

Effect of YAG Laser Posterior Capsulotomy on Central Macular Thickness in Pseudophakic Patients

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ABSTRACT

Background: posterior capsular opacification (PCO), also known as ‘secondary cataract’ or ‘after cataract’, develops a few months to a few years over the clear posterior capsule after an uncomplicated cataract surgery.

Purpose: evaluation the impact of Neodymium-doped Yttrium Aluminum-Garnet (Nd: YAG) laser capsulotomy on central macular thickness (CMT) by optical coherence tomography (OCT).

Patients and Methods: the present study examined 50 eyes (24 males, 26 females) with an average age of 63.58 ± 7.7 which was pseudophakic and had PCO, preoperative evaluation included history taking, ophthalmological examination and OCT was done. All patients underwent YAG laser posterior capsulotomy and CMT assessed at 3 days, 1 week, 1 month and 3 months by OCT.

Results: there was significant improvement of BCVA (LogMAR) post laser capsulotomy ($P < 0.001$), IOP statistically significant increased ($P < 0.001$) at the first postoperative 3 days, 1 week, 1 month with mean \pm SD of 16.46 ± 2.54 mmHg 17.50 ± 2.67 mmHg, 15.50 ± 2.39 mmHg respectively when compared to preoperative values 13.0 ± 1.67 mmHg. At 3 months there was minimal change ($P = 0.02$). As regard CMT values at 1 week post laser (mean \pm SD of 270.92 ± 24.88) was highly significant increased ($P < 0.001$) and values at 3 months (mean \pm SD of 248.70 ± 21.66) showed non-significant difference ($P = 0.285$) when compared to pre laser values (mean \pm SD of 245.58 ± 23.30).

Conclusion: typical treatment of the PCO is YAG laser capsulotomy, IOP elevation is the most prevalent complication so antiglaucoma drugs is recommended and IOP return to normal values in the follow up period.

Keywords: Posterior Capsule Opacification (PCO), Nd: YAG laser, Central Macular Thickness (CMT)

INTRODUCTION

Posterior capsular opacification (PCO), also known as ‘secondary cataract’ or ‘after cataract’, develops a few months to a few years over the clear posterior capsule after an uncomplicated cataract surgery⁽¹⁾. PCO is the most prevalent complication of uneventful cataract surgery that appears lately⁽²⁾. There are known two types of PCO, pearl and fibrous, or combination of both. PCO developed by abnormal proliferation, migration and differentiation of LECs (lens epithelial cells)^(1,3). PCO incidence is at a rate of between 3% and 50% in the first 5 postoperative years in eyes undergoing uncomplicated cataract surgery⁽⁴⁾. Pseudophakic patients with PCO complaining of decreasing visual acuity as well a slight scatter and affects contrast sensitivity^(5,6). PCO typical treatment is Neodymium-doped Yttrium Aluminum-Garnet (labeled as Nd : YAG) laser capsulotomy, which is valuable, quick, noninvasive, relatively secure technique and outpatient procedure^(7,8).

The method is credible but some complications may occur as IOP elevation, IOL pitting, iritis, vitreous prolapse, retinal detachment, macular edema and change in refraction⁽⁹⁾. IOP elevation is the most prevalent complication of YAG laser posterior capsulotomy despite using anti- glaucoma as a prophylactic treatment⁽³⁾.

The rise of IOP was mostly due to blocking of the trabecular meshwork by cells and flare released after capsulotomy in the anterior chamber⁽⁸⁾. Macular edema

resulting from increasing the permeability of the perifoveal capillaries due to releasing of inflammatory mediators as YAG laser capsulotomy causing damage of the vitreous⁽⁹⁾. OCT is a noncontact diagnostic tool that can perform cross-sectional imaging of the retina. The spectral domain (SD)-OCT system measures retinal thickness from the retinal pigment epithelium to the internal limiting membrane, thereby giving the correct thickness of the retinal layers, OCT images allow investigation of retinal pathology and visualization of internal retinal architecture⁽¹⁰⁾.

AIM OF THE WORK

This work aims to evaluate the impact of YAG laser capsulotomy on the central macular thickness (CMT) by optical coherence tomography (OCT).

PATIENTS AND METHODS

This study included 50 eyes (24 males, 26 females) with an average age of 63.58 ± 7.7 which was pseudophakic and had PCO.

Inclusion criteria: The patients had PCO which graded as Grade 1: Minimal PCO: red reflex is not reduced, no pearls at all, slight opacity at the periphery. Grade 2: Mild PCO: reduced red reflex, Elschnig pearls to the IOL edge. Grade 3: Moderate: Elschnig pearls or fibrosis within IOL edge but with clear the visual axis .with slit lamp grading

in pseudophakic patients underwent uneventful cataract surgery. The time between cataract extraction surgery and PCO development was at least three months. Both male & female patients attended outpatient clinic of Al-Azhar University Hospital (Damietta branch) & referred from other doctors were included.

Exclusion criteria: 1- Presence of any past or current retinal disease and involve the macula, 2- An abnormal measurement of the macula on OCT preoperatively, 3- Patients with a history of complicated cataract surgery or uveitis, and 4- Media opacity that interfere with preoperative retinal evaluation including dense PCO.

Written informed consent: An approval of the study was obtained from Al- Azhar University academic and ethical committee.

Every patient signed an informed written consent for acceptance of the operation.

Preoperative Evaluation : included history taking, and, preoperative ophthalmological examination in the form of: refraction using Nidek automated refractometer, uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA) were evaluated by landot C optotype using Snellen's chart which was translated into a logarithm of the minimal angle of resolution (logMAR) scale, pupil reactivity, slit lamp examination to assess: Cornea, Anterior chamber, Posterior chamber intraocular lens, diagnosis of PCO and confirmation of the grade, intraocular pressure (IOP), fundus examination. Preoperative investigation included OCT by Topcon 3D 2000 OCT.

Operative steps: Q-switched YAG laser VISULAS YAG III was used. The Procedure explained to the patient about the aim and painless nature of the procedure and importance of maintenance of steady fixation and he may hear clicking sound, Full mydriasis with topical tropicamide 1% and phenylephrine hydrochloride 2.5% was done. Topical anesthesia with benoxinate hydrochloride 0.5% eye drops was obtained. A contact laser capsulotomy lens with lubricating gel (methyl cellulose) was used during the capsulotomy.

Capsulotomy Technique: In this study we use an average 3.2 ± 0.5 mJ per pulse which was sufficient to open posterior capsule. The energy setting per pulse may be increased according to thickness of posterior capsules Starting at low energy and gradually increase if necessary. In this study the average total laser shots was 26.4 ± 19.4 which was sufficient to open the posterior capsule. Capsulotomy size is determined by size of the pupil in ambient light conditions (approximately: 4-5mm). All capsulotomies were completed in one session. Pattern of capsulotomy

opening was Cruciate opening or Christmas tree pattern opening.

Postoperative Advice: prescription of topical prednisolone acetate 1% 4 times per day and brimonidine tartrate 0.2% 2 times per day for 1 week post Laser therapy.

Follow-Up Schedule: The postoperative findings will be scheduled within the first three days, first week, first month and third month. All patients did ophthalmic examination including: (BCVA), Slit lamp examination (for: Cornea, Anterior chamber, pupil, Posterior chamber intraocular lens), IOP, Fundus examination and OCT.

Statistical analysis

All follow up score assessments were calculated considering pre-assessment score as baseline. Descriptive statistics were made for all variables. Continuous normally distributed data were expressed as mean and standard deviation (SD). Ordinal data and continuous data not fitting to the normal distribution curve were presented as medians (range) meanwhile categorical data were reported as percentage of the total number. We did a stratified analysis to compare the mean change of the variables (BCVA, IOP and CMT) at different follow up points through a two-sample t-test (Welch t-test). Then we used linear regression to find the relation between patients' characteristics and change of CMT score from baseline till 3 months of follow up. All tests were two-sided with statistical significance below 0.05. All statistical analyses were performed using R software version 3.4.4 (R Foundation for Statistical Computing, Vienna, Austria). Our figures were generated using R package.

RESULTS

Table (1): Baseline Characteristics

Total number	50
Age (mean (SD))	63.58 (7.78)
Gender = Female (%)	26 (52.0)
Male (%)	24 (48.0)
Diabetic History = Present (%)	7 (14.0)
Absent (%)	43 (86.0)
Pseudophakic eye = Left (%)	27 (54.0)
Right (%)	23 (46.0)
Type operation = Phaco (%)	4 (8.0)
Ecce (%)	46 (92.0)
PCO degree = Minimal (%)	3 (6.0)
Mild (%)	40 (80.0)
Moderate (%)	7 (14.0)
Energy shot (mean (SD))	3.28 (0.53)
Total shots (mean (SD))	26.44 (19.40)
Total energy (mean (SD))	81.77 (58.98)

In the present work, Age of patients ranged from 47 to 82years with mean of 63.5 years and standard deviation 7.78 years. There were 24 males (48.0%) and 26 females (52.0%).As regard side of the eye, it was right eye in 23 patients (46.0%) and left eye in 27 patients (54.0%). As regard type of cataract extraction operation there was 46 eyes (92.0%) by phacoemulsification and 4 eyes (8.0%) by extra capsular cataract extraction (ECCE).

As regard grades of PCO there were 3 eyes (6.0%) minimal degree, 40 eyes (80.0%) mild degree and 7 eyes (14.0%) moderate degree. As regard time from cataract extraction till YAG procedure, it ranged from 3 to 96 months with mean duration of 21.72 months and standard deviation 16.96 months table (1).

As regard BCVA There was significant improvement of BCVA (Log MAR) postoperatively (P< 0.001), the preoperative measurements ranged from 0.30 to 1.30 with the mean \pm SD of 0.85 \pm 0.26. At the first three days postoperative, BCVA ranged from 0.20 to 0.80 with a mean of 0.32 \pm 0.17. At one week the BCVA ranged from 0.00 to 0.80 with a mean of 0.26 \pm 0.15.

At one month and three months there was no difference in postoperative values, the BCVA ranged from 0.00 to 0.80 with a mean of 0.25 \pm 0.14 table (2). As regard IOP, the preoperative IOP ranged from 11.0 to 18 mmHg with the mean \pm SD of 13.0 \pm 1.67 mmHg. At three days post laser, IOP ranged from 12 to 21.0 with mean of 16.46 \pm 2.54 mmHg, At one week IOP ranged from 12 to

23.0 with mean of 17.50 \pm 2.67 mmHg, At one month IOP ranged from 11 to 21.0 with mean of 15.50 \pm 2.39 mmHg, At three months IOP ranged from 11 to 17.0 with mean of 14.04 \pm 1.62 mmHg.

When comparing pre- operative values to post-operative values, there was statistically significant increase of IOP at the first postoperative three days, one week and one month and there was minimal change in IOP at three months table (3).

As regard CMT, the preoperative CMT ranged from 173.0 to 289.0 with mean \pm SD of 245.58 \pm 23.30, At three days post laser, CMT ranged from 203.0 to 304.0 with mean \pm SD of 260.64 \pm 22.50, At one week post-operative CMT ranged from 211.0 to 336.0 with mean \pm SD of 270.92 \pm 24.88, At one month post-operative CMT ranged from 200.0 to 300.0 with mean \pm SD of 256.22 \pm 22.44, At three months CMT ranged from 193.0 to 290.0 with mean \pm SD of 248.70 \pm 21.66.

When comparing values of CMT preoperative and postoperative we found that high significant increase in CMT at one week and no significant change at three months table (4,5). As regard studying factors that affectCMT we found that factors as age , gender , type of operation, duration from operation, degree of PCO, number of shots and energy used not significantly affect CMT after YAG procedure Except there was significant effect of diabetes in CMT change table (6).

Table (2): BCVA (LOG MAR) comparison at different time points

	BCVA_ preyag	BCVA_ 3days	BCVA_ 1week	BCVA_ 1month	BCVA_ 3months
N	50	50	50	50	50
Mean	0.58	0.32	0.26	0.25	0.25
Std. Deviation	0.26	0.17	0.15	0.14	0.14
Minimum	0.30	0.20	0.00	0.00	0.00
Maximum	1.30	0.80	0.80	0.80	0.80
t-test from baseline		< 0.001	< 0.001	< 0.001	< 0.001

Boxplot, dotplot and SEM plot of weight for BCVA

Gray dots=sample data points, Black dot=outlier, Blue dot=mean, Red=95% confidence interval

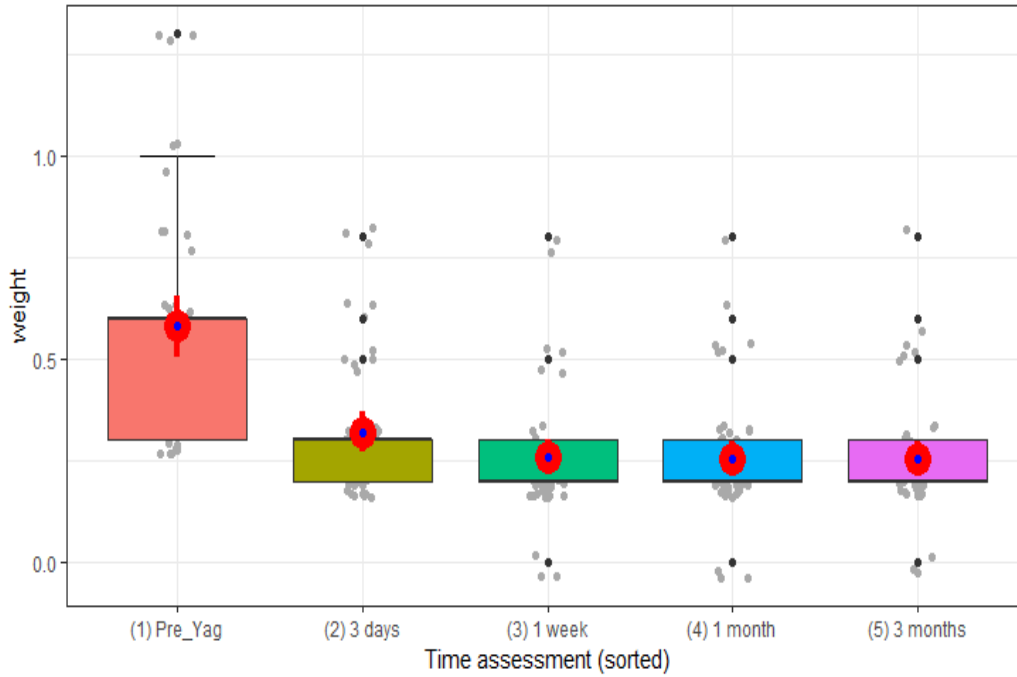


Figure (1): BCVA (LOG MAR) comparison at different time points

Table (3): IOP comparison at different time points

	IOP_ pre_yag	IOP_ 3days	IOP_ 1 week	IOP_ 1 month	IOP_ 3months
N	50	50	50	50	50
Mean	13.02	16.46	17.50	15.30	14.04
Std. Deviation	1.67	2.54	2.76	2.39	1.62
Minimum	11.00	12.00	12.00	11.00	11.00
Maximum	18.00	21.00	23.00	21.00	17.00
t-test from baseline		< 0.001	< 0.001	< 0.001	0.02

Boxplot, dotplot and SEM plot of weight for IOP

Gray dots=sample data points, Black dot=outlier, Blue dot=mean, Red=95% confidence interval

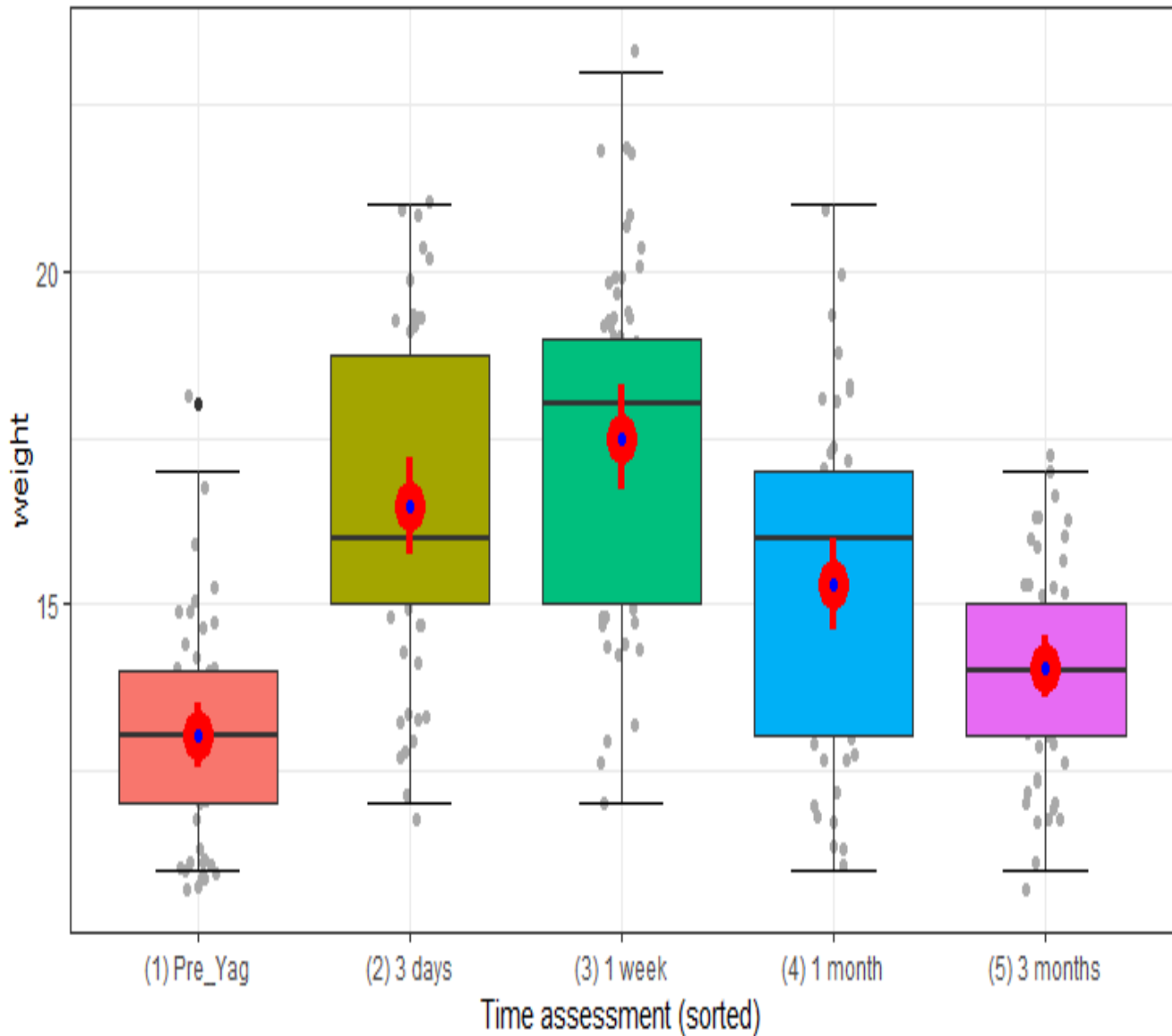


Figure (2): IOP comparison at different time points

Table (4): CMT comparison at different time points

	CMT_ pre_yag	CMT_ 3days	CMT_ 1week	CMT_ 1month	CMT_ 3month s
N	50	50	50	50	50
Mean	245.58	260.64	270.92	256.22	248.70
Std. Deviation	23.30	22.50	24.88	22.44	21.66
Minimum	173.00	203.00	211.00	200.00	193.00
Maximum	289.00	304.00	336.00	300.00	290.00

Boxplot, dotplot and SEM plot of weight for CMT

Gray dots=sample data points, Black dot=outlier, Blue dot=mean, Red=95% confidence interval

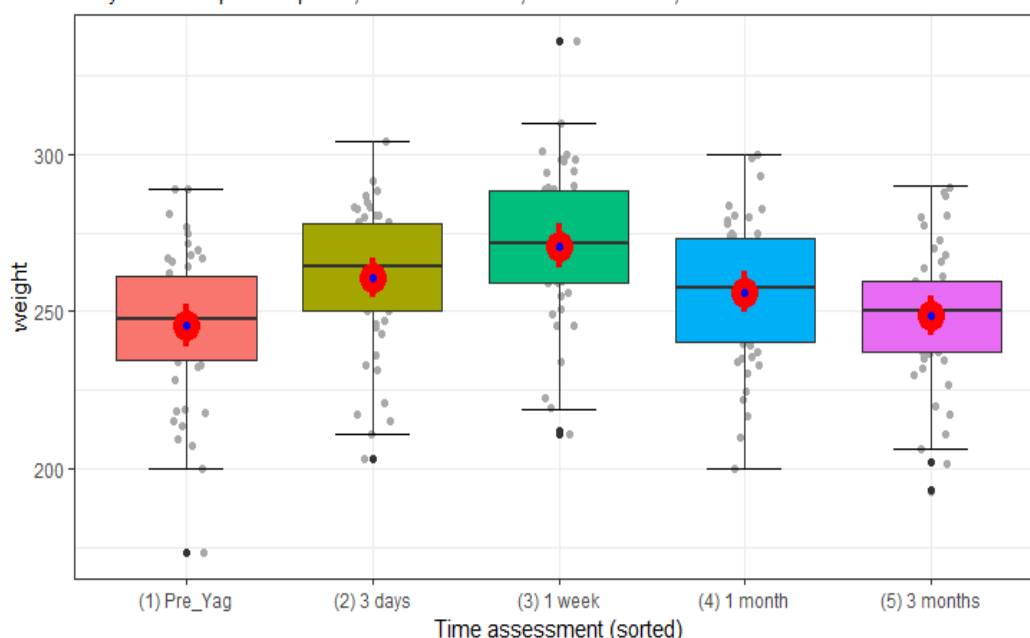


Figure (3): CMT comparison at different time points

Table (5): Central Macular Thickness (CMT) comparison at different time points:

	Paired Differences					P value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		
				Lower	Upper	
CMT_pre_yagVS CMT_3days	-15.06	18.48	2.61	-20.31	-9.80	0.001
CMT_pre_yagVS CMT_1week	-25.34	22.93	3.24	-31.85	-18.82	<0.001
CMT_pre_yag VS CMT_1month	-10.64	24.41	3.45	-17.57	-3.70	0.003
CMT_pre_yagVS CMT_3monthes	-3.12	20.41	2.88	-8.92	2.68	0.285

Table (6): Factors affecting change of CMT (linear regression between study covariates and change of CMT score from baseline till after 3 months)

	Hazard ratio	Standard error	P-value
(Intercept)	63.12	43.78	0.15
Age	-0.51	0.44	0.25
Gender (male vs female)	10.06	6.38	0.12
Diabetic state	-19.65	9.82	0.05
Durationfromoperation	-0.25	0.18	0.16
Phacovs ECCE	2.72	12.22	0.82
Degree			
• (mild)	-19.87	12.40	0.11
• (moderate)	-6.18	9.51	0.52
Energy per shot	-7.98	11.83	0.50
Total shots	-1.07	0.81	0.19

Total energy	0.37	0.27	0.19
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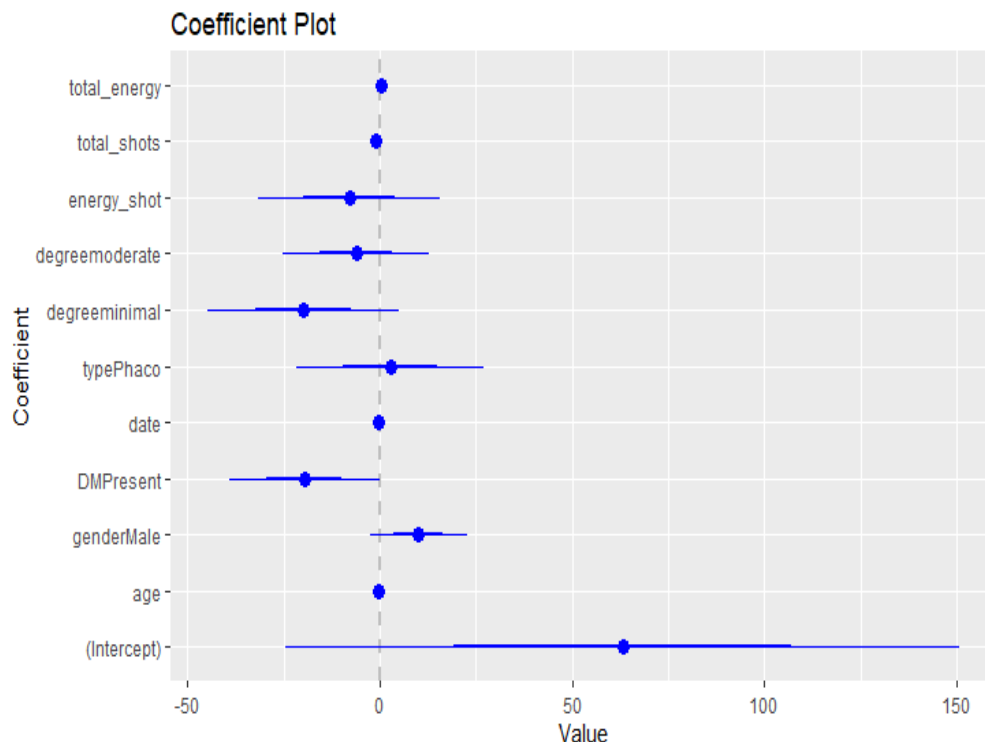


Figure (4): Factors affecting change of CMT (linear regression between study covariates and change of CMT score from baseline till after 3 months).

DISCUSSION

In the present study, when comparing postoperative values at three days, one week, one month and three months to corresponding preoperative value, there was statistically significant improvement of BCVA up to 0.00 (Log MAR) in majority of patients consistent with decrease of all postoperative numerical values of BCVA (Log MAR) with no statistically changes in values from one week till three month. This was consistent with what was proved by other studies done by **Mayuri et al.**⁽⁸⁾ whose study was on 100 eyes of 100 patients, **Jitendra et al.**⁽⁷⁾ whose study was on 160 eyes, 95% of the patients had visual function improvement, **Ohm Vrajlal et al.**⁽¹¹⁾, **Selim et al.**⁽⁹⁾.

As regards IOP in the present study, comparing pre laser values and post laser values, the mean IOP levels were significantly higher than preoperative levels. Increasing in IOP was transient and returned to normal values within few days in most cases. The rise of IOP was mostly due to blocking of the trabecular meshwork by cells and flare released after capsulotomy in the anterior chamber⁽⁸⁾.

In the present work we prescribed topical prednisolone acetate 1% 4 times per day and brimonidine tartrate 0.2% 2 times per day for 1 week postoperatively. there was 5 cases (10%) showed IOP elevation >5 mm

Hg, In 12% patients the IOP was ≥ 20 mm Hg, 25 cases (50%) showed rise in IOP ranged from 2-5 mm hg. **Vrajlal et al.**⁽¹¹⁾ observational study, they found transient rise in IOP in 64% cases, 59% patients showed IOP elevation ≤ 5 mm Hg and only 5% of the patients had IOP elevation > 5 mm Hg. IOP was above 25 mm Hg in 5% patients, the patients were prescribed 0.5% timolol maleate eye drops twice a day for one week. The IOP elevation was transient and no patient showed rise in IOP at 1 week. **Maqsood et al.**⁽¹²⁾ and **Gore**⁽¹³⁾ mentioned transient IOP elevation in 56.2% and 59.4% of cases respectively. **Ari et al.**⁽¹⁴⁾ studied the impact of YAG laser energy in capsulotomy procedure on IOP and found that the rise of IOP was less when the total energy was less than 80 mJ. **Eyyup et al.**⁽³⁾ studied the impact of YAG Laser Posterior Capsulotomy Size on IOP and they divided patient into two groups, small and large size capsulotomy, they found that significant increase in the mean IOP values in both groups. IOP elevation was more in large capsulotomy group. This is may be due to releasing large particles of capsulotomies in second group.

They recommend using apraclonidine hydrochloride 0.5% twice daily for at least 5 days. **Rahul et al.**⁽¹⁵⁾ mentioned that the incidence of IOP elevation was 12.6% and this was significantly more in the group

with higher total energy levels (226 ± 233 mJ). Series of 30 patients with PCO Mean IOP on the post-operative day one was 21.5 ± 6.6 mmHg. Mean laser energy in the subgroup with IOP elevation ($n = 60$) was 57.8 ± 26.8 mJ as compared to 42.3 ± 26.6 mJ in eyes with no IOP elevation ($n = 414$) ($P < 0.001$). IOP returned to normal limits at 2 weeks in most patients following topical treatment with 0.5% apraclonidine eye drops twice daily. Out of 6 patients who developed sustained IOP elevation, two had medically controlled glaucoma. These were referred to the glaucoma clinic for further management. **Selim et al.**⁽⁹⁾ did not find significant increase, Brimonidine tartrate was prescribed post laser twice daily for 1 week.

In the present work, when comparing postoperative values of CMT with preoperative values we found highly significantly increase in CMT at one week post laser. Also there was significant increase in CMT at three days and one month values at three months showed non-significant changes when compared to preoperative values. No cases of Cystoid Macular Edema noticed in the present study. In the present study we prescribed topical prednisolone acetate 1% four times a day as an anti-inflammatory drug. On studying the factors may influence CMT as age, gender, type of operation, duration from operation, degree of PCO, number of shots and energy used not significantly affect CMT post laser. In the present work we observe significant increase in CMT especially in diabetic patients who had no retinopathy versus non diabetic this is consistent with the study **Ugur et al.**⁽¹⁶⁾. **Altıparmak et al.**⁽¹⁷⁾ used 1% prednisolone 4 times per day and brimonidine tartrate twice a day for 1 week to patients post laser capsulotomy and they found there was no statistically significant difference in CMT during 1 year follow-up. They used OCT after 2 days, 7 days, and after 1, 3, 6, and 12 months for CMT assessment. **Auré'ganet al.**⁽¹⁸⁾ applied topical rimexolon 4 times per day, acetazolamide 2 times per day for 1 week post laser capsulotomy and did not find any significant increase in CMT during 3 months follow-up. **Ari et al.**⁽¹⁴⁾ studied 30 patients and prescribed 1% prednisolone 4 times per day and 0.5% apraclonidine hydrochloride 2 times per day for 1 week post laser therapy, they divided the patients into two groups as regard to the total laser energy was used; less than 80 mJ and more than 80 mJ.

They noticed an increase in CMT in both groups by OCT. which was more in the group with total energy more than 80 mJ. **Turkey et al.**⁽¹⁹⁾ did not find significant change in CMT in long term follow up. **Karahan et al.**⁽³⁾, divided the patients into two groups according to capsulotomy size (group 1 < 3.9mm, group 2 > 3.9mm). They prescribed topical 1% prednisolone 4 times per day

and 0.5% apraclonidine hydrochloride 2 times per day for 5 days after laser capsulotomy CMT assessed by OCT after 1, 4 and 12 weeks, and they found significant increase in CMT at the first week in both groups. They observed that there was no significant difference in CMT after 4 and 12 weeks compared to pre laser values. **Ugur et al.**⁽¹⁶⁾ study divided the patients into four groups according to presence of diabetes mellitus (DM) and drugs used after capsulotomy. Group 1: Patients with DM using only 0.1% Fluorometholon (22 patients). Group 2: Patients with DM using 0.5% ketorolac and 0.1 Fluorometholon (20 patients). Group 3: Patients without DM using only 0.1% Fluorometholon (22 patients). Group 4: Patients without DM using 0.5% ketorolac and 0.1% Fluorometholon (24 patients). They did not find significant increase in CMT in both diabetic and non-diabetic patient groups who used ketorolac with fluorometholon.

CMT increased in diabetic patients using only fluorometholon through follow up period of six months. Non diabetic patients using only fluorometholon showed non-significant difference in CMT at the end of six month period of follow up. They postulated that an inflammation occurring post laser capsulotomy and might cause an increase in CMT in diabetic patients who have a higher risk for macula edema because of retinal microangiopathy. Adding topical ketorolac to topical steroid therapy after laser treatment can prevent this increase in CMT. **Rahul et al.**⁽¹⁵⁾ mentioned the incidence of CME after Nd: YAG laser capsulotomy ranges from 0.6- 4.4%. Those patients received high total laser energy levels. **Selim et al.**⁽⁹⁾, did not find significant change in CMT during the first month. They also studied CMT according to the energy levels, they did not observe any significant change in short follow-up period. They did not observe cystoid macular edema in any patient. In the present study there was one case had vitreous prolapse as complication of YAG laser posterior capsulotomy.

CONCLUSION

Typical treatment of the PCO is YAG laser capsulotomy. YAG laser capsulotomy therapy is non-invasive, valuable, out-patient procedure, quick relatively secure technique. Nd: YAG laser capsulotomy clearing visual axis from opacification so visual functions improved directly after performing the procedure. This method is credible but it has some complications, the most common one is increased IOP so prescription of anti-glaucoma drugs is recommended and IOP return to normal values in the follow up period. Increased CMT was reported as complication of YAG

laser posterior capsulotomy. Although this not clinically observed but follow up with OCT revealed this changes.

Here was no relation between age, gender, energy used, PCO type and increased CMT. An increase in CMT noticed after Nd: YAG laser capsulotomy more in diabetic patients. Vitrous prolapse known complication post YAG laser and we observe one case in present study.

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