

Effect of Quantum of Energy used During Nd:YAG Laser Posterior Capsulotomy on Magnitude of IOP Rise

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Objective: To find out whether there exists a correlation between the quantum of energy used and the amount of rise of intra ocular pressure (IOP) following Nd:YAG laser capsulotomy.

Materials and methods: The subjects were enrolled after taking a written informed consent. A total of 110 patients undergoing Nd:YAG laser posterior capsulotomy for management of posterior capsule opacification with a minimum of 3 months following cataract surgery. After detailed history and ocular examination, Nd:YAG laser capsulotomy was performed. Pre-laser IOP was noted. Nd:YAG laser posterior capsulotomy was performed. Laser energy used was noted following which post-laser IOP was recorded after 1, 2 and 4 hours post-procedure. Paired t-test was used for comparison of means of IOP and energy levels. ROC analysis was used to predict the cutoff value of energy on the basis of change of IOP from baseline.

Abstract

Results: Mean energy used in Nd:YAG Laser posterior capsulotomy procedure for all patients was 58.57 ± 34.63 mJ. Mean IOP at 1st hour follow-up was 15.32 ± 2.91 mmHg, at 2nd hour follow-up was 16.24 ± 3.23 mmHg and at 4th hour follow-up was 16.18 ± 3.35 mmHg. At all three follow-ups, mean change in IOP was found to be statistically significant ($p < 0.001$).

Conclusion: Post laser IOP rise is minimal and transient; it varies with the amount of energy used.

Delhi J Ophthalmol 2020;31;56-61; Doi <http://dx.doi.org/10.7869/djo.592>

Keywords: Intra Ocular Pressure (IOP), Posterior Capsular Opacification (PCO), Laser Capsulotomy.

Introduction

Cataract is the major cause of blindness in India accounting for about 62.6% amongst all causes of blindness.¹ Cataract surgery is probably the most common Ophthalmic surgical procedure being carried out throughout the world. Posterior capsular opacification is a frequent complication of cataract surgery. It varies from 7% to 31%, 2 years post cataract surgery. Although the incidence of PCO varies among studies, rates as high as 11.8% at 1 year after cataract surgery, 20.7% at 3 years, and 28.4% at 5 years have been reported.² Neodymium Yttrium Aluminum Garnet (Nd:YAG) laser capsulotomy is a safe, non-invasive and time-trusted procedure for the management of PCO.¹¹ PCO occurring within 3 mm of the central posterior capsule affects visual acuity significantly.³ Since 1980, Nd:YAG laser capsulotomy has become a standard treatment to improve visual acuity in pseudophakic patients with PCO.^{4,5} Improvement in visual acuity after Nd:YAG laser capsulotomy in patients with significant PCO has been well documented.^{6,7,8} Improvements in glare and contrast sensitivity may also be important outcome measures for many patients.^{9,10,11} Although Nd:YAG laser capsulotomy is accepted as standard treatment for PCO and has been found to be safe and effective, it is not without complications, some of which can be sight-threatening such as retinal edema and detachment.¹²

It is important to evaluate anterior and posterior chamber parameters before and after Nd:YAG laser capsulotomy because it can cause complications, like elevation of intraocular pressure (IOP) and corneal injury.^{13,14,15} In our study we tried to evaluate the correlation between quantum of energy used during Nd:YAG laser capsulotomy for PCO after cataract surgery with an objective to find out if there exists a correlation between the two, which would help us determine those patients who require prophylactic

anti-glaucoma drugs and a closer follow-up and avoid any inadvertent usage of anti-glaucoma drugs in all pseudophakes undergoing laser capsulotomy.

Materials and methods

This being a prospective observational study, carried out at the Department of Ophthalmology, Sant Parmanand Hospital, New Delhi, and involved 110 pseudophakic eyes with PCO following cataract surgery studied over a 12 month period after taking a written informed consent from the patients and approval from the ethical committee.

Inclusion criteria

Pseudophakic eye with visual impairment due to significant PCO following a minimum of three months of uneventful cataract surgery, with no other complications were included in the study.

Exclusion criteria

- Patients with glaucoma or any anti-glaucoma medications
- Cases with postoperative complications like endophthalmitis.
- Any active ocular inflammation
- Posterior capsular opacification in aphakic eyes.
- Undergone any anterior segment LASER procedure or any intraocular surgery other than cataract surgery
- Uncooperative patients, e.g. patient with mental retardation, neurological problems.
- Having baseline (prelaser) IOP ≥ 22 mm of Hg,
- Patients having any corneal abnormality or physical/mental limitation.

A total of 110 consecutive patients were recruited in this study. An evaluation of the patients requiring Nd:YAG laser capsulotomy was carried out prior to the procedure.

Amount of total laser energy used was recorded. Intraocular pressure was recorded.

After a thorough history and ocular examination including visual acuity, slit lamp biomicroscopy, fundus and applanation tonometry, Nd:YAG laser capsulotomy was carried out by using a Zeiss laser model VISULAS II PLUS. Only one eye underwent the procedure on one day. In case the capsulotomy was required in both the eyes, the second eye was undertaken independently and was recruited in the study to avoid any confounding factors related to the subject. Dilatation of the pupil was carried out using Tropicamide 1%. The procedure was carried out after anaesthetizing the eye with topical proparacaine hydrochloride 0.5%, while a capsulotomy size of 3 mm or more was considered adequate. Post-laser all patients were prescribed Loteprednol etabonate 0.5% eye drops 4 times a day along with Carboxymethylcellulose sodium 0.5% lubricating eye drops 4 times a day, beginning immediately after laser and for one week. The post laser IOP was recorded by Goldmann Applanation Tonometer at 1hour, 2 hours and 4 hours.

Case Definitions

- **Mild rise of IOP:** Any elevation of IOP less than 5 mm of Hg above the baseline pre laser IOP. For all considerations including data analysis, this was clubbed with no rise of IOP.
- **Moderate Rise of IOP:** A rise of ≥5 mm of Hg above the baseline pre laser IOP
- **Severe Rise of IOP:** A rise of ≥10 mm of Hg above the baseline pre laser IOP

The data was analyzed using Statistical Package for Social Sciences, version 23.0. All data were reported as averages and standard deviations. Independent samples or paired ‘t’-test and ANOVA was used to compare before and after capsulotomy data. ROC analysis was used to predict the cutoff values of energy with respect to IOP change (from baseline to follow- up). A “p” value less than 0.05 was considered to be statistically significant.

Results

The mean age of the study sample was found to be 56.83±8.14 years (ranging from 42-75 years), implying that the majority of patients were in their 60s. Males being 62 (56.4%) followed by females 48 (43.6%) with male to female ratio as 1.29:1. The mean time difference between cataract surgery and current procedure was 2.68±1.34 years. The mean baseline (Pre-capsulotomy), BCVA value was 0.539±0.242 LogMAR and mean intraocular pressure value was 14.52±2.86 mm Hg. [Table No. 1] The elevation in IOP was recorded at 1 hour, 2 hour, and 4 hour following Nd:YAG laser capsulotomy and it was mostly found that patients showed 1-5mmHg rise in IOP. [Table No. 2] Mean IOP elevation with respect to time interval after laser capsulotomy measured at 1 hour, 2 hour and 4 hour was found to be highly statistically significant (p<0.001). [Table No. 3]The association between amount of energy used and rise in IOP at different follow-up intervals after Nd:YAG Laser Posterior Capsulotomy was also found to be statistically significant (p<0.05).

Table 1: Demographic and Pre-operative findings for all patients

Variables		Mean ±SD
Age (in years)	All patients (n=110)	83±8.14
	Male	56.11±7.82
	Female	57.75±8.54
Time difference between cataract surgery and current procedure (years)		2.68±1.34
Pre-capsulotomy Best Corrected Visual acuity (LogMAR)		0.539±0.24
Pre-capsulotomy Intraocular Pressure (mmHg)		14.52±2.86

Table 2: No. of patients with IOP elevation after laser capsulotomy according to time interval

IOP changes (mmHg)	Post Nd:YAG laser capsulotomy		
	No. of patients (n=110) after 1 hour	No. of patients (n=110) after 2 hour	No. of patients (n=110) after 4 hour
No rise	20 (18.2)	10 (9.1)	13 (11.8)
1-5	77 (79.1)	76 (79.0)	77 (79.1)
6-10	3 (2.7)	14 (11.9)	10 (9.1)
>10	0 (0.0)	0 (0.0)	0 (0.0)

Table 3: Mean IOP elevation with respect to time interval after Nd:YAG laser capsulotomy

Time Interval	Intraocular pressure (IOP) Mean±SD (mmHg)	Mean change from baseline	P value (paired sample t test)
Pre capsulotomy	14.52±2.86	-	-
Post capsulotomy	At 1 hour	15.32±2.91	0.80±2.29
	At 2 hour	16.24±3.23	1.72±2.90
	At 4 hour	16.18±3.35	1.66±3.04

Table 4: Association between amount of energy used and rise in IOP at different follow up intervals after Nd:YAG Laser Posterior Capsulotomy

Energy Level Groups	<40 mJ (n=40)	40-80 mJ (n=46)	>80 mJ (n=24)	‘p’ value (Anova Test)	
	Mean±SD	Mean±SD	Mean±SD		
Energy level used (mJ)	27.87 ± 7.08	58.70 ± 11.84	110.46 ± 29.59	<0.001	
Baseline IOP values (mmHg)	14.13±2.55	15.13±3.38	14.0±2.02	0.162	
Post procedure rise in IOP at	1 hour	0.40±2.06	0.58±2.58	0.30±2.04	0.010
	2 hour	0.50±2.54	1.30±2.76	1.17±3.05	<0.001
	4 hour	2.04±1.73	4.42±1.89	4.88±1.99	<0.001

[Table No. 4] A positive significant correlation between change in IOP following posterior capsulotomy and total energy use was observed. The magnitude of this correlation was mild at 1 hour ($r=0.35$) and moderate at 2 hour ($r=0.553$) and 4 hour (0.633) intervals (Figure 1).

Receiver operating (Table No.5) characteristic (ROC) analysis was used to predict the cutoff value of energy on the basis of their IOP change from baseline. For ≥ 5 mm of Hg IOP from baseline, Area under curve (AUC) of energy at 1 hour, 2 hour and 4 hour after Nd:YAG Laser Posterior Capsulotomy procedure was 0.655, 0.802 and 0.918, respectively. The

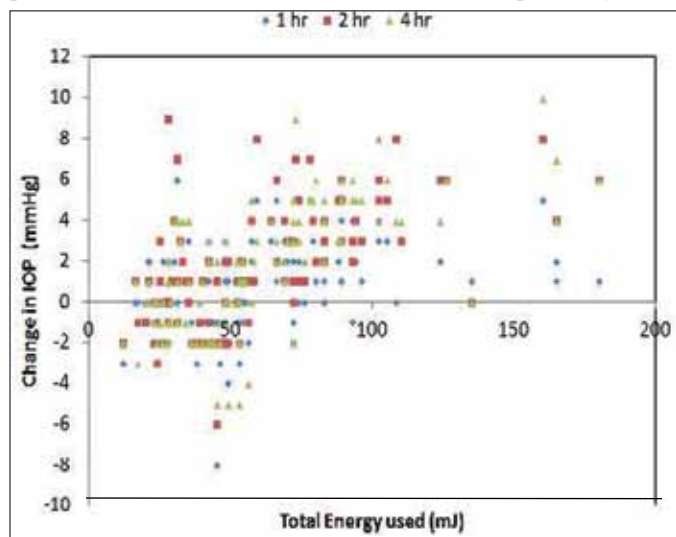


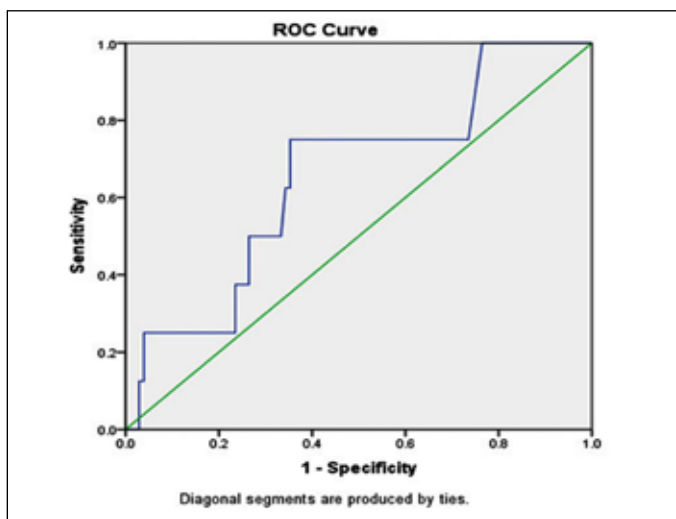
Table 5: ROC analysis showed that the optimal cutoff values of energy for all follow up

		ROC 1 IOP0-IOP1	ROC 2 IOP0- IOP2	ROC 3 IOP0- IOP4	
Positive (Valid N)		8	20	20	Larger values of the test result variable(s) indicate stronger evidence for a positive actual state. a. The positive actual state is ≥ 5
Negative (Valid N)		102	90	90	
Area		0.655	0.802	0.918	The test result variable(s): energy has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.
Std. Error		0.097	0.059	0.026	
Asymptotic Sig. ^{--b}		0.145	0.000	0.000	
Asymptotic 95% Confidence Interval	Lower Bound	0.465	0.686	0.866	a. Under the nonparametric assumption
	Upper Bound	0.845	0.919	0.969	b. Null hypothesis: true area = 0.5
Cutoff		58.50	65.0	71.0	The test result variable(s): energy has at least one tie between the positive actual state group and the negative actual state group
Sensitivity		75.0	80.0	95.0	a. The smallest cutoff value is the minimum observed test value minus 1, and the largest cutoff value is the maximum observed test value plus 1. All the other cutoff values are the averages of two consecutive ordered observed test values.
Specificity	64.7	73.3	85.6		
Accuracy	65.50	80.2	91.8		

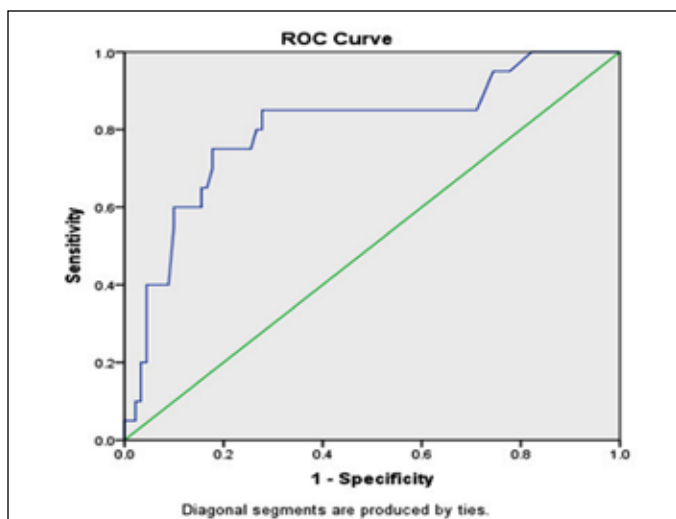
optimal cutoff point of energy at 1 hour, 2 hour and 4 hour after procedure was 58.50, 65.0 and 71.0 respectively for IOP rise from baseline. It was observed that YAG energy determination 4 hours after procedure has high accuracy for prediction of IOP rise. (Demonstrated in graphs ROC 1, 2 & 3)

Discussion

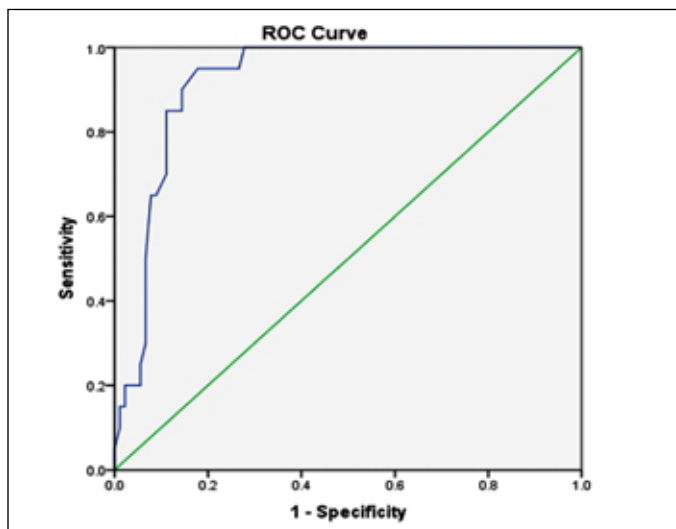
Posterior Capsular Opacification (PCO) causes glare, impairs contrast sensitivity and remains a major concern of decreased vision after cataract surgery. The use of Nd:YAG laser has definitely simplified the treatment of posterior capsular opacification. It being an entirely non-invasive technique, has become popular for doing posterior capsulotomy and has been established as a standard treatment for PCO replacing surgical capsulotomy.¹⁶ Nd: YAG laser breaks the posterior capsule following a pressure wave created by infrared light of 1064 nm which is amplified and focused so that electrons are ripped away from nuclei to form energy plasma and corresponding shock wave. In our study of 110 cases, majority of the patients were males 62 (56.4%), mostly above 50 years of age; it was the also commonest age group that underwent cataract surgery. A similar trend was noted by Shetty NK and Sridhar N et al who depicted 60% males and 40.0% females and 68.6% of the studied patients were in the age group ranging 50-70 years. Kaur P et al and HavaleNG et al¹⁷ also reported a higher proportion of males over females in their respective studies. However, gender difference does not indicate any gender



Graph 1: ROC 1 (IOP0-IOP1): Change in IOP from baseline to 1st hour post Nd:YAG capsulotomy



Graph 2: ROC 2 (IOP0-IOP2): Change in IOP from baseline to 2nd hour post Nd:YAG capsulotomy



Graph 3: ROC 3 (IOP0-IOP4): Change in IOP from baseline to 4 hour post Nd:YAG capsulotomy

fondness neither for cataract surgery nor for PCO. The mean age of the studied patients was found to be 56.83 ± 8.14 years, similar to Bhargava R et al¹⁸ where mean age was 55.6 ± 8.7 years. The mean time elapsed between cataract surgery and laser capsulotomy procedure was reported as 2.68 ± 1.34 years, similar to Khanzada MA et al¹⁹ where mean period was 2.5 years, and Bhargava R et al reported this period to be 22.9 months. PCO development rates vary at different post-cataract surgery durations and the mean duration after cataract surgery might generally ranges from 2 to 3 years.

In our study, 81.8% patients showed transient rise in IOP after 1 hour of procedure whereas after 2 hours it was 91.9% and after 4 hour of the procedure it was 88.2%. (None of our study patients required any anti-glaucoma medication). Similar to Flohr et al²⁰ and Mohammed YK et al,²¹ they found IOP elevation in >75% and 84% of cases respectively in their studies. In Kaur P et al [16] study only 62.47% patients showed transient rise in IOP after procedure. In this study, mean IOP at 1st hour follow up was 15.32 ± 2.91 mmHg, at 2nd hour follow up it was 16.24 ± 3.23 mmHg and at 4th hour follow up, it was 16.18 ± 3.35 mmHg, thus showing a mean increase of 0.80 ± 2.29 , 1.72 ± 2.90 and 1.66 ± 3.04 mmHg from baseline respectively. At all three follow ups mean change in IOP was found to be statistically significant ($p < 0.001$). Similar trend was reported by Richter CU et al.²² This relatively lower rise in present study could be attributed to reduced levels of energy used. In another study, it was observed that there was statistically significant increase in IOP at 1 and 4 hour post-laser when higher energy was used²³ In Barnes et al²⁴ study the change in IOP was also relatively lower. Compared to this in the present study during entire evaluation period, the rise of >5 mm Hg was seen to be maximum at 2 hours when 18.2% patients showed a rise of >5 mm Hg. In the present study >10 mm rise was observed in only 1 (0.9%) case at 4 hour interval. When topical hypotensives are used the rise in IOP could also be reduced. In a study by Singh M et al²⁵ the rise of IOP from baseline to 1 hour, 3 hour, 5 hour and 24 hours post-procedure was not found to be significant in the groups receiving ocular hypotensive drug. Shetty NK and Sridhar N et al reported that almost all the patients had a rise in IOP 2 hours post-procedure. Hence IOP documentation of IOP 2 hours post-procedure was observed to be more predictive of persistent IOP rise compared to immediate post-procedure IOP. In our study, the duration of IOP elevation study was only upto 4 hour post-operative interval and the reason for limiting this assessment only upto 4 hour interval was because we had used a limited range of laser energy only.

In our study, the mean energy required for Nd:YAG laser posterior capsulotomy was 58.57 ± 34.63 mJ. Patil MS et al observed almost similar findings and they reported mean energy used as 62.47 ± 33.65 mJ. In our study, patients were divided into three groups, in maximum number of cases 46 (41.8%) 40 to 80 mJ was used with a mean energy 58.70 ± 11.84 mJ and in 24 (21.8%) patients >80 mJ energy was used with mean 110.46 ± 29.59 mJ and in rest <40 mJ energy with a lowest mean energy 27.87 ± 7.08 mJ used highly significant ($p < 0.01$). In a study by Waseem M et al,²⁶ the low energy group was exposed to laser energies below 50 mJ

with a mean energy of 36.46±6.42 mJ and the high energy group had IOP above 50mmHg with a mean of 56.84±2.65 mJ. In their study they found rise of about 5.51±1.58 mmHg in the high energy group and 3.83±1.84 in the low energy groups.

Similar results were reported by Ari S et al²⁷ as 58±18 mJ and 117±36 mJ respectively energy was used among two groups of patients receiving 14 to 80 mJ and 84 to 200 mJ of energy respectively in their study. In Kaur P et al also used similar mean energy levels among two study groups (38.01±9.34mJ and 62.46± 10.07 mJ).

In the present study, the relation between the amount of energy used and rise in IOP at different intervals of follow up, we observed that mean rise in IOP was nominal for cases in which <40 mJ energy was used, followed by 40-80 mJ energy used and maximum among >80 mJ total energy use. We observed statistically significant association between energy used and rise in IOP (p<0.05). The results of present study showed that frequency of 'raised IOP' was associated with the high laser energy delivered to the eyes and must be expected to be greater in patients who receive excessive amount of YAG laser energy. Our results correspond with Kaur P et al study results as pre-laser mean IOP was 14.45 + 2.52 mmHg which raised to 16.08±3.69 mmHg at 1 hour and peaked to 16.83±3.69 mmHg by 2 hour after laser capsulotomy procedure. Similarly, Ge J et al²⁸ and Dawood Z et al²⁹ concluded transient IOP rise within 1.5-4hour and 1-3 hour after laser capsulotomy procedure respectively in their study. Higher energy was required for higher grades of PCO. Our study patients presented with both fibrous and pearl types of PCO. However, our study did not compare the energy requirement with the grade of PCO. The possible mechanisms for an increase in IOP could be: more the energy used during the procedure, more particles were liberated from posterior capsular breakdown, thus clogging of angle of anterior chamber and subsequently increasing the IOP. Additionally, the acoustic shock waves release inflammatory mediators that alter the trabecular meshwork and the aqueous dynamics causing IOP rise.

Conclusion

Raised IOP is a frequent complication of Nd:YAG laser posterior capsulotomy .It is dependent upon the amount of laser energy delivered to the eye during the procedure. The higher the energy used, the greater the rise in IOP .(Our study did not compare the rise of IOP with the number of shots used for performing the procedure)

Hence, it is recommended that each patient undergoing Nd: YAG laser posterior capsulotomy should receive minimum possible laser energy and should be followed up for raised IOP. Also limiting the use of amount of energy levels (< 50 mJ/ sitting) during Nd:Yag laser procedures can prevent post laser IOP spikes. This will prevent unnecessary use of anti-glaucoma drugs in most patients.

Recommendations

It was difficult to compare different studies due to different techniques of cataract surgery and different intraocular lens implant materials, their designs and the thickness of PCO.

We recommend further studies with larger sample size and variable energy use with same follow up intervals as used in present study to explore this relationship further.

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Cite This Article as: Neha Verma, Ashish Ahuja. Effect of Quantum of Energy used during Nd:YAG Laser Posterior Capsulotomy on Magnitude of IOP Rise. Delhi J Ophthalmology. 2020;31(2):56-61

Acknowledgments: Nil

Conflict of interest: None declared

Source of Funding: None

Date of Submission: 30th Aug 2019

Date of acceptance: 22nd May 2020

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