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Assessment of Retinal Microvascular Alterations After YAG Laser Capsulotomy Using Optical Coherence Tomography Angiography

Osama Abdelgalil Abokahla [1], Ehab Mahmoud Ghoneim [2], Mohamed Mounir Mohamed [3]

[1] Resident of ophthalmology, Port Said Ophthalmic Hospital, Port Said, Egypt

[2] Professor of ophthalmology, Faculty of medicine, Port Said University, Egypt

[3] Lecturer of ophthalmology, Faculty of medicine, Suez Canal University,

Corresponding author: Osama Abdelgalil Abokahla

Email: abokahla50@gmail.com

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Abstract:

Purpose This study aimed to evaluate the effect of Neodymium-doped Yttrium Aluminum-Garnet (Nd: YAG) laser capsulotomy on retinal vessel perfusion densities and macular thickness using optical coherence tomography angiography.

Patients and methods The study included 35 eyes of 35 participants with an average age of 70 years old. The participants having posterior capsule opacification were non-diabetic. The preoperative evaluation included history taking, ophthalmological examination and OCT-A was done. All patients underwent YAG laser posterior capsulotomy and then macular thickness and retinal microvascular changes were assessed at one month using OCT-A.

Results There was significant improvement of Best Corrected Visual Acuity (BCVA) (Decimal) post laser capsulotomy ($P < 0.001$), No significant change was determined before and after capsulotomy in macular thickness measurements, and Perfusion density in parafovea and perifovea layers. (All $p > 0.05$).

Conclusion Nd-YAG laser capsulotomy for posterior capsule opacification is considered to be a safe procedure and has no visible effect on macular thickness measurements, flow areas, and vessel perfusion densities.

Keywords: Nd: YAG laser, Optical Coherence Tomography Angiography (OCT-A), Central Macular Thickness (CMT), Posterior Capsule Opacification (PCO).

1. Introduction

According to reports, the retina has the body's highest energy. Numerous studies demonstrate that ocular perfusion is impacted by a wide range of ocular diseases, with the severity of ocular perfusion reduction being associated to the degree of neural structure damage [1].

One of the main reasons for a poor visual prognosis following straightforward cataract surgery is cystoid macular edema (CME). The development of macular cysts and/or a decline in visual acuity can be used to diagnose postoperative CME, which has a 0.6–2.6% occurrence rate after cataract surgery. CME has no racial dominance and equally affects both sexes [2].

It is brought on by several different types of illnesses, such as retinal dystrophies (retinitis pigmentosa), retinal vascular disorders (diabetic retinopathy, retinal vein occlusion), and ocular inflammatory diseases (uveitis, scleritis). Additionally, it can happen post-operatively (after cataract surgery, YAG laser capsulotomy, and laser photocoagulation) and with the administration of specific medications (topical 2% adrenaline, topical latanoprost) [3].

A few potential side effects of the outpatient Nd:YAG laser capsulotomy surgery include lens pitting, an increase in IOP, retinal detachment, and cystoid macular edoema. Though its pathophysiology is assumed to be caused by a number of causes, the precise cause of CME remains unknown [4].

Macular edema can accompany any changes in retinal and/or choroidal circulation, and OCTA can be used to observe any of these likely changes. Macular edema is typically detected and monitored by conventional OCT by the appearance of hypo-reflective pockets of edema and macular thickness. However, it can also be caused by damage to the blood aqueous barrier, which is caused by inflammatory mediators released due to movement and damage of the vitreous gel.) [5].

The most recent imaging technique that can be utilized to assess the microvasculature of the retina and choroid without injecting dye is optical coherence tomography angiography (OCTA). OCTA is based on the idea of "motion contrast" as opposed to "fluorescein angiography (FA), which stains the vasculature." By identifying dynamic structures between other static tissues, like the neurosensory retina, it can visualize blood flow and as a result, due to its non- invasiveness and repeatability, OCTA quickly gained popularity in the study, assessment, and monitoring of retinal and choroidal vascular disorders [6].

OCTA has been used to assess the Foveal Avascular Zone area and superficial and deep macular vascular flow density in healthy and pathologic eyes and these quantitative measurements can be used for a quantitative assessment of macular vasculature after uneven YAG laser Capsulotomy in non-diabetic patients [7].

This study aimed to evaluate the effect of Neodymium-doped Yttrium Aluminum-Garnet (Nd: YAG) laser capsulotomy on retinal vessel perfusion densities and macular thickness using optical coherence tomography angiography.

PATIENTS AND METHODS

This is an observational study that was performed at Port Said ophthalmology hospital on selected patients from ophthalmology outpatients clinics. The study protocol was approved by Port Said University and with Ethical Committee number, OPT824_002.1/8/2023.

The included patients were diagnosed nondiabetic with unilateral or bilateral PCO Following straight forward cataract surgery with posterior chamber intraocular lens implantation, good Fundus view using Fundoscopy and the recovery period following cataract procedure was at least six months. We excluded patients with current ocular pathology, patients with diabetes mellitus, patients with systemic vascular disease and patients with history of treated macular disease e.g. CME after cataract surgery.

Our sample size was done According to Dawson and Trapp (2004), the sample size was determined using the following formula:

n = Sample size / = 1.96 (The critical Value corresponds to 95% level of confidence).

Sample size was estimated as 30 participants. Additionally, 20% drop out rate to compensate for non-response was considered so the sample size was recalculated as n / (1- 0.2) so a total of 35 participants was recruited in this study.

In each visit, All the patients were subjected to complete slit lamp exam of anterior segment, Fundus examination using slit lamp bio microscopy by TOPCON Slit Lamp SL-3G and 90 volk, IOP measurement by TOPCON Computerized Tonometer CT-1,JAPAN, Visual acuity assessment; Best Corrected visual acuity (BCVA) (Decimal).

Concerning the procedure of Nd: YAG laser posterior capsulotomy, full pupillary dilatation was done using tropicamide 1% eye drops which were instilled into the eye before the procedure every 10 min for half an hour. Topical anesthesia was applied as benoxinate hydrochloride 0.4% (Benox; EIPICO) eye drops were applied into the eye before the procedure. Abraham capsulotomy lens was used in all eyes. Posterior capsulotomy was done in all eyes with Zeiss Visuals YAG III (Zeiss YAG III, Zeiss Corp, Germany).

Optical coherence tomography angiography imaging

NIDEK RS- 3000 OCT Angiography, JAPAN (OCTA) was used after good pupillary dilatation and the macular area was covered by 6.0 mm x scans with an OCT of 6.0mm. Also produce en face retinal angiograms (RPE), the signal was propagated from the inner limiting membrane (ILM) to the retinal pigment epithelium and or each subject, images with a signal strength index of at least 40 and no persistent motion artefacts were retained and used for additional analysis. The contour and measurement of the foveal avascular zone Nidek software. The perifoveal region was described as an annulus with an outward diameter of 5.0 mm and an inner diameter of 3.0 mm following additional research.

The parafoveal zone was defined as an annulus with an exterior diameter of 3.0 mm and an inner diameter of 1.0 mm. The OCTA system automatically offer information on the perfusion density of these 2 areas. The retinal thickness measured using the same OCT apparatus at the same time as the retinal vasculature using the retina map mode, which covers a 6.0 mm x 6.0 mm rectangle centered at the fovea. The entire thickness of the retina determined from the ILM to the center of the RPE-Bruch membrane complex. The area between the ILM and the outer boundary of the IPL was referred to as the inner retina, while the area between the outer boundary of the IPL and the middle of the RPE-Bruch membrane complex was referred to as the outer retina. Average thickness of that particular location was referred to as retinal thickness. The parafovea and perifovea are defined similarly to how they are in OCT angiography, and the fovea is the central 1.0 mm ring region.

Statistical analysis

All data was analyzed using SPSS 26.0 for Windows statistical software (SPSS, Inc., Chicago, IL, USA) and expressed as the mean ± standard deviation (SD). Continuous data that is regularly distributed will be expressed as mean standard deviation, and continuously distributed data that is not normally distributed will be expressed as median (first quartile to third quartile) and a p-value of 0.05 or less will be regarded as statistically significant for the results.

Results

This quasi experimental study was done on 35 nondiabetic patients with Posterior Capsule Opacification attending ophthalmology outpatient clinic for YAG Laser intervention. The study patients had mean age of 70 years old ranged from 60 to 80 years old. Males represent 51.4% of the study patients and females represented 48.6% **(Table 1)**.

Table 1: Baseline data of the patients (n=35)

Variable	N=35
Age	
mean±SD median	70±3.6 70(60-80)
Gender (n, %)	
Female Male	17(48.6%) 18(51.4%)

There was no statistically significant changes in IOP from pre to post- Nd:YAG ($p > 0.05$). There was a statistically significant increase in BCVA from pre to post-Nd: YAG ($p < 0.001$) **(Table 2)**.

Table 2: Preoperative and One-month postoperative baseline examination data of the patients (n=35)

Variable	Preoperative(n=35)		One-month postoperative(n=35)		p Value
IOP (mmHg)	**mean±SD**	14.4±1.5	**mean±SD**	14.6±1.5	$p > 0.05$
BCVA	**mean±SD**	0.4±0.18	**mean±SD**	0.8±0.082	$p < 0.001$

Abbreviations: IOP: intraocular pressure, BCVA; best corrected visual acuity.

The macular thickness showed no significant change in in foveal, parafovea and perifovea thickness one month postoperatively ($p > 0.05$) **(Table 3)(Supplemental Figure1, 2)**

Table 3: Preoperative and One-month postoperative central macular thickness measurements of the patients (n=35)

Variable	Preoperative(n=35)		One-month postoperative(n=35)		p Value
Macular thickness	Fovea(μm)		Fovea(μm)		
	mean±SD	253.6±9.4	**mean±SD**	253.9±10.1	$p > 0.05$
	median(range)	264(233-268)	**median(range)**	264(239-274)	$p > 0.05$
	Parafovea(μm)		Parafovea(μm)		
	mean±SD	317.5±4.3	**mean±SD**	318.6±6	$p > 0.05$
	median(range)	317(305-324)	**median(range)**	318(315-340)	$p > 0.05$
	Perifovea(μm)		Perifovea(μm)		
	mean±SD	293±6.7	**mean±SD**	295.6±7.8	$p > 0.05$
	median(range)	293(279-305)	**median(range)**	295(280-315)	$p > 0.05$

Regarding Perfusion density in parafovea and perifovea layers, No significant change was observed in parafovea and perifovea perfusion density one month postoperatively ($p > 0.05$) **(Table 4)(Supplemental Figure 3,4).**

Table 4: Preoperative and One-month postoperative perfusion density measurements of the patients (n=35)

Variable	Preoperative(n=35)		One-month postoperative(n=35)		p Value
Perfusion density	**Parafovea**		**Parafovea**		
	mean±SD	27.1±3.7	**mean±SD**	27.1±3.9	$p > 0.05$
	median(range)	27(22-36)	**median(range)**	27(22-36)	$p > 0.05$
	Perifovea		**Perifovea**		
	mean±SD	30.8±4.1	**mean±SD**	30.4±4.2	$p > 0.05$
	median(range)	30(24-40)	**median(range)**	30(24-40)	$p > 0.05$

The Fovea avascular zone area showed no significant change in one month postoperatively ($p > 0.05$) **(Table 5).**

Table 5: Diameter of FAZA pre-operative and one month postoperative:

FAZA	Preoperative(n=35)	One-month postoperative(n=35)	p Value
Mean±SD mm	0.40±0.05	0.39±0.05	$p > 0.05$
Median (range)mm	0.40 (0.32-0.52)	0.39 (0.31-0.51)	$p > 0.05$

Abbreviations;FAZA;foveaavascular zone area.

So, there was a statistically significant increase in BCVA from pre to post-Nd: YAG (p <0.001) and no significant difference was determined before and after capsulotomy in macular thickness measurements, flow areas, and vessel perfusion densities ($p > 0.05$).

Figure legends

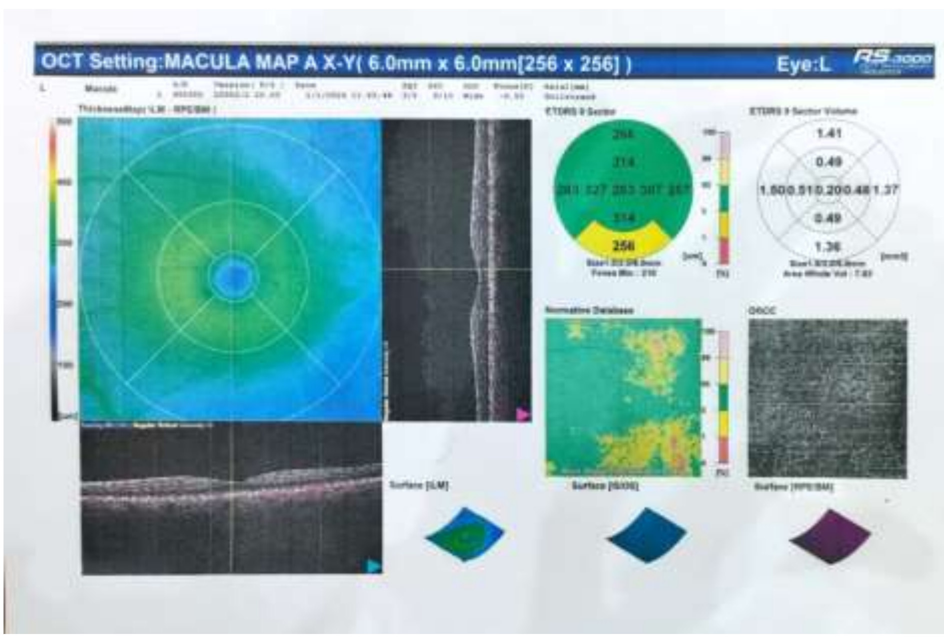

Figure 1: A 6.0×6.0 mm optical coherence tomography angiography showing macular thickness of the left eye 60 year-old- female patient before YAG laser Capsulotomy.

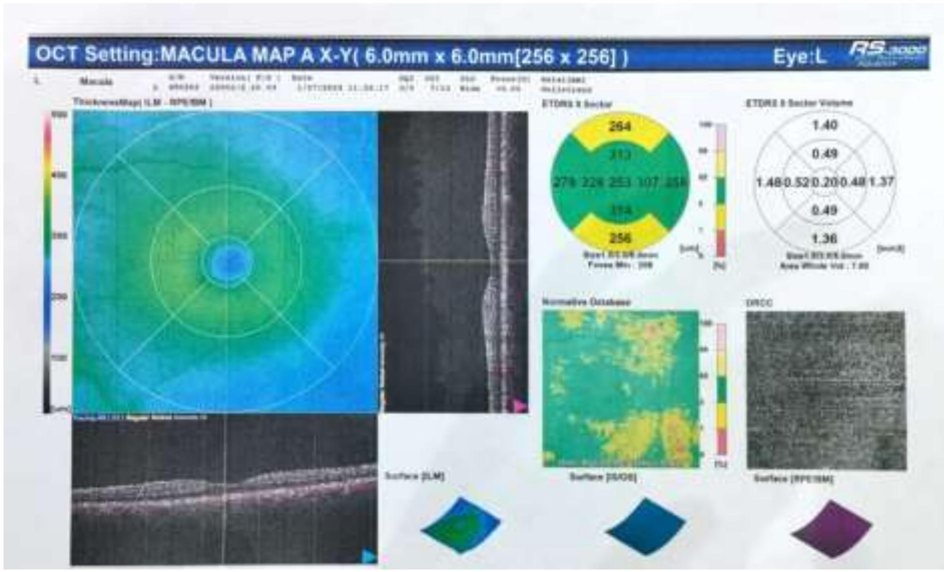

Figure 2: A 6.0×6.0 mm optical coherence tomography angiography showing macular thickness of the left eye 60 year-old- female patient 1 month after YAG laser Capsulotomy.

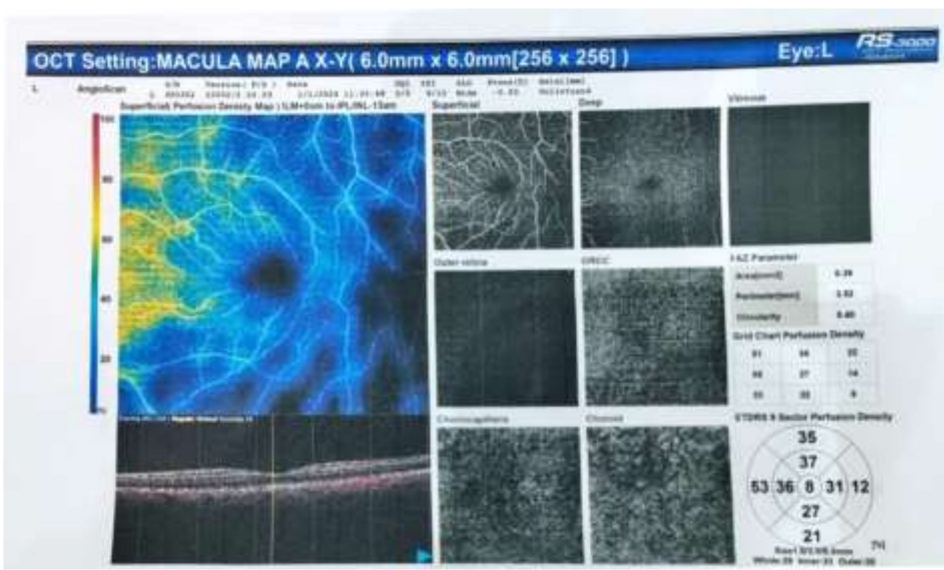

Figure 3: A 6.0×6.0 mm optical coherence tomography angiography showing vessels perfusion densities of the left eye 60 year-old- female patient before YAG laser Capsulotomy.

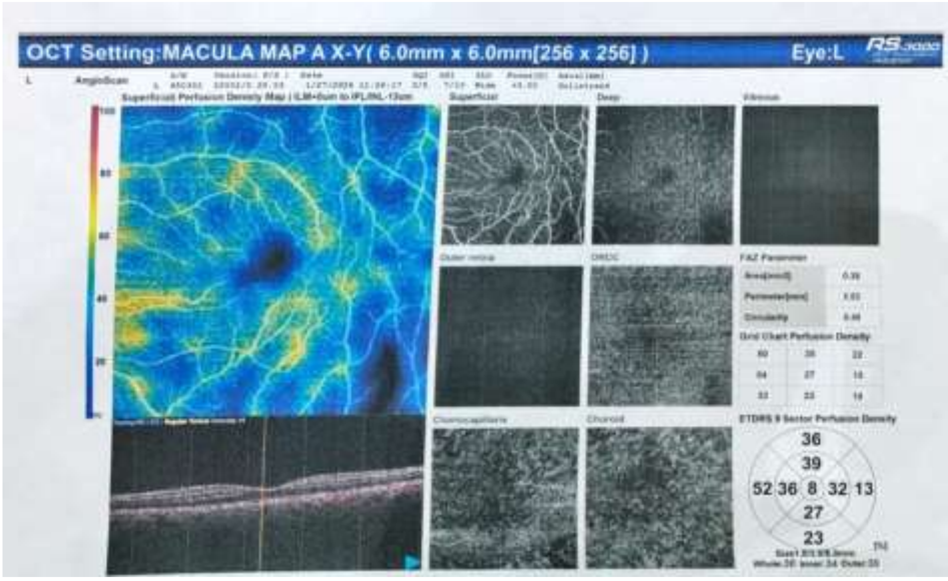

Figure 4 : A 6.0×6.0 mm optical coherence tomography angiography showing vessels perfusion densities f the left eye 60 year-old- female patient 1 month after YAG laser Capsulotomy.

DISCUSSION

Fibrosis of the posterior lens capsule that results after cataract surgery is known as posterior capsule opacification. It remains a common complication of lens surgery despite advancements in phacoemulsification procedures and intraocular lens design. The yttrium-aluminum-garnet (Nd-YAG) laser, with its high success rate, noninvasive nature, and ease of use in polyclinic settings, is the commonly used therapy option for posterior capsule opacification following cataract surgery. Late problems following Nd-YAG capsulotomy can affect both the anterior and posterior segments. These complications can include changes in intraocular pressure, damage to the intraocular lens, retinal detachment, vitritis, haemorrhage from the vitreous, and cystoid macular edema.

Numerous studies have examined how Nd-YAG capsulotomy affects the posterior section. Using optic coherence tomography (OCT), various research looked for macular and foveal thickness among retinal effects. The noninvasive technique known as optic coherence tomography angiography (OCTA) has recently been used as a diagnostic tool to show retinal vascular architecture. It allows for the quantitative assessment of vascular flow areas and vascular density, providing important information on retinal and choroidal vascular diseases such as diabetic retinopathy, retinal vein occlusion, and central serous chorioretinopathy. This information helps to illuminate the pathophysiology of these conditions. Furthermore, OCTA makes it possible to examine vascular density and vascular flow in the area of the optic nerve head. Changes in the posterior segment may occur subsequent to the application of Nd-YAG; however, no quantitative investigation has been carried out to yet to record these occurrences. Using optical coherence tomography angiography, we compared the retinal microvasculature and macular thickness before and after Nd-YAG laser capsulotomy in order to investigate the impact of the procedure.

This quasi experimental study was done on 35 patients with Posterior capsule opacification attending ophthalmology outpatient clinic for YAG laser intervention. Patients in this study ranged in age from 60 to 80 years old, with a mean age of 70. Males represent 51.4% of the study patients and females represented 48.6%. Investigations are currently ongoing to determine how Nd-YAG capsulotomy affects the anterior and posterior regions. Our study is remarkable since it is one of the first studies to examine retinal vessels perfusion density using OCTA. According to our research, there was no discernible difference in macular thickness measurements, flow regions, or vessel perfusion densities before and after capsulotomy.

This is in agreement with Selma Urfalioglu *et al* study. The study included 15 eyes from 15 non-diabetic patients who had Nd-YAG laser capsulotomy and posterior capsule opacification. Prior to, one hour after, one week after, and one month after the laser operation, patients had OCTA imaging. Measurements of macular thickness, flow regions, and vessel densities were compared before and after capsulotomy, and no discernible differences were found [8].

Similarly, Mehmet Icoz *et al* study at which thirty-two non-diabetic patients who received PCO treatment with a Nd:YAG laser and had their 32 eyes examined. Using an optical coherence tomography equipment (OCT), visual acuity (VA), intraocular pressure (IOP), and central macular thickness (CMT) are measured. IOP and CMT readings did not significantly differ across all comparisons made before and after the laser. ($p>0.05$ for all values) [9].

In the same line with our study But before the era of OCTA, Ewa Wroblewska-Czaika *et al* evaluated central macular thickness change after Nd: YAG capsulotomy using optical coherence tomography (OCT). 55 non-diabetic individuals (43 females and 12 males) with a mean age of 65.1 +/- 13.9 years (range 21-87) received posterior capsule opacification with Nd: YAG capsulotomy. Prior to surgery and one month following Nd: YAG capsulotomy, patients underwent examinations. OCT was used to measure the central retinal thickness. There was no statistically significant change of the central macular thickness in any time point. [10]. Also Giocanti-Aurégan *et al* did a prospective study on patients who underwent Nd:YAG laser capsulotomy between May 2008 and November 2009. Clinical characteristics (visual acuity, intraocular pressure) prior to and following Nd:YAG laser treatment, as well as demographic factors (age, sex, and medical history), were examined. OCT (Stratus OCT 3, Zeiss) was used to measure the central foveal thickness. Data were gathered one week, one month, and three months following Nd:YAG laser capsulotomy. A comparison was made between the thicknesses before and after surgery. After laser treatment, the foveal thickness did not change much in the first three months [11].

In 2017 Tolga Yilmaz *et al* evaluated long-term changes in central macula thickness after Nd:YAG laser capsulotomy. This prospective study comprised 42 eyes from 42 non-diabetic patients who had Nd:YAG laser capsulotomy. Prior to surgery, at postoperative week 1, and in the first three, six, and twelve months following surgery, CMT was assessed. Prior to surgery, the CMT was 238.1 ± 27.6 µm (mean ± SD). After surgery, it was 239.7 ± 29.8, 241.3 ± 28.7, 242.7 ± 27.2, 238.8 ± 23.7, and 238.3 ± 21.7 µm at weeks 1, 3, 6, and 12, respectively [12].

An increase in Macular Tickness can be observed after Nd:YAG laser capsulotomy, especially in diabetic patients. Uğur Yılmaz *et al* performed a study to assess the changes in macular thickness in diabetic and non-diabetic patients . Patients were categorised into groups based on whether or not they had diabetes mellitus (DM). Prior to laser capsulotomy, as well as the first day, first week, first month, third month, and sixth month following the procedure, measurements were taken. Increased MT was observed in Group 1 (DM patients) throughout the first week and in the first, third, and sixth months following laser treatment ($p < 0.001$). Patients in Group 2, which did not have diabetes, had higher MT during the first week. At the first and third months, there was no statistically significant difference, and at the sixth month, there was no change ($p > 0.05$) [13].

CONCLUSION

Nd-YAG laser capsulotomy for posterior capsule opacification is considered to be a safe procedure and as there was significant increase in BCVA from pre to post-Nd: YAG (p <0.001) and no significant difference was determined before and after capsulotomy in macular thickness measurements, flow areas, and vessel perfusion densities ($p > 0.05$).

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