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Changes in macular perfusion after Phacoemulsification surgery

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Abstract: Background: Optical coherence tomography angiography (OCT-A) is a non-invasive, non-dye-based imaging modality that is used worldwide in the daily practice of ophthalmology. OCTA enhances our understanding of retinal diseases and retinal vascular changes. **Objective**: To evaluate, by means of optical coherence tomography angiography (OCTA) the changes that may occur at the macular vessels after phacoemulsification surgery and if these changes can affect the post-operative visual acuity. **Patients and Methods:** It was a prospective study carried out at Al Zahraa University Hospital on 30 eyes of 21 Patients with senile cataract were included. Retina vessel density at the macular area was checked by OCT A at 1 week, 1 month, and 3 months after cataract surgery. **Results:** Thirty eyes (21 patients) were included in the final analysis. There was a significant increase in retinal vessel density at the macular area after the cataract surgery, repeated-measures which extended to the end of the follow-up period. At 3 months postoperatively, Appearance of hyper reflective retinal spots post operatively was also noted. **Conclusions:** Macular vessel density increased after phacoemulsification surgery**.** These changes seem not to affect visual acuity. Whether these changes will persist over a longer period of time, that still needs to be studied**.**

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1. Introduction

Recently, the success rate in cataract surgery has significantly increased as a result of advances in surgical methods and equipment 1,2 The effects of cataract surgery on ocular hemodynamics were analyzed in several previous studies. However, these studies reported conflicting results. Whether ocular hemodynamics changes are caused by IOP changes or changes in existing auto regulation mechanisms in cases with cataract that has not been determinedyet. 3-6.

Optical coherence tomography angiography (OCTA) is a recent imaging modality that can be used to image the microvasculature of retina and choroid without dye injection, instead of staining vasculature as fluorescein angiography (FA).

OCTA is a non-invasive, non-dye-based imaging technique that employs motion contrast to create high-resolution and depth-resolved angiographic images of vascular flow in a matter of seconds.7-9. It is based on the concept of "motion contrast". It visualizes blood flow by detecting dynamic structures among others static tissues such as the neurosensory retina. Thus, with its features of non-invasiveness, repeatability, OCTA rapidly gained widespread usage in the investigation, evaluation and monitoring of retinal and choroidal vascular diseases. 10-12.

The software compares the decorrelation signal or phase variance between consecutive OCT B-scans acquired at the same retinal cross-section to detect motion contrast.13-15Differences between OCT B-scans are assumed to represent movement due to erythrocytes in the vasculature. Using this information from multiple retinal cross-sections, a volumetric retinal map (OCT angiogram) is constructed and co-registered with the OCT B-scans used to develop the OCT angiogram. This allows the evaluation of blood flow in the OCT angiogram and structural information in the OCT B-scans. The scanning areas currently vary from 2 x 2 mm to 12 x 12 mm, and are comprised of multiple A-scans, depending on machine parameters. OCT angiograms can be segmented into en face slabs to evaluate the different retinal vascular layers separately (e.g. superficial inner retina, deep inner retina, outer retina, choriocapillaris). 16.

OCTA is one of the in vivo techniques to visualize choroidal flow in details.17 Image artifacts are still unavoidable in OCTA.18Artifacts are more common in patients with ocular pathology and poor visual acuity. 19.20 Nevertheless, respective artifacts were believed not to interfere with qualitative image

interpretation.14Many patients with retinal pathologies, which are nowadays evaluated with OCTA are of old age and have already developed significant cataract.

This study was designed to evaluate ocular hemodynamics by means of OCTA which allows more precise evolution of microvasculature in patients with cataracts to evaluate the effects of phacoemulsification surgery on ocular hemodynamics.

2. Patients and Methods

In this prospective interventional non randomized and non-controlled study, patients were consecutively recruited from the Department of Ophthalmology, Al Zahraa University Hospital. Collection and analysis of-OCTA images were conducted in compliance with the tenets of the Declaration of Helsinki. Informed consents were obtained from all participants. Thirty eyes of twenty one patients scheduled for phacoemulsification, and intraocular lens implantation were enrolled. A thorough ophthalmic exam was completed on every patient before and after surgery, including best-corrected visual acuity (BCVA), slit-lamp Goldman applanation tonometry, and (Optovue, Inc, Fremont, CA) software version (2016.2.).

Angio Vue software of the RTVue XR Avanti spectral domain OCT (SD-OCT), which uses a split-spectrum amplitude decorrelation angiography (SSADA) algorithm. The software offers the option of 2 × 2 mm, 3 × 3 mm, 6 × 6 mm, and 8 × 8 mm OCT angiograms. Images have been taken pre and post-operative.

Cataract severity was assessed using the Lens Opacities Classification system III (LOCS scale).21 Patients diagnosed with glaucoma or any retinopathies that might result in abnormal microvasculature (e.g., age-related macular degeneration, diabetic retinopathy, retinal vascular disorder, etc.) and previously treated by laser or photodynamic therapy were also excluded.

Preoperative OCTA exam was performed before the operation. To be included in the analyses, scans had to show good signal strength to allow quantitative assessment. Postoperative OCTA images were therefore obtained of patients on the follow-up visit after one week, 1 month and 3months postoperatively.

Image acquisition 6 mm×6 mm raster scans centered on the fovea were obtained by a 100-kHz SS-OCTA instrument (Optovu-angio) software version (2016.2.) with a central wavelength of 1060 nm, an axial resolution (optical) of 6.3µm, and a lateral resolution of 20µm. The scanning rate is 70 000 A-scans per second. It consists of 304 A scans per B scan (with 10µm spacing between adjacent scans), 4 B-scan repetitions per location, and 300 B-scan positions in the raster. The en-face images of the superficial capillary plexus (SCP) were captured using the customized segmentation between an inner boundary at the inner limiting membrane (ILM) and an outer boundary at the inner plexiform layer (IPL), while the deep capillary plexus (DCP) were visualized between the IPL and the outer plexiform layer (OPL). Vessel density of SCP and DCP were measured. And the mean was calculated. Vessel density (VD) refers to the total length of perfused vasculature per unit area in a region of measurement in units of inverse millimeters. VD were analyzed**. 22.**

Statistical analyses

Analysis of data was performed using SPSS v. 25 (Statistical Package for Scientific Studies) for Windows & Med Calc v. 18 The postoperative measurements were compared using repeated measures analysis of variance tests with Bonferroni corrections. Pearson correlation.

Analyses were performed to determine the magnitude of the changes in retinal vasculature parameters and related factors. A P value less than 0.05 was considered statistically significant.

3. Results

The patients' mean age was 62 years±8.42 (SD), the mean preoperative CDVA was 0.13. After the cataract surgery, the CDVA was significantly improved to be 0.49 after 3 months postoperatively. There is statistically significant decrease of mean post-operative IOP after one week, one month, and three months in comparison to pre-operative values.

There was also a significant change in the mean VD. VD of the macular area increased significantly after 1 week, 1 month, and 3 months of cataract surgery whereas the preoperative mean vessel density was 40.5 ±4.29, which significantly increased to 41.74±4.57 and 44.11±4.73 & 42.47±4.27 at 1 week, 1 month, and 3 month after surgery (P =.047 and P =.035, respectively). Table1.

There is negative correlation between postoperative IOP and postoperative retinal VD after 1 week, 1 month and 3months. This was statistically insignificant (Table2).

The mean postoperative retinal VD in macular area after 1week, 1month and 3 months of surgery also correlated with post-operative BCVA but there is statistically no significant difference (p.> 0.05).

In our study there was appearance of hyper reflective foci (HRF) at first month post-operative, there were 22 patients with hyper reflective foci (73.3%) and 8 patients with no hyper reflective foci (26.7) (Table 2).

Presence of hyper reflective foci at one month post-operative was checked and correlated with mean post-operative BCVA at one month. But it was statistically insignificant difference.

Table 1: Comparison between Pre and post-operative VD in the study group by ANOVA test.

Retinal (VD) (µm)	**Mean**	**SD**
Preop. VD	40.50	4.29
VD 1 week	41.74	4.57
VD 1month	44.11	4.73
VD 3months	42.47	4.27

Table 2: Pearson correlation between postoperative retinal vascular density (VD) and postoperative IOP in the study group.

Postop. Retinal (VD)	**Postop. IOP** (mm Hg)	
	Correlation (r)	**P. value**
VD 1week	0.05978	0.7537
VD 1 month	0.04645	0.8074
VD 3months	0.01615	0.9325

Table 3: Pearson correlation between postoperative retinal VD and BCVA.

Postop. Retinal (VD)	**Postop. BCVA**	
	Correlation (r)	**P. value**
VD 1week	0.1762	0.3516
VD 1 month	0.1336	0.4814
VD 3months	0.2171	0.2491

Table 4: Relation between BCVA and HRF at first month in the study group by ANOVA test.

HRF	**Postop. BCVA**	
	Mean	SD
Present	0.35	0.16
Absent	0.54	0.25
P. value	0.063	

4. Discussion

Cataract removal using phacoemulsification is one of the most common ophthalmic surgical procedures, usually resulting in a significant improvement in vision quality. phacoemulsification developed progressively to reduce the amount of ultrasound energy available to do collateral damage to various ocular tissues making the ultrasound in smaller pulses of energy, to remain effective but minimize tissue trauma 10(OCTA) is non-invasive, depth-resolved and able to repeatedly measure the retinal microvasculature. OCTA is able to visualize the fine retinal vasculature in multiple layers, which is impossible using FA.[23]

In our study, the change in retinal VD at the macular area after cataract surgery using OCT A was studied. Our study showed a statistically significant changes in the vessel densities after cataract surgery. The mean VD of the included group VD±SD was (41.74±4.57) (44.11±4.73) (42.47±4.27) at 1 week, 4 weeks, and 12 weeks post-operative respectively. We noticed that these changes reached its peak after 4 weeks of phacoemulsification surgery and showed gradual decrease till 12 weeks but still away from base line (preoperative value).

(Zhao et al. 24, Yu et al. 25 and **Yifan** et al., 26) all agreed with our study result in post-operative VD changes.

In our study we found that there is appearance of hyper reflective (HRF) foci at the inner retinal layers on OCT which has been appeared one month after cataract surgery and disappeared after 3 months of the follow up, there were 22 patients with hyper reflective foci (73.3%) and 8 patients with no hyper reflective foci (26.7%), **Pilotto et al, 27** agree with our study results about presence of HRS at first in inner retina (IR) and later in outer retina (OR) seemed to confirm their inflammatory nature.

Also our study showed there was statistically significant decrease in pe op. mean IOP in comparison to post op 1 week,1 month and 3 months.

Melancia et al. 28, and Shingleton et al., 29 all agree that there was IOP reduction after phacoemulsification. This was consistent with our results.

We have studied the relation between VD and HRF. we found statistically insignificant correlation between VD and HRFafter1 month post-operative.

Pilotto et al, 27 studied changes in OCT and OCTA after cataract surgery. They found that there was presence of HRS at first in inner retina (IR) and later in outer retina (OR). Also increase in VD occurred one day post-operative and reached baseline level 90 days after. They concluded that these changes could be due to localized inflammatory reaction induced by cataract surgery.

Our study showed negative correlation between VD and IOP. Also our study showed that there was an increase in mean retinal VD when IOP decreased. This effect was noticed at 1 week,1 month and 3 months follow up periods.

That agreed with the results of **Alnawaiseh et al. 30** who demonstrated an improvement of flow density of both the macular area and peripapillary region after cataract with I stent. Also **Shin et al**. 31 showed microvascular improvement after trabeculectomy in OCT angiography. However, **Zeboulon et al**. 32 demonstrated a very limited effect of surgically induced IOP reduction on peripapillary and macular VD.

Conclusion:

There is a temporary increase in mean retinal vascular density, this effect is well demonstrated by OCT A, which allows more focused studying of macular microvasculature. An effect that seems to be subclinical and not affect final BCVA.

Limitations:

Small number of patients. Short follow up period. Lack of other studies on relation of VD to BCVA.

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Nil

Conflicts of interest

None declared.

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