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Clinical implications of energy used in Neodymium: Yttrium Aluminum Garnet posterior capsulotomy on intraocular pressure

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Purpose: To study the trend of the rise of intraocular pressure (IOP), with the energy used during Neodymium: Yttrium Aluminum Garnet (Nd: YAG) posterior capsulotomy. **Methods:** This is a prospective interventional study undertaken at a tertiary care center. The study was conducted on 221 non-glaucomatous eyes that underwent Nd: YAG posterior capsulotomy, of which 181 patients completed the study. IOP was recorded before laser and at 1, 2, 3, 4 hours, one day, one week, and one month during the post-laser period. Patients were grouped, depending on the amount of energy used, into Group 1 (≤ 40 mJ), Group 2 (40–80 mJ), and Group 3 (>80 mJ). **Results:** Raised IOPs were noted in all the groups at various time points; however, such cases were more in Group 3 (P = <0.001). IOP was noted to peak at the fourth hour and declined to reach baseline by one week in Group 2 and by one month in Group 3. **Conclusion:** There exists a relationship between the quantum of energy used and the amount of rising of IOP following Nd: YAG laser capsulotomy. In uncomplicated cases without preexisting glaucoma, if the amount of energy for posterior capsulotomy is limited to 40 mJ, routine use of ocular hypotensive medication can be avoided.

Key words: Complications of cataract surgery, intraocular pressure, Nd: YAG posterior capsulotomy, posterior capsule opacification, secondary cataract

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The modifications to sharp-edge optic intraocular lenses (IOL) and the advances in phacoemulsification have led to decreased rates of posterior capsule opacification (PCO). Still, it remains the most common consequence of cataract extraction.[1,2] Neodymium: Yttrium Aluminum Garnet (Nd: YAG) posterior capsulotomy is the current standard treatment for PCO.

Although safe and effective, it carries a finite risk of complications, for example, damage to IOLs, intraocular pressure (IOP) rise, cystoid macular edema (CME), and retinal detachment.[3,4]

The peak of the IOP rise is seen to occur mostly within the first three hours after the procedure.[5] This elevation of IOP is typically transient; however, it may persist for longer periods.[3,4] Worsening of preexisting glaucoma, as well as the onset of glaucoma, has been reported following this procedure.[6,7]

Prophylactic use of apraclonidine 0.5% or brinzolamide 1% has been widely accepted to prevent the rise of IOP.[8] The principal aim of this study is to investigate whether there is a direct relationship between the quantum of energy used and the rise of IOP.

Methods

This study was conducted consistent with the tenets of the Declaration of Helsinki. Written informed consent was obtained from patients before enrolment and the internal review board approved the study. This was a prospective interventional study conducted at a single center. Two hundred twenty-one eyes of 221 patients with visually disturbing PCO and a vision > 6/9 were recruited over one year. All patients underwent a complete ocular examination before the procedure, including best-corrected visual acuity (BCVA), refraction, slit-lamp examination including IOP measurement (using Goldmann applanation tonometer) and posterior segment examination. Patients with baseline IOP ≥22 mmHg, those using any ocular hypotensive drugs, patients who have undergone prior anterior segment laser procedures or any intraocular surgery other than cataract surgeries, presence of vitreous in the anterior chamber, and active ocular inflammation were excluded from the study. Ethics approval granted on 9/2/2013.

Tropicamide 1% and phenylephrine 2.5% were administered for dilating the pupil before the procedure. Nd: YAG laser capsulotomy (Zeiss laser model VISULAS II plus) was carried out using a standardized laser technique. Capsulotomy of three

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millimeters over the visual axis was considered optimum. To avoid movement of eyes and to increase precision, Abraham capsulotomy lens was also used in less cooperative or one-eyed patients. Minimal energy shots were given at the beginning and the energy was titrated from 1 mJ, based on the thickness of the PCO. The total amount of energy and the pulse count of laser shots were noted. The incidence of IOL pitting and other complications were also recorded.

After capsulotomy, loteprednol etabonate 0.5% four times/day for one week was prescribed. For the current study, after the procedure, IOP was recorded at 1, 2, 3, 4 hours, and one day, one week, and one month. The rise of IOP was categorized into mild, moderate, and severe rise, for treatment and statistical analysis as depicted in Table 1.

At the end of four hours, if there was a moderate to severe rise of IOP, then the patient was given appropriate treatment to lower the IOP to a level considered safe for each patient. In case, a patient required treatment for control of IOP, IOP was again recorded two hours after giving medication. The treatment regime for the rise of IOP is given in Table 2. If IOP remained in the moderate or severe range, then treatment was appropriately modified, otherwise, no further treatment was given. One day post laser, IOP was recorded at least 12 hours after the last dose of an ocular hypotensive drug, in case needed, to ensure that the peak effect of the drug is over. In patients with moderate/severe rise of IOP, follow up was done daily till IOP lowered to a mild/no rise level.

The study population was grouped based on the amount of energy used in three groups (Group 1: <40 mJ, Group 2: 41–80 mJ, and Group 3: >80 mJ). The three groups were compared for the rise of IOP and change in BCVA. Statistical analysis was performed by the SPSS program for Windows, version 17.0. Normally distributed continuous variables were compared using ANOVA. Categorical variables were analyzed using the Chi-square test. For all statistical tests, a *P* value less than 0.05 was taken to indicate a significant difference.

Results

One hundred and eighty-one patients out of 221 recruited, completed the study. The distribution of 181 patients into three groups showed a maximum number of subjects in Group 2, i.e. 62 cases (34.3%), in Group 1, 89 (49.2%) in Group 2, and 30 (16.6%) in Group 3.

The mean age of the patients was 59.38 ± 7.99 (range: 46–75) years in Group 1, 60.53 ± 7.99 (range: 45–75) years in Group 2, and 58.17 ± 5.72 (range: 48–72) years in Group 3. There was no gender preponderance. Baseline variables including age, IOP, and BCVA were comparable within the three groups [Table 3]. The average total energy used was 56.23 mJ (range: 12–180 mJ). The average pulse count was 30.5, ranging from 8 to 87. The mean time interval of undertaking Nd: YAG posterior capsulotomy since cataract surgery was 2.48 years.

In Group 1, no mean rise of IOP from baseline was noted at any point of time. In Group 2, the mean rise of IOP from baseline was statistically significant at 2, 3, 4 hour, and day 1 and in Group 3, the mean rise of IOP was noted at all points of time except at 1 hour and 1 month [Table 4].

In the present study, a peak in IOP rise was noted at four hours post laser, after which IOP showed a decreasing trend and reached the baseline values by one week in Group 2 and by one month in Group 3 [Fig. 1].

At any point of time, a maximum number of cases registered a mild rise in IOP, and a maximum number of cases recorded a rise in IOP at 2nd hour after laser. At 1 hour, 82 cases (45.3%) registered a rise in IOP of which 76 cases (41.9%) recorded a mild rise and 6 cases (3.3%) registered a moderate rise. At 2 hours after laser, 99 cases (54.6%) showed a rise in IOP out of which, 75 cases (41.4%) recorded a mild rise, and 24 cases (13.2%) cases recorded a moderate rise. At 3rd hour, 92 cases (50.8%) showed a rise in IOP out of which, 66 cases (36.4%) recorded a mild rise, and 26 cases (14.3%) cases recorded a moderate rise. At 4th hour, 92 cases (50.8%) showed a rise in IOP out of which, 71 cases (39.2%) recorded a mild rise, and 20 cases (11%) cases recorded a moderate rise, and 1 case (0.5%) showed a severe rise in IOP. At day 1, 84 cases (46.4%) showed a rise in IOP out of which, 66 cases (36.4%) recorded a mild rise, and 17 cases (9.3%) cases recorded a moderate rise. At 1 week, 80 cases (44.19%) showed a rise in IOP out of which, 64 cases (35.3%) recorded a mild rise, and 14 cases (7.7%) cases recorded a moderate rise, and 2 cases (1%) showed a severe rise in IOP. At one month after laser, 71 cases (39.2%) showed a rise in IOP out of which, 64 cases (35.3%) recorded a mild rise, and 7 cases (3.8%) cases recorded a moderate rise, and 1 case (0.55%) showed a severe rise in IOP.

Table 1: Definitions for categorization of rise of intraocular pressure (IOP)

Definitions	Amount of rise of IOP from baseline
Mild rise	<5 mmHg
Moderate rise	≥5-<10 mmHg
Severe rise	≥10 mmHg

Table 2: Treatment protocol for increase in intraocular pressure (IOP)

Type of rise of IOP	Treatment given
Mild/No Rise	nil
Moderate Rise	Topical Brimonidine 0.15% stat
Severe Rise	Topical Brimonidine 0.15% + Tab Acetazolamide 250 stat

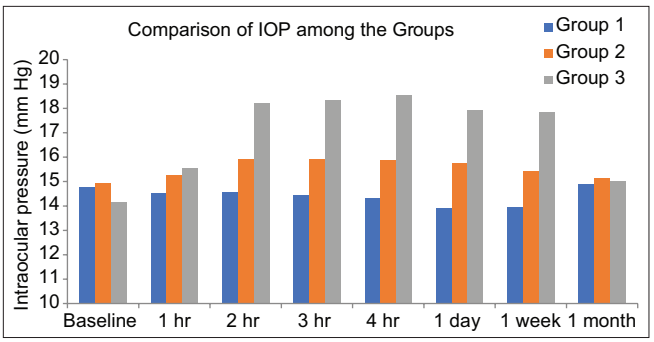

Figure 1: Trends of intraocular pressure change in relation to energy used over a period of one month (Group 1:<40 mJ, Group 2:41–80 mJ, Group 3:>80 mJ)

Table 3: Comparison of baseline variables in all three groups

Baseline variables		Group 1 (*n*=62)	Group 2 (*n*=89)	Group 3 (*n*=30)	*P*
Age (years) (mean±SD)		59.38±7.99	60.53±7.99	58.17±5.72	0.313
Sex (*n*)	males	33 (53.2%)	44 (49.4%)	18 (60.0%)	0.599
	females	29 (46.8%)	45 (50.6%)	12 (40.0%)	
BCVA (LogMAR) (mean±SD)		0.517±0.221	0.577±0.259	0.578±0.245	0.299
Type of cataract surgery	Phacoemulsification	33	57	12	0.185
	Small incision cataract surgery	27	28	16	
	Extracapsular cataract extraction	2	4	2	
Mean duration since cataract surgery (years) (mean±SD)		2.18±1.19	2.47±1.29	2.72±1.48	0.146
IOP (mmHg) (mean±SD)		14.76±2.69	14.94±3.06	14.17±2.51	0.425

Table 4: Mean difference of IOP from baseline at all study periods and its pattern among the three groups

	Baseline	1 h	2 h	3 h	4 h	1 day	1 week	1 month
Group 1	14.76±2.69	14.52±2.81	14.58±3.14	14.44±2.77	14.34±2.81	13.92±2.72	13.95±2.96	14.91±3.02
Mean difference		-0.242±1.75	-0.177±2.29	-0.323±2.13	-0.419±1.95	-0.881±1.77	-0.893±1.78	0.071±2.01
P		0.281	0.545	0.238	0.096	<0.001	<0.001	0.792
Group 2	14.94±3.06	15.26±2.94	15.92±2.97	15.92±3.12	15.89±3.13	15.76±3.05	15.44±2.54	15.15±2.62
Mean difference		0.315±2.26	0.978±2.49	0.978±2.60	0.944±2.69	0.805±2.41	0.35±2.35	0.197±1.98
P		0.193	<0.001	0.001	0.001	0.002	0.187	0.403
Group 3	14.17±2.51	15.57±3.22	18.23±2.79	18.33±2.60	18.53±2.74	17.93±3.15	17.86±3.52	15.0±3.13
Mean difference		1.40±2.28	4.07±2.12	4.17±2.39	4.37±2.30	3.77±3.01	3.54±3.73	0.68±3.01
P		0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.243

Table 5: Number of cases in each group showing rise in IOP after laser at 1-4 h, day 1, 1 week, and 1 month after laser

Duration after laser	Amount of rise of IOP	Group 1 (*n*=62)	Group 2 (*n*=89)	Group 3 (*n*=30)
at 1 h	Mild rise	19 (30.30%)	36 (40.80%)	21 (71.40%)
	Moderate rise	1 (1.78%)	2 (2.80%)	4 (14.20%)
	Severe rise	0	0	0
at 2 h	Mild rise	21 (33.90%)	41 (46.40%)	13 (42.8%)
	Moderate rise	2 (3.57%)	8 (9.80%)	14 (46.40%)
	Severe rise	0	0	0
at 3 h	Mild rise	16 (26.70%)	36 (40.80%)	14 (46.40%)
	Moderate rise	1 (1.78%)	11 (12.6%)	14 (46.40%)
	Severe rise	0	0	0
at 4 h	Mild rise	15 (25%)	43 (49.2%)	13 (42.8%)
	Moderate rise	0	6 (7.04%)	14 (46.40%)
	Severe rise	0	0	1 (3.57%)
at 1 day	Mild rise	11 (17.8%)	41 (46.40%)	14 (46.40%)
	Moderate rise	0	4 (4.2%)	13 (42.8%)
	Severe rise	0	0	0
at 1 week	Mild rise	13 (21.4%)	38 (43.6%)	13 (42.8%)
	Moderate rise	0	4 (4.2%)	10 (32.1%)
	Severe rise	0	0	2 (7.1%)
at 1 month	Mild rise	11 (17.8%)	36 (40.80%)	17 (57.1%)
	Moderate rise	0	1 (1.4%)	6 (21.4%)
	Severe rise	0	0	1 (3.57%)

Overall, at any given point of time, most of the cases showing rise in IOP belonged to Group 3 [Table 5]. The maximum rise in IOP from the baseline, seen in the entire study group was recorded as 18 mmHg.

No correlation was seen between the pulse count and the rise of IOP at any point of time ($r = 0$).

Discussion

Durham and Gills performed 3000 Nd: YAG laser posterior capsulotomies. An IOP of 25 mmHg or elevation of 8 mmHg above the baseline value was considered as a significant IOP elevation. Elevation of IOP was noted in 6% of patients with no history of glaucoma at two hours as compared to 16.9% of patients with a history of glaucoma.[9] Among 66 patients, Slomovic *et al*.[10] reported that 55% of patients had a significant rise of IOP following YAG laser capsulotomy. In another study, three groups were given different anti-glaucoma medicines while the fourth group was given no medicine. In the untreated group, IOP was found to be raised significantly at one hour (3.90 ± 5.35) and three hours (5.95 ± 5.32) following Nd: YAG laser procedure.[4] These results are in unison with the present study, except that the energy level was not considered a key factor in these studies.[4,9,10]

In our study, a significant rise of IOP was noted in groups that received energy >40 mJ, whereas the groups that received energy ≤40 mJ showed nil or a mild rise of IOP. Similar to our outcomes, Waseem and Khan[11] observed a mean rise in IO*P* value of 3.83 ± 1.84 mmHg if the energy used was ≤50 mJ, whereas in the group that received >50 mJ, the mean rise in IO*P* value was 5.51 ± 1.58 mmHg.

Ari *et al*.[5] found that IOP elevation was less and short-lived when a total energy level of less than 80 mJ was used. IOP rise was noted at 1 week in all patients, which was seen to return to baseline at 1 month in cases receiving < 80 mJ. Interestingly, cases receiving >80 mJ energy showed a persistent elevation of IOP even at 3 months after the procedure.

Similarly, we observed IOP peaked at the fourth hour after the procedure and declined to baseline at one week in the 40–80 mJ group; however, in >80 mJ group, IOP reached baseline at one month. It was observed that the higher the amount of energy used, the longer the IOP takes to reach the baseline level. Ge *et al*.[12] support the observation that peak IOP observed in their study was within the first four hours post laser.

Although the exact mechanism of the rise of IOP with Nd: YAG laser remains undetermined, the probable mechanism could be based on its photo disruptive nature. The more the energy used, the more particles are released from the breakdown of the posterior capsule, which in turn, clog the anterior chamber angle, leading to raised IOP. Furthermore, the acoustic shock waves could release inflammatory mediators that alter the trabecular meshwork and the aqueous dynamics and result in pressure rise.

The rise of IOP becomes even more significant in glaucomatous eyes after ND: YAG capsulotomy, where need for additional antiglaucoma medications or complications like bleb failure have been reported.[13]

Conclusion

In light of our study, we conclude that in un-complicated cases without preexisting glaucoma, if the amount of energy for posterior capsulotomy is limited to 40 mJ, routine use of ocular hypotensive medication is not required.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Apple DJ. Influence of intraocular lens material and design on postoperative intracapsular cellular reactivity. Trans Am Ophthalmol Soc 2000;98:257-83.
2. Werner L, Apple DJ, Pandey SK. Postoperative proliferation of anterior and equatorial lens epithelial cells: A comparison between various foldable IOL designs. Cataract Surgery in Complicated Cases. Thorofare, NJ: Slack Inc.; 2000. p. 399-417.
3. Majeed A, Bangash T, Muzaffar W, Durrani O. Macular Hemorrhage: An Unusual Complication of Nd: YAG Laser Capsulotomy. Pak J Ophthalmol. 1998; 14: 118-20.
4. Jahn CE, Emke M. Long-term evaluation of intraocular pressure after neodymium-YAG laser capsulotomy. Ophthalmologica 1996;210:85–9.
5. Ari S, Cingu AK, Sahin A, Cinar T, Caca I. The effects of Nd: YAG laser posterior capsulotomy on macular thickness, intraocular pressure and visual acuity. Ophthalmic Surg Lasers Imaging 2012;12:1-6.
6. Lin JC, Katz LJ, Spaeth GL, Klancnik JM Jr. Intraocular pressure control after Nd: YAG laser posterior capsulotomy in eyes with glaucoma. Br J Ophthalmol 2008;92:337-9.
7. Barnes EA, Murdoch IE, Subramaniam S, Cahill A, Kehoe B, Behrend M. Neodymium: yttrium-aluminium garnet capsulotomy and intraocular pressure in pseudophakic patients with glaucoma. Ophthalmology 2004;111:1393-7.
8. Unal M, Yücel T, Akar Y. Brinzolamide 1% versus apraclonidine 0.5% to prevent intraocular pressure elevation after neodymium: YAG laser posterior capsulotomy. J Cataract Refract Surg 2006;32:1499-502.
9. Durham DG, Gills JP. Three thousand YAG lasers in posterior capsulotomies: An analysis of complications and comparison of polishing and surgical discussions. Trans Am Ophthalmol Soc 1985;83:218-35.
10. Slomovic AR, Parrish RK 2nd, Forster RK, Cubillas A. Neodymium: YAG laser posterior capsulotomy. Central corneal endothelial cell density. Arch Ophthalmol 1986;104:536-8.
11. Waseem M, Khan HA. Association of raised intraocular pressure and its correlation to the energy used with raised versus normal intraocular pressure following Nd: YAG laser posterior capsulotomy in pseudophakes. J Coll Physicians Surg Pak 2010;20:524-7.
12. Ge J, Wand M, Chiang R, Paranhos A, Shields MB. Long term effect of Nd: YAG laser posterior capsulotomy on intraocular pressure. Arch Ophthalmol 2000;118:1334-7.
13. Diagourtas A, Petrou P, Georgalas I, Oikonomakis K, Giannakouras P, Vergados A, *et al*. Bleb failure and intraocular pressure rise following Nd: Yag laser capsulotomy. BMC Ophthalmol 2017;17:18.