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Effect of Nd:YAG laser posterior capsulotomy on intraocular pressure, refraction, anterior chamber depth, and macular thickness

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Purpose: To see the effect of Nd:YAG laser capsulotomy on intraocular pressure (IOP), refraction, best-corrected visual acuity (BCVA), anterior chamber depth (ACD), and macular thickness.

Methodology: The authors conducted a prospective, descriptive study on pseudophakic eyes with posterior capsule opacification who underwent Nd:YAG laser capsulotomy. BCVA, IOP, spherical equivalent (SE), macular thickness, and ACD were noted preoperatively, at 1 hr postoperatively and at 1-month follow-up. Patients were divided into two groups based on energy used (Group I ≤50 mJ, Group II >50 mJ). None of the patients received prophylactic antiglaucoma medications either before or after the procedure.

Results: There were 96 eyes of 83 patients. Mean total energy levels were 26.64±12.92 mJ in Group I and 81.96±32.10 mJ in Group II. BCVA at 1 hr and 1 month postoperatively improved significantly in both the groups compared to preoperative BCVA (P<0.001). There was no significant change in SE compared to preoperative values in both the groups. The ACD continued to increase significantly in both the groups at both 1 hr and 1-month follow-up. In Group I, IOP increased at 1 hr postoperatively (P=0.023) and declined to preoperative levels at 1 month. In Group II, IOP increased at 1 hr postoperatively (P<0.001) and did not return to preoperative levels at 1-month follow-up (P=0.003). Likewise, macular thickness increased at 1 hr in both groups (P<0.001). In Group I, macular thickness decreased significantly to preoperative level at 1 month whereas in Group II, it remained significantly high at 1-month follow-up (P=0.006). There was no case with serious rise in IOP or cystoid macular edema.

Conclusion: Statistically significant increment in IOP and macular thickness occurs after Nd:YAG laser capsulotomy which however may not necessitate the use of any medications.

Keywords: ACD, IOP, macular thickness, Nd:YAG, PCO, refraction

Introduction

Posterior capsule opacification or "secondary cataract" is the most common long-term complication of modern extracapsular cataract surgery.[1,2] Decreased visual acuity, impaired contrast sensitivity, glare disability, and monocular diplopia are the usual visual complications secondary to posterior capsule opacification (PCO), which often require further treatment.[3,4] Currently, the standard treatment for PCO is Nd:YAG laser posterior capsulotomy, which has a success rate of more than 95%.[5]

Laser capsulotomy uses a quick-pulsed Nd:YAG laser to apply a series of focal ablations in the posterior capsule and create a small circular opening in the visual

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axis.[6] Although safe and effective, the reported complications of Nd:YAG laser posterior capsulotomy include retinal detachment,[7–9] cystoid macular edema (CME),[7,10] and rise in IOP.[11,12]

Explanations for the rise in intraocular pressure following Nd:YAG laser capsulotomy include the deposition of debris in the trabecular meshwork, trabeculitis as a consequence of the radiating "shock waves", neurovascular mechanisms, pupillary block and inflammatory swelling of the ciliary body or iris root associated with angle-closure.[13]

This procedure also causes a shift in the position of the implant,[14,15] which can cause a change in the effective power of the lens in the eye and potentially alter the refraction of the patient. This might necessitate further refraction for the patient to ensure optimal vision. Movement and damage in the vitreous cavity and release of inflammatory mediators due to the damage of blood-aqueous barrier cause macular edema.[16]

Retinal tears and retinal detachments too are known complications after Nd:YAG capsulotomy with rates ranging between 0% and 3.6%.[9,10,17–23] The mechanism behind Nd:YAG capsulotomy leading to retinal tear and detachment is still unclear. Some postulate that rupture of the anterior vitreous hyaloid with the laser initiates a posterior vitreous detachment with subsequent retinal tear and detachment.[24]

A commonly accepted theory regarding the development of CME after cataract surgery is that it is secondary to intraocular inflammation.[25] The protocol of this study was therefore to perform Nd:YAG laser capsulotomy after at least 3 months from cataract surgery or at least 1 month after the intraocular inflammation had resolved (whichever was longer). To the best of authors' knowledge, no controlled prospective trials have specified the optimum time to perform Nd:YAG laser capsulotomy.

The primary goal of this study was to examine the influence of Nd:YAG laser capsulotomy on SE and IOP. The requirement to re-refract following Nd:YAG laser capsulotomy would lead to an increase in the workload. We wanted to formulate a patient convenient protocol regarding the necessity of re-refraction after Nd:YAG laser capsulotomy and ascertain the optimum interval for re-refraction. We also aimed to find the necessity of treating eyes undergoing Nd:YAG laser capsulotomy with prophylactic anti glaucoma medications. The secondary goal was to see the effect of Nd:YAG laser capsulotomy on BCVA, macular thickness, and ACD.

Methodology

This study was performed according to the tenets of the Declaration of Helsinki and written informed consent was obtained from the patients before the intervention. The local ethical committee board of Mechi Eye Hospital approved the research protocol. The study was a prospective, descriptive study. A total of 96 pseudophakic eyes of 83 patients with PCO with BCVA ≤6/9 (LogMAR 0.176) were included in the study. Only those cases that had undergone uncomplicated manual small incision cataract surgery or phacoemulsification with posterior chamber intraocular lens (PCIOL) in the bag implantation surgery at Mechi Eye Hospital were included in the study. Multiple surgeons performed the surgeries. Exclusion criteria included complications during cataract surgery or during the postoperative period. Diagnosed cases of glaucoma and steroid responders, those with corneal opacities, retinal diseases, uveitis, optic neuropathy, and those who had undergone any other ophthalmic surgeries prior to Nd:YAG laser posterior capsulotomy treatment were also excluded from the study.

All the patients underwent Nd:YAG laser capsulotomy from January 15, 2017 to January 14, 2018 at Mechi Eye Hospital. They were examined preoperatively, at 1 hr postoperatively, and at 1 month after Nd:YAG laser capsulotomy. Patients were divided into two groups according to total energy used during the procedure (Group I ≤50 mJ, Group II >50 mJ). There were 56 eyes in Group I and 40 eyes in Group II. Multiple surgeons performed the capsulotomy, though each capsulotomy was performed by a single surgeon in a single session with a Nd:YAG laser, Zeiss Visulas III laser (Carl Zeiss Meditec Inc, Dublin, California, USA).

All patients underwent a complete ocular examination on all visits, including BCVA, refraction (autorefraction followed by subjective refraction), slit lamp biomicroscopy, IOP measurement. BCVA was measured in a darkened room using projection-type Snellen chart. Objective refraction was done using an autorefractometer Nidek ARK-510A (NIDEK Co. Ltd, Gamagori, Japan). The spherical equivalent (SE) values were calculated as the sum of the sphere plus half the cylindrical power. The IOP was recorded by Reichert 7CR (Reichert Technologies, NY, USA). The spectral domain optical coherence tomography (OCT) (Cirrus OCT, Carl Zeiss Meditec, Dublin, CA, USA) was used for macular thickness measurements. OCT measurements were repeated until satisfactory scans were achieved with signal strength of at least 6. The IOLMaster 500 (Carl Zeiss Meditec, Dublin, CA, USA) was used to measure ACD.

Combination of tropicamide 0.8% and phenylephrine 5% (Auromide Plus®, Aurolab, Madurai, India) were administered for pupillary dilatation prior to the procedure. All pretreatment data and data at 1-month follow-up were collected from nondilated eyes. However, data at 1 hr after treatment were taken from dilated eyes. After capsulotomy, a combination of antibiotic and steroid (ciprofloxacin 0.3%+dexamethasone 0.1%) (Zoxan-D®, FDC limited, Mumbai, India) was prescribed four times daily for 7 days.

IBM SPSS Statistics for Macintosh, Version 20.0. Armonk, NY: IBM Corp. was used for statistical analysis. The independent *t*-test was used for the comparisons between the groups and the paired t was used to detect intragroup differences for repeated measurements. A *P*-value of <0.05 was considered statistically significant.

Results

Fifty-four male and 29 female patients were enrolled in this study. Seventy patients received treatment in unilateral eyes and 13 patients in both eyes. There were 56 eyes of 46 patients in Group I and 40 eyes of 37 patients in Group II. Mean age of the patients was 62.72±11.14 years (range: 32–82) in Group I and 60.68±14.70 years (range: 19–85) in Group II. Mean age and gender were not significantly different between the two groups (*P*=0.474, 0.343, respectively). The mean duration from surgery was 3.26±1.74 years in Group I and 2.46±1.37 years in Group II which was significantly different (*P*=0.018).

Table 1 shows the total amount of energy used in Nd:YAG laser posterior capsulotomy in each group and compares BCVA, SE, IOP, macular thickness measurements, and ACD between the two groups preoperatively, at 1 hr postoperatively, and 1 month postoperatively. The total amount of energy used during Nd:YAG laser capsulotomy was significantly higher in Group II (*P*<0.001). There was no significant difference between the groups by means of BCVA, SE, IOP, macular thickness, and ACD preoperatively, at 1 hr postoperatively, and 1 month postoperatively (*P*>0 0.05).

Table 2 compares the amount of change in IOP, macular thickness, SE, and ACD between the two energy groups at 1 hr postoperatively and 1 month postoperatively from the preoperative level. Higher energy use was associated with significantly higher rise in IOP and macular thickness at 1 hr (*P*<0.001). This effect was not seen at 1 month (*P*=0.052) for both IOP and macular thickness. Difference in energy levels had no significant effect on the amount of change in SE and ACD.

Tables 3 and 4 show the comparison of the repeated measurements of BCVA, SE, IOP, macular thickness, and ACD in Groups I and II, respectively. The BCVA improved significantly in both the groups at 1 hr and 1 month. There was no significant difference between the pretreatment SE and SE at 1 hr postoperatively and 1 month postoperatively in both the groups.

In both groups, I and II, IOP increased 1 hr postoperatively (*P*=0.023 and <0.001, respectively). IOP declined to preoperative levels at 1 month in Group I. Though the IOP at 1 month decreased significantly from 1 hr value, it remained significantly higher than the preoperative value in Group II (*P*=0.003). The maximum IOP spike was observed at 1 hr in both the groups. One patient (from Group II) had a rise in IOP from 18 to 24 mmHg, which normalized on the following day without any glaucoma medication. Likewise, the maximum increment in IOP in Group I was of 5 mmHg, which was observed in a single patient (IOP rose from 10 to 15 mmHg at 1 hr). There were eight patients with an IOP increment of 4 mmHg at 1 hr out of which seven were from Group II and one from Group I. None of these patients had an IOP >18 mmHg at 1 hr.

Mean macular thickness measurements at 1 hr postoperatively compared to preoperative values were significantly higher in both Groups I and II (*P*<0.001). In Group I, macular thickness decreased to preoperative levels at 1 month follow-up. In Group II though the macular thickness decreased significantly at 1-month follow-up, it remained significantly high compared to pretreatment level (*P*=0.006). Likewise in both Groups I and II, ACD increased significantly at 1 hr compared to preoperative value (*P*<0.001, 0.046 respectively) and continued to increase significantly at 1 month follow-up (*P*=0.001) compared to 1 hr.

We did not observe any case with serious rise in IOP, anterior chamber reaction or CME. None of the patients had to be treated with topical antiglaucoma medications. One patient (from Group I) developed minimal vitreous hemorrhage during his follow-up at 1 month. It resolved completely in 1 month by conservative management with topical ketorolac 0.4% solution, four times per day for 1 month. None of the patients developed retinal tear or retinal detachment.

Table 1 Total amount of energy used in Nd:YAG laser posterior capsulotomy in Groups I and II and comparison of BCVA, SE, IOP, macular thickness, and ACD between the groups at preoperative evaluation and at 1 hr postoperatively, and 1-month follow-up

	Group I (N=56)	Group II (N=40)	*P*
Total energy (mJ)	26.64±12.92	81.96±32.10	<0.001
BCVA (LogMAR)			
Pretreatment	0.68±0.36	0.69±0.36	0.917
1 hr post-treatment	0.22±0.15	0.25±0.15	0.297
1 month post-treatment	0.14±0.13	0.17±0.14	0.316
Spherical equivalent (D)			
Pretreatment	−0.39±0.66	−0.40±0.52	0.981
1 hr post-treatment	−0.35±0.67	−0.36±0.55	0.929
1 month post-treatment	−0.34±0.67	−0.37±0.52	0.775
IOP (mmHg)			
Pretreatment	14.51±2.53	13.60±2.78	0.097
1 hr post-treatment	14.98±2.28	15.72±2.63	0.144
1 month post-treatment	14.64±2.16	14.30±2.32	0.460
Macular thickness (µm)			
Pretreatment	224.51±13.51	221.85±12.63	0.330
1 hr post-treatment	228.26±12.70	231.52±13.36	0.229
1 month post-treatment	224.82±12.90	224.20±12.26	0.813
AC depth (mm)			
Pretreatment	3.94±0.26	3.96±0.35	0.693
1 hr post-treatment	3.95±0.25	3.98±0.35	0.707
1 month post-treatment	3.97±0.26	3.99±0.34	0.701

Abbreviations: BCVA, best corrected visual acuity; SE, spherical equivalent; ACD, anterior chamber depth.

Table 2 Comparison of amount of change in IOP, macular thickness, SE, and ACD between the two energy groups at 1 hr and 1 month postoperatively

	Group I (N=56)	Group II (N=40)	*P*
IOP rise at 1 hr (mmHg)	0.46±1.48	2.12±1.68	<0.001
IOP rise at 1 month (mmHg)	0.12±1.41	0.70±1.39	0.052
Macular thickness rise at 1 hr (µm)	3.75±5.32	9.67±6.52	<0.001
Macular thickness rise at 1 month (µm)	0.30±4.96	2.35±5.08	0.052
SE change at 1 hr (D)	0.03±0.23	0.03±0.11	0.811
SE change at 1 month (D)	0.05±0.23	0.02±0.08	0.328
ACD change at 1 hr (mm)	0.01±0.02	0.01±0.04	0.948
ACD change at 1 month (mm)	0.03±0.03	0.03±0.06	0.905

Abbreviations: SE, spherical equivalent; ACD, anterior chamber depth.

Table 3 Comparison of the repeated measurements of BCVA, SE, IOP, macular thickness, and ACD in Group I

	Mean (SD)	*P*
BCVA (LogMAR)		
1 hr to pretreatment	−0.46±0.37	<0.001
1 month to pretreatment	−0.53±0.34	<0.001
1 hr to 1 month	0.07±0.12	<0.001
SE (D)		
1 hr to pretreatment	0.03±0.23	0.204
1 month to pretreatment	0.05±0.23	0.080
1 hr to 1 month	−0.01±0.09	0.212
IOP (mmHg)		
1 hr to pretreatment	0.46±1.48	0.023
1 month to pretreatment	0.12±1.41	0.511
1 hr to 1 month	0.33±1.49	0.095
Macular thickness (µm)		
1 hr to pretreatment	3.75±5.32	<0.001
1 month to pretreatment	0.30±4.96	0.649
1 hr to 1 month	3.44±4.36	<0.001
ACD (mm)		
1 hr to pretreatment	0.015±0.028	<0.001
1 month to pretreatment	0.032±0.035	<0.001
1 hr to 1 month	−0.016±0.034	0.001

Abbreviations: BCVA, best corrected visual acuity; SE, spherical equivalent; ACD, anterior chamber depth.

Discussion

The reported incidence of PCO is 20.7% at 2years and 28.5% at 5years after cataract surgery.[26] PCO is the most frequent cause of diminished visual acuity after extra-capsular cataract surgery.[13] Nd:YAG laser capsulotomy is the standard treatment of PCO.[5]

In general ophthalmic practice, we give most of our attention to visual acuity when assessing a patient's visual performance in relation to any procedures. All our patients underwent capsulotomy with the complaint of DOV. Aron-Rosa et al[27] reported an immediate improvement in visual acuity in 94% of cases treated by capsulotomy. In a review by Weiblinger et al,[28] overall visual acuity improved in 83–94% and decreased in 3.5–6% of cases. In our study, all the patients of either group had significant improvement in their visual acuity after Nd:YAG laser

Table 4 Comparison of the repeated measurements of BCVA, SE, IOP, macular thickness, and ACD in Group II

	Mean (SD)	*P*
BCVA (LogMAR)		
1 hr to pretreatment	−0.43±0.35	<0.001
1 month to pretreatment	−0.51±0.36	<0.001
1 hr to 1 month	0.07±0.13	0.001
SE (diopters)		
1 hr to pretreatment	0.03±0.11	0.096
1 month to pretreatment	0.02±0.08	0.128
1 hr to 1 month	−0.00±0.12	0.628
IOP (mmHg)		
1 hr to pretreatment	2.12±1.68	<0.001
1 month to pretreatment	0.70±1.39	0.003
1 hr to 1 month	1.42±1.72	<0.001
Macular thickness (μm)		
1 hr to pretreatment	9.67±6.52	<0.001
1 month to pretreatment	2.35±5.08	0.006
1 hr to 1 month	7.32±4.90	<0.001
ACD (mm)		
1 hr to pretreatment	0.01±0.04	0.046
1 month to pretreatment	0.03±0.06	0.003
1 hr to 1 month	−0.01±0.02	0.001

Abbreviations: BCVA, best corrected visual acuity; SE, spherical equivalent; ACD, anterior chamber depth.

capsulotomy. In our study, the mean interval from the time of cataract surgery to capsulotomy was 3.26±1.74 years in Group I and 2.46±1.37 years in Group II. The interval ranged from 4months to 8years. We avoided performing capsulotomy within the first 3months after cataract surgery to avoid the increased risk of CME.

Though reliable, Nd:YAG capsulotomy can lead to complications like spike in IOP, lens damage, change in refraction, macular edema, retinal tear, and retinal detachment.[7–16] The most common complication of Nd: YAG laser posterior capsulotomy is increased IOP. In the absence of antiglaucoma or anti-inflammatory prophylaxis, 59–67% of patients showed IOP increment of at least 10 mm Hg following Nd:YAG laser capsulotomy.[29,30] Despite the prophylactic treatment, increased IOP was reported in 15–30% of patients in several studies.[31,32] Whereas Ozkurt et al[33] concluded no significant change in IOP after Nd:Yag capsulotomy. Ari et al[34] divided their study population based on energy used; Group I ≤80 mJ, Group II >80 mJ. They observed that after significant increase at 1 week postoperatively in both groups, IOP decreased to preoperative levels at 1 month in Group I. However, it remained at significantly high levels at 3 months postoperatively in Group II when compared to preoperative levels.

In their study on 101 eyes where they instilled apraclonidine hydrochloride 0.5% before and after the capsulotomy, Holweger and Marefat[35] concluded that there was no significant rise in IOP and routine IOP measurements at 1–3 hrs and 1 day after capsulotomy was not necessary. In our study, there was statistically significant increase in IOP in both the groups at 1 hr. IOP declined to preoperative levels at 1 month in Group I. Though the IOP at 1 month decreased significantly from 1 hr value, it remained significantly higher than the preoperative value in Group II. However, none of the patients had serious rise in IOP that required treatment with antiglaucoma medications.

Nd:YAG laser capsulotomy has been found to affect the lens position. Findl et al[15] reported that a subtle posterior shift of the PCIOL can occur with deepening of the anterior chamber (mean 25±13 μm). Thornval and Naeser[14] however failed to observe this effect and did not observe any significant change in the SE after the procedure. Theoretically, the posterior shift of the PCIOL may cause a hyperopic shift. Chau et al[36] observed no significant change in SE after Nd:YAG capsulotomy. Likewise, Ozkurt et al[33] observed no significant change in ACD and SE after Nd:YAG capsulotomy. Likewise, Yilmaz et al[37] too failed to observe any significant change in refractive error after Nd:YAG capsulotomy. However, Ramachandra and Kuriakose[38] concluded improved vision and significant change in refraction after Nd:YAG posterior capsulotomy and thus the need for a new spectacle correction. In our study, we did not observe any statistically significant change in SE at both 1 hr and 1 month postoperatively compared to preoperative value in both the energy groups. A clinically significant increase in anterior chamber depth was observed in both the groups. The increment was progressive even up to the 1-month follow-up.

Ari et al[34] observed significant increase in macular thickness following Nd:YAG capsulotomy and that the increment was higher in patients who received higher energy. Karahan et al[39] found significant increment in central macular thickness after Nd:YAG capsulotomy at 1 week which decreased to preoperative levels at 4 weeks irrespective of the capsulotomy size. Raza[40] reported CME in 3% of 550 patients treated with Nd:YAG laser capsulotomy for pseudophakic and aphakic PCO. In our study, there was statistically significant increment of macular thickness at 1 hr in both the groups. The mean macular thickness decreased to preoperative levels at 1 month in Group I. Though the macular thickness decreased significantly from 1 hr level at 1-month follow-up, the macular thickness was still significantly higher than preoperative value in Group II. However, none of the cases developed serious increment in macular thickness or CME that required treatment.

Retinal tears and detachments are established complications of Nd:YAG capsulotomy. It has been estimated that the risk of retinal detachment is four times higher after laser capsulotomy.[9,41,42] However, none of our patients developed these complications. This can be attributed to our small sample size and short duration of follow-up of only 1 month.

Another limitation of this study is that the authors have not taken into account the IOP rising potential of topical steroids. The issue of steroid-induced glaucoma was first described in the 1950s with the observation of glaucoma in association with administration of systemic adrenocorticotropic hormones or topical and systemic steroids.[43–45] Regarding the timing of rise of IOP following the topical use of steroid, the majority of studies reported that IOP rises 3–6 weeks after the beginning of topical steroid use, while some elevation of pressure can be found in most patients as early as the first or second week.[46–49] Armaly[46,47] noted that normal patients developed the hypertensive effect of steroid at the end of first week, with a mean increase in pressure of 19%. The steroid-induced IOP increase is usually short-lived and reversible by discontinuance of therapy. The IOP usually returns to normal within 2–4 weeks after discontinuing the steroid.[50] In this study, we assumed that the short course of steroid use had no effect on IOP during its measurement at 1-month follow-up.

Conclusion

Increase in IOP and macular thickness is common after Nd:YAG laser capsulotomy, whose severity and duration changes regarding with the amount of total energy used. However, this might not necessitate regular prophylactic treatment. BCVA improves significantly after Nd:YAG laser posterior capsulotomy in otherwise healthy pseudophakic eyes with PCO. There is usually no need for repeat refraction, which even if needed, can be done after 1 hour of the procedure. ACD too increases after Nd:YAG laser capsulotomy.

Ethics and consent

Ethics approval was obtained from the local ethical committee board of the Mechi Eye Hospital and written informed consent was obtained from the patients before the intervention.

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Disclosure

The authors report no conflicts of interest in this work.

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