ABENHA MEDICAL JOURNAL bmj

Print ISSN 1110-208X

Online ISSN 2357-0016

Original article

Microvascular Changes in Macular Area after Phacoemulsification Assessed by Optical Coherence Tomography Angiography

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Received: 28 March 2023

Accepted: 17 April 2023

Abstract

Background: Phacoemulsification with intraocular lens implantation for cataracts is amongst the most prevalent ophthalmology procedures for cataract patients to improve eyesight. **This study is aimed to** investigate the alteration in microvascular blood flow and macular retinal thickness by OCTA in cataract individuals following phacoemulsification. **Methods:** This study included 50 Egyptian patients with cataract that were selected from the department of ophthalmology at Benha University hospital and Benha Health Insurance hospitals. The main aim was to evaluate macular vasculature changes pre and post phacoemulsification. Two groups of participants were formed: Low energy power group: 25 patients were enrolled with low energy used in phacoemulsification surgery group, and a high energy power group: 25 patients were enrolled with high energy used in the phacoemulsification surgery group. **Results:** The nuclear hardness showed a significant difference between both groups. Eyes number with grade 3 nuclear toughness was substantially lower in low-energy than high-energy group, since eyes number with grade 2 nuclear hardness was substantially higher in low-energy than high-energy group (P value= 0.001). 1 week post-surgery, low-energy group postoperative BCVA was greater compared to high-energy group. (0.86 ± 0.17 vs 0.70 ± 0.18, P value=0.002) and at 1m (0.84± 0.19 vs 0.74 ± 0.18, P value=0.044) post-operation. **Conclusion:** After cataract surgery, phacoemulsification provides a reasonable effective result, with improved macular thickness, decreased foveal avascular zone (FAZ) area, and insignificant modifications in microvascular density in the peripapillary region.

Keywords: Microvascular Changes; Macular Area; Phacoemulsification; OCTA

Introduction

Among the most prevalent ophthalmology therapies for restoring vision in cataract patients is cataracts phacoemulsification with implantation of intraocular lens (1).

Multiple researches revealed that modifications after phacoemulsification in macular vascular density and areas of blood flow may influence visual acuity healing.

Nevertheless, recent researches primarily examine phacoemulsification effectiveness in ocular pulsatile blood flow or macrovascular retinal changes, and phacoemulsification impacts on the thickness of macula and microvascular changes in cataracts remain controversial (2).

Latest studies have not given adequate evidence to determine changes in microvascular system of macula following a cataract operation. However, the majority of these studies have recommended that blood-retinal barrier (BRB) disruptions are the most significant cause of macular edema after surgical procedure (2).

During cataract surgery, variations in arterial blood pressure, blood vessel location, venous blood return, and CO2 levels influence ocular perfusion (3).

Among the greatest tissues of the body with metabolic demands is the retina (4). There are three levels of blood vessels in the retina: deep, intermediate and superficial, (5).

OCTA is the most recent microvascular imaging technique commonly utilized for imaging of microvascular retina (6). OCTA using a frequency-division-based decorrelation approach may provide 3D microvascular images of the retina. That noninvasive technology exceeds standard angiographic methods in terms of contrast agent exemption, high-speed imaging to blood flow recording, and microvascular structures 3D imaging at varying depths (7).

This study aimed to investigate the alterations in the thickness of the macular retina and microvascular flow of blood utilizing OCTA following phacoemulsification in patients with cataract. This was investigated with the intension of examining the following process of microvascular changes impacting the patient's quality of vision preoperatively, one day after phacoemulsification, one week, after 3 months, and lastly six months.

Patients and methods

That cohort prospective interventional research involved fifty Egyptian participants suffering cataract selected from department of ophthalmology at Benha University hospital and Benha Health Insurance hospitals, age ranged from 50 to 65 years. The study was done over a period of two years from January 2020 to January 2022. The aim was to evaluate macular vasculature changes pre and post phacoemulsification after an approval from the Research Ethics Committee in Benha Faculty of medicine and fully informed written consent from all patients as regard surgical procedure, photographing and follow up period for one year.

All participants consented to the research and completed a written informed consent. This study's approval adheres to the standards of Benha University Declaration.

Inclusion criteria were if both eyes needed cataract surgery, the operated eye was the only one involved. **Participants qualified for inclusion in this research if they were** above the age rang from 50 to 65years old, with ≤ 21 mmHg intraocular pressure in the affected eye, Unsettled head fixation impairing OCTA signal collection; no other ocular illnesses detected on patient history (like retina, glaucoma and uveal tract,), patient without history of past intraocular surgery or diabetes and other systemic diseases.

Exclusion criteria were retinal vascular disease, collagen vascular disease, diabetic fundus changes, congenital cataract, complicated cataract, posterior capsule rapture, vitrouse prolapse, hyper mature cataract, previous intra ocular surgery in same operated eye and previous ocular trauma history.

Study population: It is the population from which the sample size would be non-randomly selected. It included **Low energy power group**: 25 patients were enrolled with low energy used in phaco surgery group and **High energy power group**: 25 patients were enrolled with high energy used in phaco surgery group

Each patient was exposed to a comprehensive medical history questioning, comorbidities and history of medications or any surgery, examination of slit lamp, visual function assessment, fundus examination, non-contact intraocular pressure measurement. In addition to axial length and other parameters derived from the A scan ultrasonic. Using the Emery-Little grading system, nuclear hardness was rated (1–4) based on nuclear colour and lens opacity. Throughout the procedure, the phacoemulsification duration and energy of every patient were documented, and the macular retinal thickness and microvascular blood flow were measured by OCTA before surgery and at 1 week, 1 month, and 3 months post-operation.

Surgical procedures: performing phacoemulsification after topical anesthetic was instilled into the eye; an incision of 2.2 mm was performed for clear corneal self-sealing. As soon as the tear developed in the capsule, lens nucleus fragments were taken, and the remaining lens cortex was eliminated by phacoemulsification. After the removal of the entire lens and all its components, sodium hyaluronate was infused into the anterior chamber and a foldable intraocular lens was placed in the capsular bag. Tobramycin dexamethasone and levofloxacin eye drops were administered postoperatively 4 times per day for two weeks, and corticosteroid eye drops were administered 4 times per day for four weeks.

OCTA Imaging: OCTA was conducted using RTvue OCT (Optovue) operating at 70,000 A-scans per second speed. The split-spectrum amplitude-decorrelation angiography (SSADA) technique was applied to improve the visibility of the retinal vasculature and acquire OCTA pictures (304 × 304 pixels). Light source centered on a bandwidth of 50 nm and a wavelength of 840 nm was utilized by OCTA system. Performing OCTA scans is done between the retinal pigment epithelium (RPE) and the inner limiting membrane (ILM). The three circular areas were parafovea (Ø = 3 mm), fovea (Ø = 1 mm) and perifovea (Ø = 6 mm).

The thickness of macular retina is known to be average thickness of macula, while the whole thickness of retina was the distance between RPE complex of Bruch's membrane and ILM. Inner retina was retina between the inner plexiform layer (IPL) outer boundary and the ILM, and the outer retina was that between the outer boundary of the IPL and the RPE-Bruch's membrane complex. The OCTA system would automatically calculate the whole, inner retinal layer, and outer retinal layer mean thicknesses (FT, IRLT, ORLT). Regarding the measurement of macular retinal microvascular density. In this work, OCTA images of superficial and deep layers of retina were analyzed.

3 µm under ILM to 15 µm under IPL, and the deep retina as 15–70 µm below the IPL is considered the superficial retina. OCTA images were utilized to analyze area of FAZ and macular blood flow. Jehad Hassan, an experienced physician, completed all scans to confirm the consistency and quality of OCTA data. According to reports, lens opacities have a considerable impact on retinal blood flow measures in OCTA and should be incorporated in quantitative vascular evaluation.

To remove the impact of lens opacity on the evaluation of macular structure using OCTA, the signal levels of each patient's OCTA were all larger than Q5 in order to exclude the influence of lens opacity. In addition, each patient's OCTA signal values exceeded Q5.

To remove the impact of diurnal fluctuation and light intensity on retinal thickness, patients were permitted to undergo tests between 9:00 and 12:00 a.m. under continuous room illumination.

Statistical analysis

SPSS v26 was used to do statistical analysis (IBM Inc., Chicago, IL, USA). Comparing the two groups using an unpaired Student's t- test, quantitative data were provided as mean and standard deviation (SD). The Chi-square test was used to examine qualitative variables expressed as frequency and percentage (%). A two tailed P value < 0.05 regarded as being considerably critical

Research ethics committee:Ms.5.5.2022

Results

Demographic and clinical data of the studied participants were presented in **Table 1**.

Post-operative intraocular pressure of patients at 1- and 3-months (14.4 ± 0.76 and 11.9 ± 0.97 mmHg) was substantially reduced than the baseline level (17.4 ± 2.23 mmHg) (P value< 0.001). **Table 2**

The nuclear hardness was significantly different between both groups. Eyes number with grade 3 nuclear toughness was substantially lower in low-energy than high-energy group, since eyes number with grade 2 nuclear hardness was substantially higher in low-energy than high-energy group (P value= 0.001). 1wk postoperatively, BCVA of high-energy was lower than low-energy group. (0.86 ± 0.17 vs 0.70 ± 0.18, P value=0.002) and at 1m (0.84± 0.19 vs 0.74 ± 0.18, P value=0.044) post-operation. The baseline and BCVA at 3m post operation were insignificantly different between both groups. **Table 3**

The Full thickness (FTs) at parafovea, perifovea and fovea considerably raised at 1& 3month post-operation compared to FTs at the baseline (before operation) (P value <0.05) and was insignificantly different at 1 wk. post-operation. Fovea and parafovea outer retinal layer thickness was insignificantly different post operation compared to baseline outer retinal layer thickness (before operation). Perifovea outer retinal layer thickness significantly decreased at 1wk. & 1-month post-operation compared to the baseline outer retinal layer thickness (before operation) (P value =0.027, 0.035 respectively) and was insignificantly different at 3 month. Post-operation thickness of inner retinal layer at fovea was insignificantly different post operation compared to thickness of inner retinal layer at baseline (before operation).

Thickness of inner retinal layer at parafovea and perifovea considerably increased at 1wk,1 month and 3 months post-operation compared to thickness of inner retinal layer at baseline (before operation) (P value <0.05). **Table 4**

The foveal avascular zone was insignificantly different at baseline between both groups, 1 wk., 1 month & 3-month post operation. **Figure 1**

Microvascular blood flow in the central fovea of deep and superficial layer were insignificantly different at baseline among groups, 1 wk., 1 month & 3-month post operation. **Table 5**

The foveal retinal thickness (FRT) (inner, outer and full thickness) was insignificantly different at baseline between groups, 1 wk., 1 month & 3-month post-operatively. **Figure 2-4**

Table 1: Clinical and demographic characteristics of the studied patients

		N=50
Age (years)		42.6 ± 8.36
Sex	Male	23 (46%)
	Female	27 (54%)
BCVA		0.29 ± 0.17
Axial length (mm)		24.8 ± 2.28
Mean nuclear hardness		2.16 ± 1.11
EPT (s)		18.28 ± 6.34
Mean phacoemulsification energy (%)		10.3 ± 8.82

BCVA: preoperative best-corrected visual acuity, EPT: effective phacoemulsification time, Data are presented as mean ± SD

Table 2: IOP of the studied patients

	N=50		
	Baseline	At 1 month	At 3 months
IOP (mmHg)	17.4 ± 2.23	14.4 ± 0.76	11.9 ± 0.97
P value		<0.001*	<0.001*

IOP: intraocular pressure, Data are presented as mean ± SD, *: statistically significant as p value <0.05

Table 3: Comparisons of nuclear hardness and postoperative BCVA between the studied groups

		Low energy group (n=25)	High energy group (n=25)	P value
Lens grade	Grade 2	19 (76%)	6 (24%)	0.001*
	Grade 3	4 (16%)	16 (64%)	
	Grade 4	2 (8%)	3 (12%)	
BCVA	Baseline	0.25 ± 0.18	0.29 ± 0.16	0.385
	1wk post-operation	0.86 ± 0.17	0.70 ± 0.18	0.002*
	1m post-operation	0.84± 0.19	0.74 ± 0.18	0.044*
	3m post-operation	0.83 ± 0.14	0.80 ± 0.24	0.499

BCVA: preoperative best-corrected visual acuity. Data are presented as mean ± SD *: statistically significant as p value <0.05.

Table 4: Changes in Foveal, Parafoveal, and Perifoveal Retinal Thickness pre and post operation

		Macular Thickness (µm)			
		Baseline	1 week	1 month	3 months
Full thickness (µm)	Fovea	260 ± 68.38	262.7 ± 27.23	282.8 ± 45.35	283.7 ± 33.01
	P value		0.810	0.044*	0.029*
	Parafovea	323.9 ± 32.08	326.4 ± 21.88	339.4 ± 24.57	337.8 ± 21.98
	P value		0.654	0.011*	0.008*
	Perifovea	282.2 ± 28.98	285 ± 19.48	293.1 ± 22.62	293.7 ± 23.65
	P value		0.613	0.039*	0.022*
Outer retinal layer thickness (µm)	Fovea	223.5 ± 60.57	207.2 ± 34.25	219.4 ± 45.21	215.9 ± 23.51
	P value		0.073	0.695	0.396
	Parafovea	229 ± 43.25	229.7 ± 27.19	231.5 ± 21.66	230.1 ± 24.09
	P value		0.929	0.700	0.872
	Perifovea	193.9 ± 25.73	183.7 ± 14.29	186 ± 12.05	189.3 ± 14.45
	P value		0.027*	0.035*	0.259
Inner retinal layer thickness (µm)	Fovea	49.1 ± 14.62	50.7 ± 16.76	54.4 ± 16.97	59.5 ± 34.1
	P value		0.624	0.124	0.073
	Parafovea	83.5 ± 23.03	102.4 ± 19.86	106.9 ± 16.02	116.2 ± 25.78
	P value		<0.001*	<0.001*	<0.001*
	Perifovea	91.3 ± 12.05	100.9 ± 15.94	106.3 ± 13.87	106.4 ± 23.53
	P value		0.001*	<0.001*	<0.001*

Data are presented as mean ± SD, *: statistically significant as p value <0.05.

Table 5: Comparison of microvascular blood flow in the central fovea between the studied groups

		Low energy group (n=25)	High energy group (n=25)	P value
Deep layers	Baseline	22.2 ± 8.62	18.9 ± 7.61	0.165
	At 1 week	14.5 ± 4.67	12.6 ± 3.55	0.116
	At 1 month	14.9 ± 3.63	13 ± 3.59	0.078
	At 3 months	13.5 ± 3.75	11.8 ± 4.96	0.183
Superficial layers	Baseline	12.0 ± 7.39	10.5 ± 6.9	0.456
	At 1 week	15.04 ± 8.23	12.4 ± 5.02	0.177
	At 1 month	15.20 ± 9.31	11.5 ± 8.15	0.143
	At 3 months	13.7 ± 4.26	12 ± 2.55	0.097

Data are presented as mean ± SD, *: statistically significant as p value <0.05.

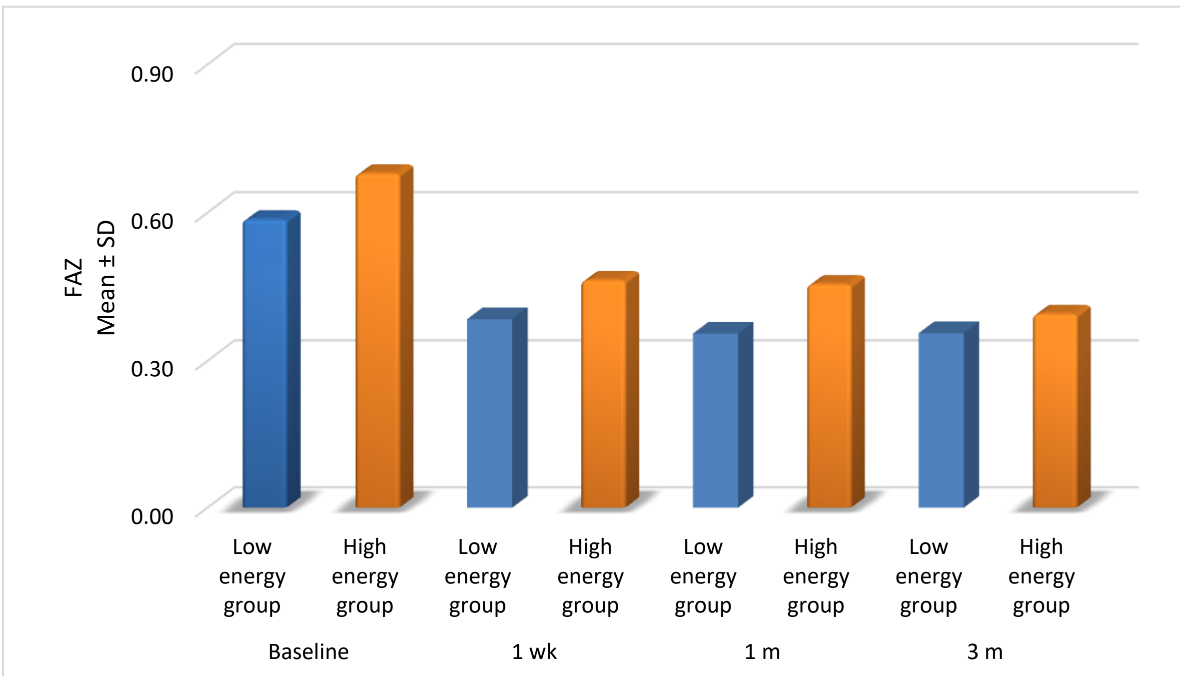

Figure 1: Comparison of FAZ between the studied groups

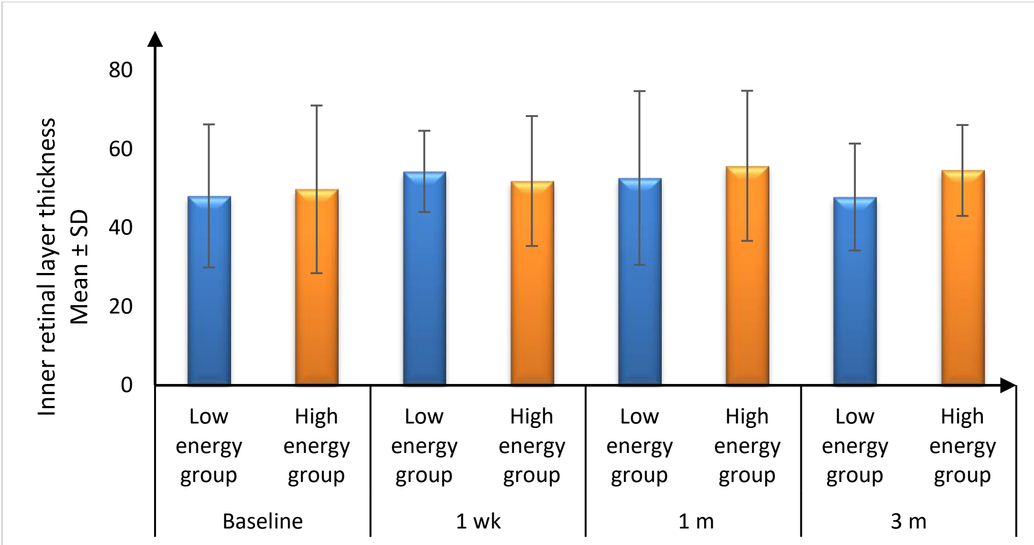

Figure 2: Comparison of inner retinal layer thickness between the studied groups

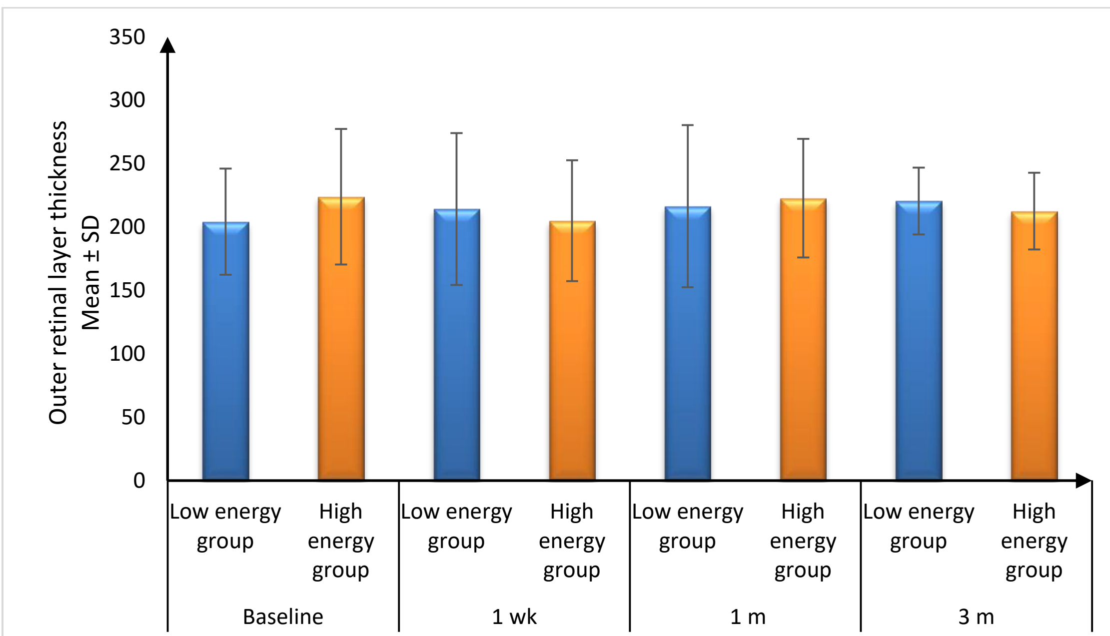

Figure 3: Comparison of outer retinal layer thickness between the studied groups

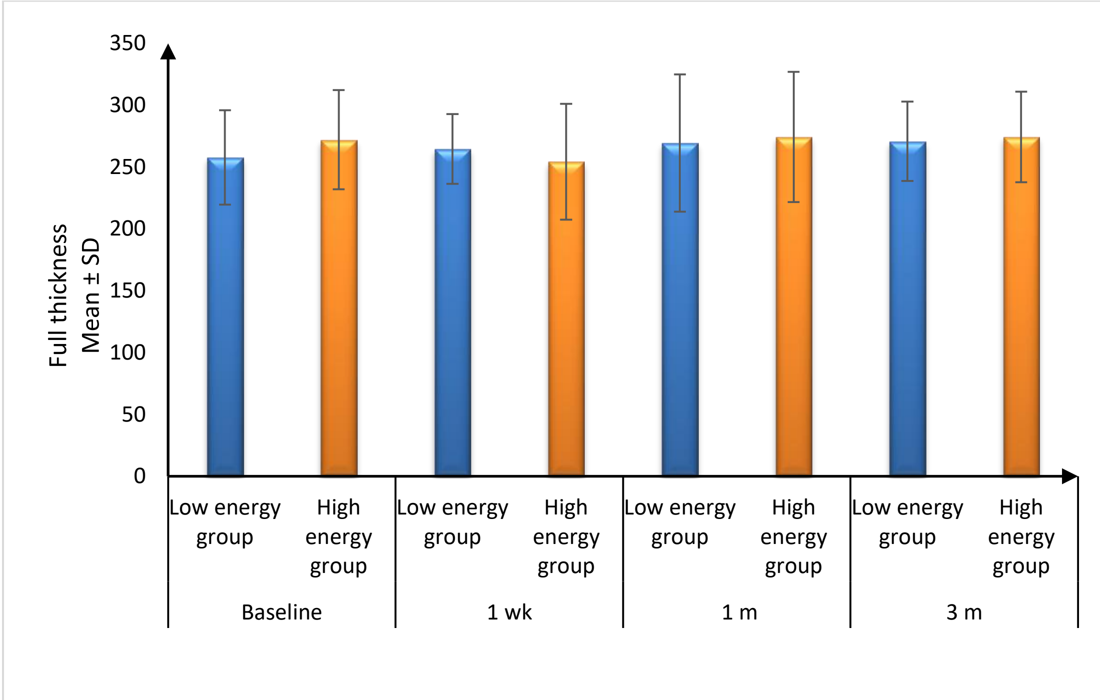

Figure 4: Comparison of full retinal thickness between the studied groups

Discussion

Cataract removal by phacoemulsification is one of the most utilized ocular surgical treatments, often resulting in a substantial improvement in older patients' visual acuity (8).

In the present study, 1- and 3-months post-operative intraocular pressure of all patients (14.4 ± 0.76 and 11.9 ± 0.97 mmHg) considerably reduced than baseline (17.4 ± 2.23 mmHg) (P value< 0.001). Parallel to our results, a study found 1- and 3-months post-operative intraocular pressure of all participants (14.53 ± 3.30 and 13.74 ± 2.86 mmHg) had reduced significantly than level of baseline (15.86 ± 3.67 mmHg) (both P < 0.05) (2).

Furthermore, a study revealed that the mean IOP decrease 2.80 ± 1.12 mm Hg (P-value < 0.01) at 3 months postoperatively (9).

In addition, a recent study investigated macular perfusion changes as measured by OCT-A following routine phacoemulsification. Before cataract surgery, 1 week, 1 month, and 3 months following surgery, OCT-A was done. They stated that IOP was much greater before surgery than one week, one month, and three months thereafter. IOP was considerably greater one week after surgery compared to one month and three months after surgery (10).

Regarding the present study finding, the nuclear hardness was significantly different between both groups. Eyes number with grade 3 nuclear toughness was substantially lower in low-energy than high-energy group, since eyes number with grade 2 nuclear hardness was substantially higher in low-energy than high-energy group (P value= 0.001). Our results agree with those documented by a recent trail revealed that Eyes number with grade 3 nuclear toughness was substantially lower in low-energy than high-energy group (P < 0.05) (2).

Consistently, stronger ultrasonic energy during phacoemulsification was linked to more serious retinal damage, according to a research (11).

Our results revealed that 1wk postoperatively, BCVA of high-energy was lower compared to low-energy group. (0.86 ± 0.17 vs 0.70 ± 0.18, P value=0.002) and at 1m (0.84± 0.19 vs 0.74 ± 0.18, P value=0.044) post-operation. The baseline and BCVA at 3m post operation were insignificantly different between both groups.

Conforming our results, research stated that 1-week postoperatively, high-energy group BCVA was lower compared to that of low-energy group (0.83 ± 0.17 vs 0.70 ± 0.16, P < 0.05) and 1-month (0.86 ± 0.14 vs 0.77 ± 0.16, P < 0.05) post-operatively. Nevertheless, there was no difference in postoperative BCVA at 3 months between the two groups (P > 0.05) (2).

In fact, a recent study supports our findings in which it reported that one week following surgery, BCVA had vastly enhanced, with additional improvement between one week and three months after surgery (10).

According to our findings, FTs at parafovea, perifovea and fovea had substantially raised at 1& 3month after operation compared to FTs at the baseline (before operation) (P value <0.05) and was insignificantly different at 1 wk. post-operation. Our results are in the same line with a study documented that the FTs at the fovea, parafovea, and perifovea significantly increased at 1- and 3-month post-operation (P < 0.05) (2).

The ORLTs at fovea and parafovea was insignificantly different post operation compared to ORLTs at the baseline (before operation). The ORLTs at the perifovea had significantly decreased at 1wk.& 1-month post-operation compared to the ORLTs at the baseline (before operation) (P value =0.027, 0.035 respectively) and was insignificantly different at 3 months, post-operation. The inner retinal layer thickness (IRLTs) at the fovea was insignificantly different post operation compared to IRLTs at the baseline (before operation). The IRLTs at parafovea and perifovea considerably raised at 1wk,1 month and 3 months post-operatively compared to the IRLTs at the baseline (before operation) (P value <0.05). Interestingly, a study found that, At 1 and 3 months post-surgery, IRLTs grew much higher in the parafovea and perifovea than in the fovea (P < 0.01), save for a little reduction in the perifoveal area, changes in ORLTs were negligible (2).

It has been reported that disruption to the blood-retinal barrier (BRB) may lead to a rise in macular retinal thickness. Surgical detachment of the vitreous might lead to vitreomacular tension, which exacerbates the BRB's injury (7).

From the other side, excess inflammatory substances are also a possible cause of BRB disturbance. Substantial elevations in pro-inflammatory proteins like as chemokine 2 and interleukin-1β, which are considered to promote vasodilation and contribute to BRB disruption, are seen in the neurosensory retina of mice after lens removal. (12).

According to our findings, at 1 week, the superficial microvascular density in the parafoveal and perifoveal areas did not vary substantially, 1month, & 3month post-operation compared with baseline levels. The parafoveal region deep microvascular density was insignificantly different at 1wk., 1month, & 3month post-operation compared with baseline levels. The perifoveal region deep microvascular density was considerably raised at 1 month post operation compared to the baseline (P value = 0.030) and was insignificantly different at 1wk. & 3month.

Consistently, a study found that one week, one month, and three months following surgery, there were no consistently critical changes in the parafoveal and perifoveal regions superficial microvascular density when compared with baseline levels ($P > 0.05$). They also revealed that at 1 month, the parafoveal and perifoveal areas deep microvascular density rose very marginally, but the foveal deep microvascular density increased dramatically ($P < 0.05$) (2).

The current study revealed that FAZ was insignificantly different between both groups at baseline, 1 wk., 1 month & 3-month post operation.

Compatibly, a study found that The FAZ area did not vary significantly between the low- and high-energy groups at baseline and the three follow-up time periods ($P > 0.05$) (2). In harmony with our findings, a trial found that the significant reductions in foveal avascular zone were seen one week, one month, and three months following operation (P-value <0.001) Moreover, the average decrease in the foveal avascular zone, three months following surgery, was 27% ± 11% (9).

Our results revealed that microvascular blood flow of deep and superficial layer in central fovea were insignificantly different among both groups at baseline, 1 wk., 1 month & 3-month post operation.

In the same line with our findings, a study reported that there was no change in the central fovea microvascular blood flow preoperatively between the low- and high-energy groups ($P > 0.05$). There were no differences between the two at any of the three follow-up time period ($P > 0.05$) (2).

In the present study, FRT (inner, outer and full thickness) was insignificantly different between both groups at baseline, 1 wk., 1 month & 3-month after surgery. Came in agreement with our findings, a study stated that at baseline, there were no critical differences in FRT as measured by FT, IRLT, and ORLT between the low- and high-energy groups (P > 0.05). There were no differences between them after surgery (P > 0.05) (2).

In our results we found that using high power energy result in changes occurred after 1 & 3 months and changes in Irvine-Gass and therefore changes in the vascularity. Also, using a minimal power and reduced phaco time minimize the inflammatory response of the macular area to the high-power usage.

Conclusion

In this investigation, in addition to recovering visual acuity, phacoemulsification in the senior population was shown to be favorable. This advantageous occurrence might assist the decision-making procedure about early cataract removal in healthy elderly people. After cataract surgery, phacoemulsification provides a reasonable efficacious reaction, with improved macular thickness, decreased FAZ area, and insignificant changes in microvascular density in the peripapillary region. Considering that minimum power and decreased phaco duration lessen the inflammatory reaction of the macular region to the use of power.

References

1. Chen Z, Song F, Sun L, Zhao C, Gao N, Liu P, et al. Corneal integrity and thickness of central fovea after phacoemulsification surgery in diabetic and nondiabetic cataract patients. Arch Med Sci. 2018;14:818-25.
2. Liu J, Liu Q, Yu H, Xia Y, Zhang H, Geng C, et al. Microvascular Changes in Macular Area After Phacoemulsification and Its Influencing Factors Assessed by Optical Coherence Tomography Angiography. Ther Clin Risk Manag. 2021;17:405-14.
3. Harris A, Guidoboni G, Siesky B, Mathew S, Verticchio Vercellin AC, Rowe L, et al. Ocular blood flow as a clinical observation: Value, limitations and data analysis. Prog Retin Eye Res. 2020:100841.
4. Kurt A, Kılıç R. The Effects of Uncomplicated Cataract Surgery on Retinal Layer Thickness. J Ophthalmol. 2018;2018:7218639.
5. Hormel TT, Jia Y, Jian Y, Hwang TS, Bailey ST, Pennesi ME, et al. Plexus-specific retinal vascular anatomy and pathologies as seen by projection-resolved optical coherence tomographic angiography. Prog Retin Eye Res. 2021;80:100878.
6. Cohen SY, Miere A, Nghiem-Buffet S, Fajnkuchen F, Souied EH, Mrejen S. Clinical applications of optical coherence tomography angiography: What we have learnt in the first 3 years. Eur J Ophthalmol. 2018;28:491-502.
7. Hussein KA, Choksi K, Akeel S, Ahmad S, Megyerdi S, El-Sherbiny M, et al. Bone morphogenetic protein 2: a potential new player in the pathogenesis of diabetic retinopathy. Exp Eye Res. 2014;125:79-88.
8. Hecht I, Kanclerz P, Tuuminen R. Secondary outcomes of lens and cataract surgery: More than just "best-corrected visual acuity". Prog Retin Eye Res. 2022:101150.
9. Zhao Z, Wen W, Jiang C, Lu Y. Changes in macular vasculature after uncomplicated phacoemulsification surgery: Optical coherence tomography angiography study. J Cataract Refract Surg. 2018;44:453-8.
10. Križanović A, Bjeloš M, Bušić M, Elabjer BK, Rak B, Vukojević N. Macular perfusion analysed by optical coherence tomography angiography after uncomplicated phacoemulsification: benefits beyond restoring vision. BMC Ophthalmol. 2021;21:71.
11. Feng L, Azhati G, Li T, Liu F. Macular Vascular Density Changes following Cataract Surgery in

Diabetic Patients: An Optical Coherence Tomography Angiography Study. J Ophthalmol. 2021;2021:6641944.
12. Xu H, Chen M, Forrester JV, Lois N. Cataract surgery induces retinal pro-inflammatory gene expression and protein secretion. Invest Ophthalmol Vis Sci. 2011;52:249-55.

To cite this article: Maha A. El Fayoumi, Hamdy A. El Gazzar, Walaa A. Osman, Walid Abdelghaffar. Microvascular Changes in Macular Area after Phacoemulsification Assessed by Optical Coherence Tomography Angiography. BMFJ 2023; 40(Ophthalmology):48-60.