high myopia.

3. IOL was measured by non-contact air puff tonometer.

4. Biomicroscopic examination of the anterior segment was done for every patient,

5. Detailed fundus examination.

Methodology

All surgeries were performed under local anesthesia with or without sedation. Surgical technique consisted of phacoemulsification and foldable IOL implantation in the capsular bag. All implanted monofocal, acrylic single piece IOL.

All UBM examinations were done in a dim room while patients in supine position. The UBM was performed before and two months after surgery with the same device (Sonomed Vumax II®, New Hyde Park, NY, USA) with a 35-MHz probe by one observer in all eyes.

All UBM examinations were done under the same environmental standards and conditions with a standard protocol. The images were taken while patient was looking at a red target hanging from the ceiling in a dim room in a supine are position to prevent accommodative effort.

After instillation of a topical 0.5% proparacaine HCL eyed, a soft silicone eyecup with appropriate diameter (18, 20, or 22 mm) was inserted between the upper and lower fornices . The eyecup was filled with an adequate amount of sterile physiologic saline for the purpose of immersion. The focus distance of the transducer was set as 12 mm in order to prevent corneal contact.

Axial images of the anterior chamber and radial section of the angle images from the temporal quadrant were be scanned.

The images were stored as videos, images with the largest equatorial diameter were chosen using slow- motion technique (fig 1) (fig2).

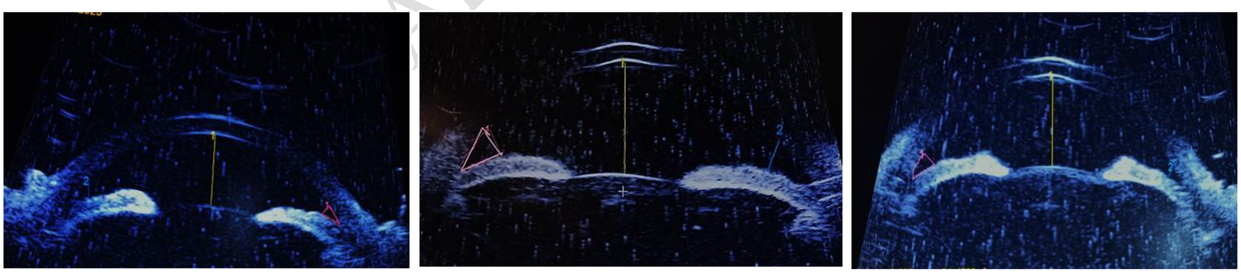

Fig1:UBM images of patients before surgery

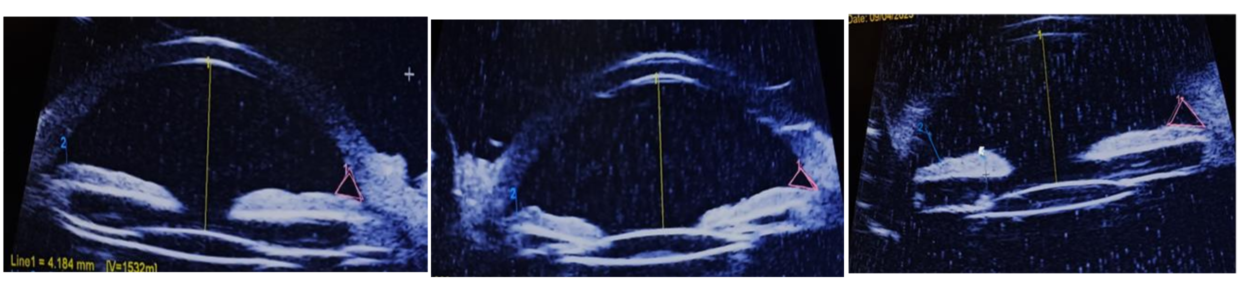

Fig2:UBM images of patients two monthes after surgery

Using the calipers included in the equipment software, the following parameters were measured:

1) Axial aqueous depth (AQD) measurement was defined as the distance between the posterior surface of the central cornea and the anterior surface of the crystalline lens or IOL in the midline of the pupil

2) Trabecular meshwork-iris angle (TIA) was measured with the apex in the iris recess and the arms of the angle passing through a point on the trabecular meshwork 500 µm from the scleral spur and a point on the iris perpendicularly opposite

3) The angle opening distance at 500µm (AOD500): the distance between the posterior corneal surface and the anterior iris surface measured on a line perpendicular to the trabecular meshwork at 500µm from the scleral spur

4) Trabecular meshwork-ciliary process distance (T-CPD) was defined as a line extending from a point 500 µm anterior to the scleral spur along the corneal endothelium and dropped perpendicularly through the iris to the most anterior ciliary process seen during scanning in that meridian

5) Iris thickness (IT) was measured at the thick area near the pupillary edge (IT3)

All measurements were done preoperatively and at the second month postoperatively and those parameters were compared to each other for the statistical analysis .

Statistical Analysis

Data analysis was done using SPSS software package version 20.0. (Armonk, NY: IBM Corp) . For category data, descriptive statistics were presented as numbers and percentages, while for normally distributed numeric variables, the mean and SD was applied. The paired sample t-test was used to compare variables before and after surgery, while Pearson correlation was used to determine the correlation between numerical variables. P value < 0.05 is considered significant.

Results:

The study was carried out on 20 eyes of 20 patients from both sexes, undergoing phacoemulsification and IOL implantation for cataract. The data were collected, tabulated and analyzed as follow:

The mean age of the studied cases was 58.10±8.57 years with a range from (45-73) years. The studied cases included 7 cases (35%) who were males and 13 cases (65%) who were females. The study included 11 right eyes (55%) and 9 left eyes (45%). The mean preoperative IOP was 17.7±2.79 mmHg and ranged from 14 – 22 mmHg. The mean postoperative IOP was 14.6 ±2.57 mmHg and ranged from 12- 17 mmHg. There was statistically significant difference between the mean of preoperative and postoperative IOP where P<0.001.

The mean preoperative LogMAR BCVA was 0.875±0.202 with a range from 1.00 to 0.6 (6\60 to 6\24) The mean postoperative LogMAR BCVA was 0.56±0.22with a range from 0.7 to 0.0 (6\30 to 6\6). There was statistically significant difference between preoperative and postoperative BCVA where P<0.001.

Comparison between Preoperative and post operative AQD
the mean Preoperative distance was 2.871±0.253mm with a range from 2.31mm to 3.28mm. Two months postoperative AQD was measured and the mean distance was 3.927± 0.344mm with a range from 3.22mm to4.61mm.(Table1)

Comparison between pre and post according to AQD showing that there is high statistically significant difference between pre and postoperative AQD where P<0.001. The mean increase in AQD is 1.056 mm, 36.7% deeper than before surgery.

Comparison between preoperative and postoperative IT3
The mean preoperative IT3 was 0.727 ±0.064 mm with a range from0.60mm to 0.83mm. Two months postoperative the meanTI3 was 0.716± 0.065mmwith a range from0.59 mm to 0.83mm. (Table2)

There was statistically significant difference between preoperative and postoperative mean IT3 where p<.001.The mean decrease in IT3 is 6.9µm, 1%thinner than before surgery

Preoperative and post operative TCPD

The mean preoperative TCPD was 1.314 ±0.250 mm with a range from 0.90 mm to1.71 mm. Two months postoperative the mean TCPD was 1.315± 0.252 mm with a range from0.86 mm to1.70 mm. (Table3)

There was statistically significant difference between preoperative and postoperative mean TCPDwhere p<.001, µmThe mean increase in TCPD is 16.5µm, 1.25% than before surgery

Preoperative and post operative AOD 500 micron

Preoperative AOD 500 micron was measured and the mean distance was0.419 ±0.058 mm with a range from0.32 mm to 0.52 mm. Two months postoperative AOD 500 micron was measured, and the mean distance was 0.487± 0.058 mm with a range from0.39 mm to 0.58 mm. (Table 4)

There was statistically significant difference between preoperative and postoperative mean AOD 500 microns where p<.001. The mean increase in AOD500 micron is 68µm, 16% more than before surgery

Preoperative and post operative TIA

Preoperative TIA was measured and the mean angle was30.931 ±2.054 degree with a range from 27.8 degree to 35.10 degree. Two months postoperative was measured and the mean angle was37.075± 1.741 with a range from 34.2degree to 40.2 degree. (Table5)

There was statistically significant difference between preoperative and postoperative mean TIA where p<.001. The mean increase in TIA is 6.14degree , 20% wider than before surgery

Correlation coefficient was conducted by Pearson correlation to measure the correlation between the parameters. (Table6)

Table1: the Mean preoperative and two months postoperative AQD

AQD	Mean	SD	Range	Mean difference	P value
Preoperative	**2.871**	**± 0.253**	**2.31-3.28**	**-1.0563**	**<.001**
Postoperative	**3.927**	**± 0.344**	**3.22- 4.61**		

p: p value for comparing between the studied groups * Statistically significant at $p \leq 0.05$

Table2: the Mean preoperative and two months postoperative IT3

IT3	Mean	SD	Rang	Mean difference	P value
Preoperative	**0.727**	**±0.064**	**0.60- 0.83**	**0.0069**	**<.001**
Postoperative	**0.716**	**± 0.065**	**0.59- 0.83**		

p: p value for comparing between the studied groups * Statistically significant at $p \leq 0.05$

Table3: the mean preoperative and two months postoperative TCPD

TCPD	Mean	SD	Rang	Mean differece	P value
Preoperative	**1.314**	**±0.250**	**0.90- 1.71**	**0.0165**	**<.001**
Postoperative	**1.316**	**± 0.252**	**0.86- 1.70**		

p: p value for comparing between the studied groups *: Statistically significant at $p \leq 0.05$

Table4: the mean preoperative and two months postoperative AOD

AOD 500 micron	Mean	sd	Rang	Mean difference	P value
Preoperative	**0.419**	**±0.058**	**0.32- 0.52**	**-0.068**	**<.001**
Postoperative	**0.487**	**± 0.058**	**0.39- 0.58**		

p: p value for comparing between the studied groups *: Statistically significant at $p \leq 0.05$

Table5: the mean preoperative and two months postoperative TIA

TIA	Mean	SD	Rang	Mean difference	P value
Preoperative	**30.931**	**±2.054**	**27.80- 35.10**	**-6.1440**	**<.001**
Postoperative	**37.075**	**± 1.741**	**34.20- 40.20**		

p: p value for comparing between the studied groups *: Statistically significant at $p \leq 0.05$

Table6: The correlation coefficient between preoperative and postoperative parameters

		Postoperative AQD	Postop erative TIA	Postoperative IT3	Postoperative TCPD	Postoperative AOD
Preoperative AQD	r	0.577**				
	P value	0.008				
Preoperative TIA	r		0.889**			
	P value		1.64E-07			
Preoperative IT3	r			1.000**		
	P value			3.81E-32		
Preoperative TCPD	r				0.999**	
	P value				2.14E-28	
Preoperative AOD	r					-0.079
	P value					0.741

****. Correlation is significant at the 0.01 level (2-tailed).**

***. Correlation is significant at the 0.05 level (2-tailed).**

There was a moderate positive correlation between Preoperative and Postoperative AQD, r= 0.577 with P value < 0.05, while there was a high significant correlation between all the other parameters preoperatively and postoperatively and the r coefficients were 0.899, 1.000 and 0.999 for TIA, IT3, and TCPD respectively as P value < 0.05, while there was no correlation between the preoperative and postoperative AOD as P value > 0.05.

Discussion

Cataract surgery is the only treatment for cataract with high success rate in restoring sight. The predominant method of cataract surgery is phacoemulsification with foldable IOL implantation [8].

Cataract surgery and IOL implantation result in clinically clear changes in the anterior chamber configuration. However, quantification of these changes is limited by conventional methods such as gonioscopy and ultrasonic biometry [9].

UBM uses high frequency ultrasound to produce images of the anterior segment in high resolution and provides useful information on the anterior segment structures including the lens, ciliary body, and lens zonules. Not only the morphologic assessment of these structures but also quantitation of the measurements [10].

The conventionally used UBM is 50 to 100MHz.It can display the anterior segment, the anterior capsule of the lens, and a small portion of the posterior lens capsule except for the whole morphology of the lens. With the emergence of 25MHz UBM, which possesses a relatively low frequency, but high penetration compared with 50-MHz UBM, its ultrasonic focal point mainly located in the lens. So, it is possible to fully display the lens from anterior to the posterior capsule as well as the zonules and study of the morphologic characteristics of cataract . [11]

In this study, we aimed to investigate the deterministic value of several anterior segment and iridocorneal angle parameters in patients who underwent cataract surgery and IOL implantation by means of ultrasonic biomicroscopy.

This study carried on 20 patients with significant cataract. These patients were examined with UBM before and two months after phacoemulsification and IOL implantation.

The main results of this study were:
Distribution of the studied cases according to sex; included 7 males (35%) and 13 females (65%). All patients aged between 45 to 73years, with mean age 58.10±8.57 years. The study included 11 right eyes (55%) and 9 left eyes (45%).

Mean IOP of cases before surgery was 17.7±2.79 mmHg and ranged from 14 to 22 mmHg. And mean LogMAR BCVA before surgery was 0.875±0.202with a range from 1.00 to 0.6; After surgery mean IOP become 13.6 ±2.57 mmHg and ranged from 12 to 17 mmHg and the mean postoperative LogMAR BCVA was 0.56±0.22with a range from 0.7 to 0.2. There was statistically significant difference between the mean of preoperative and postoperative IOP, also between the mean pre and postoperative BCVA.

The current study showed that there was high statistically significant difference between pre and postoperative values of AQD ; with mean preoperative AQD of 2.871±0.253mm and mean postoperative value of 3.927± 0.344mm so there is increase in the postoperative measurement by 1.0563mm mean difference (P<0.001).

The current study also showed that there was high statistically significant difference between pre and postoperative values of TIA ;with mean preoperative TIA of 30.931 ±2.054 degree and mean postoperative value of 37.075± 1.741degree so there is increase in the postoperative measurement by 6.1440 degrees mean difference (P<0.001).

There was statistically significant difference between pre and postoperative values of IT3,TCPD and AOD500micron ;with mean preoperative measures of 0.727 ±0.064 mm,1.314 ±0.250 mm and0.419 ±0.058 mm respectively ; and mean postoperative values were 0.716± 0.065mm, 1.315± 0.252 mm and 0.487± 0.058 mm so there is change in the postoperative measurement by 0.0069 ,0.0165 and -0.068 mean difference (P<0.001).

These findings confirmed that an enlarged lens narrows the anterior chamber depth and by extracting the lens, the iris shifts backwards which causes significant change in AC depth and IOP.

There have been some reports showing the effects of phacoemulsification and foldable

IOL implantation on the anterior chamber angle using UBM.

Our results were supported by study of as they found that the mean preoperative ACD was 2.75 ± 0.43 mm. The mean postoperative ACD was 4.14 ±0.31 mm at 2 days after cataract surgery, approximately 50.5% deeper than before surgery ($p < 0.001$). Changes in ACD and preoperative ACD showed a negative correlation ($r = -0.680$, $p < 0.01$) [(12)]**.**

Authors in reference 13 evaluated the anterior chamber configurations with UBM preoperatively and at postoperative month 1 and month 3. The central AQD, TIA, and other angle-related parameters based on the axial images of the anterior chamber as well as the radial section images of the angle were manually measured similar to our study at 4 quadrants. The authors reported that AQD significantly increased in the postoperative period by 30% on average (~850 μm) and TIA significantly increased by approximately 50% of the initial value. Moreover, the authors could not detect any difference in those parameters at 1 month and 3 months. We measured several parameters preoperatively and at a single time point, postoperatively, when the refractive outcome stabilized. [(13)]

Also, some authors stated that at the first postoperative month, all eyes (100%) had ACD increased to 3 mm or more, with a mean ACD of 3.85 mm ± SD 0.29 (range 3.29–4.34). The mean ACD increased further to 3.91 mm ± SD 0.26 (range 3.27–4.31) at 6 months postoperatively. Alt3.27–4.31) at 6 months postoperatively. Although this increase was small, it was statistically significant ($p = 0.01$, paired t-test). The mean ACD stabilized thereafter and did not show any subsequent significant change from 6 months to the end of the24-month follow-up period. [(14)]

Furthermore, authors in reference 15 revealed that the mean ACA on UBM is increased by8.66±7.08; this signifies an increase by 26.3% from the preoperative mean value. In group1(ECCE), the mean preoperative ACA was 33.82 ± 7.52 while the mean postoperative ACD was 42.7 ±7.93, there was significant change ($P = 0.008$). In group2(phacoemulsification), the mean preoperative ACA was 31.58 ±6.22 while the mean postoperative ACA was 40.0 ±5.16, there is a significant increase of ACA ($P = 0.015$) .[(15)]

On the other hand, some authors found a significant change in the AQD and in the TIA using segment optical coherence tomography in both narrow angles and open angle eyes after cataract surgery; however, narrow angle eyes showed greater increase in the AQD compared to open angle eyes. Despite not including eyes with a narrow angle, they found an increase in TIA by 7.3 at postoperative month 2. [(16)]

Some authors, in their study on ACD after phacoemulsification of intumescent cataract resulted in statistically significant increase in the mean ACD. The mean ACD was 3.44± 0.28 mm with a mean relative change (80.19%) in Group I, 3.3 ± 0.39 mm with a mean relative change (52.76%) in Group II and 3.33±0.32 mm with a mean relative change (30.76 %) in Group III ($P < 0.05$) [17].

Although there have been relatively new techniques such as rotating Scheimpflug camera for the evaluation of corneal and anterior chamber parameters, the visualization of angle recess and retroiridal structures is poor due to inability of penetration of that device. Ultrasound biomicroscopic imaging can be used to evaluate the retro-iris structures and the ciliary body.

There are some limitations of this study, including small sample size of eyes and not comparing the outcomes with another imaging modality. The quality of the image acquisition and the analysis differences of UBM evaluation of the anterior chamber angle may be affected by physiologic variables as room illumination, fixation, and accommodative effort

Finally, UBM assessment was performed with the patients in a supine position. This may result in deepening of the ACD when compared to the upright position. Future studies should include a comparison with upright ACD measurements to evaluate for any differences in IOL position and tilt between the supine and upright position.

Conclusion: There are some morphological changes in the anterior segment structures after cataract surgery. The anterior chamber deepens, and its angle widens. The quantitative changes in anterior chamber depth and angle may be determined by UBM. Numerical values that we detected in our study could provide an anatomical reference for further studies

References

1. Gimbel, HV; Dardzhikova, AA :Consequences of waiting for cataract surgery. Current Opinion in Ophthalmology January 2011.. 22 (1): 28–30.
2. Davis G: The Evolution of Cataract Surgery. Mo Med. 2016 Jan-Feb;113(1):58-62.
3. Martinez MB, Moyano DB, Gonzalez-Lezcano, RA : Phacoemulsificationproposals for improvement in its application. Healthcare (Basel). 2021 Nov;9(11):1603.
4. Wang JK, Chang SW: Optical biometry intraocular lens power calculation using different formulas in patients with different axial lengths: Int J Ophthalmol. (2013);6(2):150-154.
5. Bhatt, D. C: Ultrasound biomicroscopy, An overview. Journal of Clinical Ophthalm o-logy and Research. 2014; 2(2), 115-1231.
6. Parija S, Behera P, Banerjee A : Ultrasound biomicroscopy for ophthalmology– an overview. J. Evid. Based Med. Healthc. 2017; 4(59), 3589-3594.
7. Ramasubramanian V, Glasser A. : Can ultrasound biomicroscopy be used to predict accommodation accurately? J Refract Surg.(2015);31(4):266-27.
8. Yu JG ,Zhao Y E, Shi JL : microincision cataract surgery versus conventional coaxial cataract surgery, meta-analysis of randomised controlled trials. J Cataract Refract Surg 2012; 38:894-901.
9. Junejo MK& Chaudhry TA: Anterior Chamber Depth Changes after Uneventful Phacoemulsification . Pak J of Ophthalmol 2016; 32.
10. Wang X C., Zhou S., Ji J., & Yang, J : Design of a Portable Very-HighFrequency Ultrasound Biomicroscope. BioMedical Engineering and Informatics 2020 (pp. 877-881).
11. Shi G., Jiang Z., Deng G., Liu G., Zong Y., Jiang C.,et al : Automatic classification of anterior chamber angle using ultrasound biomicroscopy and deep learning.

Translational vision science & technology. 2019; 8(4), 25-25.
12. Kim M.& Park K. H : Changes in anterior chamber configuration after cataract surgery as measured by anterior segment optical coherence tomography. Korean journal of ophthalmology: KJO. 2011; 25(2), 77.
13. Pereira F. A., & Cronemberger S: Ultrasound biomicroscopic study of anterior segment changes after phacoemulsification and foldable intraocular lens implantation. Ophthalmology. 2003; 110(9), 1799- 1806.
14. Ang G. S., Duncan L., & Atta H. R: Ultrasound biomicroscopic study of the stability of intraocular lens implants after phacoemulsification cataract surgery. Acta ophthalmologica. 2012; 90(2), 168-172.
15. Mansour N M., Fatma Atwa, Eman Abd El-Rahman, Naglaa Alkosy & Horeya A. Sadallah: Ultrasound Biomicroscopic Changes of the Eye after Cataract Surgery. Journal of American Science. 2013; 9(11).
16. Kasai K, Takahashi G, Kumegawa K, Dogru M: Measurement of early changes in anterior chamber morphology after cataract extraction measured by anterior segment optical coherence tomography. Graefes Arch Clin Exp Ophthalmol. 2015;253(10):1751-1756.
17. Awnallah, M., Salamah, M., Shawki, M., & Solaiman, K. A. M: Changes in Anterior Chamber Depth and Angle Before and After Phacoemulsification of Intumescent Cataract. Zagazig University Medical Journal. 2020; 26(4), 663-668.

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