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Original Research Article

Effects of Nd:YAG Laser Posterior Capsulotomy on Intraocular Pressure, Best-Corrected Visual Acuity, and Central Macular Thickness in Posterior Capsular Opacification

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ABSTRACT
Background: Posterior capsular opacification (PCO) is a common complication of cataract surgery that can happen weeks to months later and results in decreased vision. Nd:YAG laser capsulotomy is the common treatment for PCO, although it can cause transient changes to the eye.
Objective: To study intraocular pressure, best-corrected visual acuity and central macular thickness after Nd:YAG laser posterior capsulotomy for clinically significant posterior capsular opacification.
Methods: Fifty-eight eyes of fifty-eight participants were included in this prospective observational study. Intraocular pressure (IOP) was measured by Goldmann applanation tonometry, best-corrected visual acuity (BCVA) was measured by Snellen chart and converted to logMAR, and central macular thickness (CMT) was measured by Spectral Domain Optical Coherence Tomography. All assessments were done prior to and at one hour, one week, and one month after capsulotomy.
Results: At baseline, mean IOP was measured at 14.6 ± 2.1 mmHg and at one hour post intervention was measured at 17.3 ± 3.4 mmHg ($p < 0.001$) with a return to 14.4 ± 2.2 mmHg at the one month follow up. Mean BCVA logMAR improved from 0.64 ± 0.22 to 0.14 ± 0.11 ($p < 0.001$) with 89.6% achieving 6/12 or better vision. Mean CMT was measured at 242.5 ± 18.4 µm with a statistically significant increase at one week post intervention to 250.7 ± 22.1 µm ($p = 0.002$) and a return to 243.9 ± 18.8 µm at one month. There was no significant increase in IOP, Cystoid Macular Oedema or other adverse events reported.
Conclusion: Nd:YAG laser posterior capsulotomy significantly improved vision. Post operative changes in IOP and CMT were mild, temporary and resolved by one month.

Keywords: Nd:Yag Laser Capsulotomy, Posterior Capsule Opacification, Intraocular Pressure, Best Corrected Visual Acuity, Central Macular Thickness, Oct.

Key Messages
- Nd:YAG laser posterior capsulotomy improved mean best-corrected visual acuity from 0.64 to 0.14 logMAR one month post-operation.
- Intraocular pressure exhibited the most significant rise at the one hour mark. Comparably baseline values were observed after one month.
- At one week, we saw a modest increase in central macular thickness, but by one month, this returned to normal levels with no signs of cystoid macular edema.

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INTRODUCTION

Posterior capsular opacification is the most frequent long-term complication of cataract surgery.[1] It may compromise visual acuity as well as the quality and contrast of vision.[2] Posterior capsular opacification remains a problem that has been reduced but not fully eradicated.[3] Its aetiopathogenesis and prevention are multifactorial.[4] Management of the posterior capsular opacification following posterior chamber lens implantation has long been a clinical concern.[5] Nd:YAG laser posterior capsulotomy creates an opening in the visual axis and is a no-touch procedure on the eye. Nevertheless, temporary elevation of intraocular pressure, inflammation, and macular edema may occur.[6] Previous research has often examined these effects separately or at non-harmonized follow-up intervals, although subtle macular changes can be assessed using spectral-domain optical coherence tomography.[7] This prospective research examined intraocular pressure, best-corrected visual acuity and central macular thickness prior to capsulotomy and at the following time intervals of one hour, one week and one month.

MATERIALS AND METHODS

Study Design and Ethical Considerations

During the defined study period, the Department of Ophthalmology carried out a prospective observational study. The Institutional Ethics Committee approved the study before subject enrollment. The study adhered to the principles of the Declaration of Helsinki, and written informed consent was acquired from all study participants.

Study Population

The study evaluated post operative complications in adults with visually significant posterior capsular opacification. It included 58 eyes from 58 adults. All study participants were adults (≥ 18 years), had cataract surgery 6 months prior, presented with visual acuity worse than 6/18, and whose baseline IOP was less than or equal to 21 mmHg. Eyes with glaucoma, ocular hypertension, uveitis, previous retinal surgery, monocular status, retinal disease, significant corneal opacities, diabetic retinopathy or were uncooperative for the laser procedure, were not included.

Pre-procedure Assessment

Prior to capsulotomy, a full external examination of the eye and associated structures was carried out on each participant. Best-corrected visual acuity was measured using a Snellen chart from 6 m within a standardised illuminated environment and was converted for analysis to logMAR.[8] Intraocular pressure was taken as the average of three readings obtained with Goldmann applanation tonometry. The anterior segment, intraocular lens, and morphology of posterior capsular opacification were assessed using slit-lamp biomicroscopy.[9] The posterior segment was assessed clinically, and central macular thickness was measured using spectral-domain optical coherence tomography.

Nd:YAG Laser Posterior Capsulotomy

Experienced ophthalmologists performed the capsulotomy. Prior to the procedure, tropicamide 1% was administered 30 minutes beforehand, and the topical anaesthetic proparacaine hydrochloride 0.5% was applied. Under slitlamp a 3-4 mm opening was formed in the visual axis using the minimum effective laser energy in either a cruciate or circular pattern.[10] To avoid an early rise in intraocular pressure (IOP), apraclonidine 0.5% or brimonidine 0.15% was administered after the procedure.[11]

Post-procedure Assessment

Intraocular pressure, best-corrected visual acuity, and central macular thickness were measured again at one hour, one week, and one month after capsulotomy.[12] The study participants were evaluated for anterior chamber inflammation, intraocular lens pitting or displacement, vitreous prolapse, cystoid macular edema, and retinal tears or detachment.[13] A clinically significant elevation in intraocular pressure was defined as an increase greater than 10 mmHg from baseline or an absolute intraocular pressure greater than 30 mmHg.

Statistical Analysis

Data were analyzed with SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables are expressed as mean ± standard deviation. The Shapiro-Wilk test was performed to assess normality of distribution. To compare intraocular pressure, logMAR best corrected visual acuity and central macular thickness at the four defined time points of assessment, repeated measures analysis of variance was performed. Bonferroni adjustment was used to make pairwise comparisons. The McNemar test was used to compare the proportion of subjects reaching 6/12 or better at baseline and one

month. A P value of < 0.05 was considered statistically significant.

RESULTS

Participant Characteristics

All 58 participants completed all the steps of the study and were included in the one-month analysis. Average age was 62.4 years (SD 8.7, range 42-79 years). There were 34 women (58.6%) and 24 men (41.4%) in the study cohort. The average period between cataract surgery and diagnosis of posterior capsule opacification was 24.3 months. All participants had an in-the-bag posterior chamber intraocular lens.

Intraocular Pressure

Before capsulotomy, the average intraocular pressure was 14.6 ± 2.1 mmHg. It increased to 17.3 ± 3.4 mmHg one hour post-surgery with the increase being statistically significant ($p < 0.001$). Mean intraocular pressure decreased to 15.1 ± 2.8 mmHg at one week ($p = 0.38$ compared with baseline) and to 14.4 ± 2.2 mmHg at one month ($p = 0.79$, compared with baseline). There was a significant change overall with time ($F = 18.6$, $p < 0.001$), and the only significant difference was baseline and one hour. No patient had an intraocular pressure greater than 30 mmHg and there were no increases greater than 10 mmHg from baseline.

Parameter	Pre-laser	1 hour	1 week	1 month
Mean IOP (mmHg ± SD)	14.6 ± 2.1	17.3 ± 3.4	15.1 ± 2.8	14.4 ± 2.2
p value versus baseline	—	<0.001*	0.38	0.79

Table 1. Intraocular Pressure at Different Assessment Time Points

*Statistically significant at $p < 0.05$. IOP, intraocular pressure; SD, standard deviation

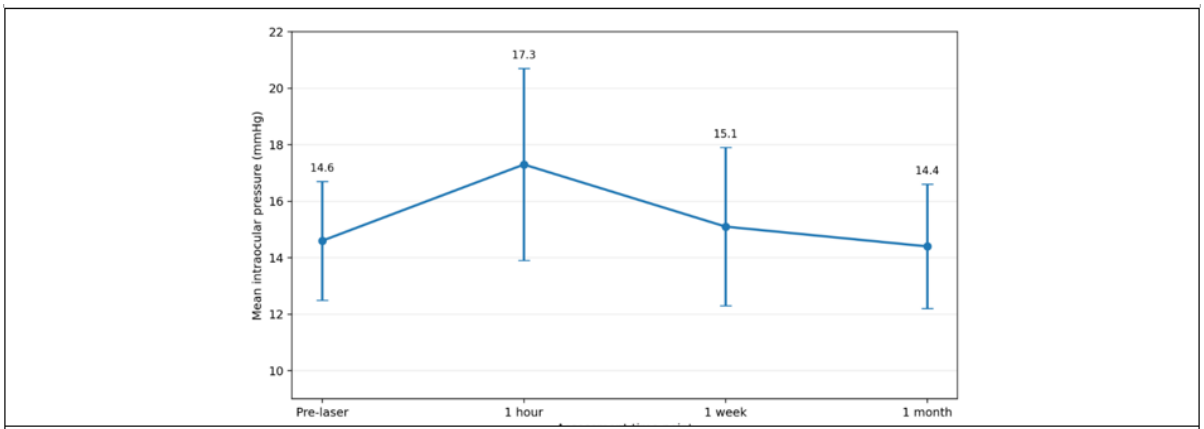

Figure 1. Mean intraocular pressure at each assessment time point; error bars represent standard deviations

Best-Corrected Visual Acuity

Prior to any procedures, nearly all subjects had best corrected visual acuity between 6/36 and 6/18. Some subjects had visual improvement to some degree at the one hour mark, but some had temporary blurriness as a result of capsular debris. Recovery for these subjects was mostly finished at the one week mark. By the one month mark, thirty six of thirty eight (89.5%) study subjects had reached 6/12 or better visual acuity, compared to five of thirty eight (8.5%) study subjects at baseline ($p < 0.001$, McNemar test). Overall, mean logMAR best corrected visual acuity improved from 0.64 ± 0.22 to 0.14 ± 0.11 at one month ($p < 0.001$). The overall time effect was significant ($F = 84.3$, $p < 0.001$).

BCVA Category	Pre-Laser, n (%)	1 Month, n (%)
6/6-6/9 (good)	2 (3.4%)	38 (65.5%)
6/12-6/18 (moderate)	18 (31.0%)	17 (29.3%)
6/24-6/36 (reduced)	28 (48.3%)	3 (5.2%)
6/60 or worse (poor)	10 (17.2%)	0 (0.0%)

Table 2. Distribution of Best-Corrected Visual Acuity at Baseline and One Month

BCVA, best-corrected visual acuity. The proportion achieving 6/12 or better differed significantly between baseline and one month ($p < 0.001$, McNemar test).

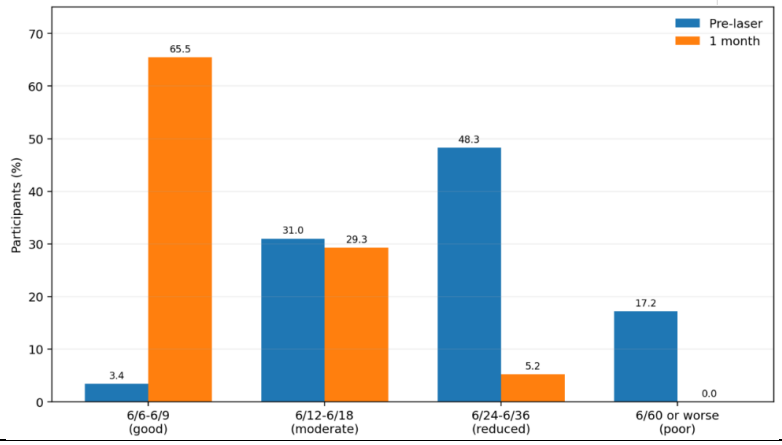

Figure 2. Percentage Distribution of Best-Corrected Visual Acuity Categories Before Capsulotomy and at One Month.

Central Macular Thickness

Mean central macular thickness at baseline was 242.5 ± 18.4 µm. One hour later, it was 246.1 ± 19.7 µm ($p = 0.04$) and 250.7 ± 22.1 µm ($p = 0.002$) at week one. At month one, it was 243.9 ± 18.8 µm ($p = 0.71$) and was similar to baseline. The overall time effect was significant ($F = 9.4$, $p = 0.001$). No subject had greater than 300 µm of central macular thickness or optical coherence tomography features of cystoid macular oedema.

Parameter	Pre-Laser	1 Hour	1 Week	1 Month
Mean CMT (µm ± SD)	242.5 ± 18.4	246.1 ± 19.7	250.7 ± 22.1	243.9 ± 18.8
p value versus baseline	—	0.04*	0.002*	0.71

Table 3. Central Macular Thickness at Different Assessment Time Points

*Statistically significant at $p < 0.05$. CMT, central macular thickness; SD, standard deviation.

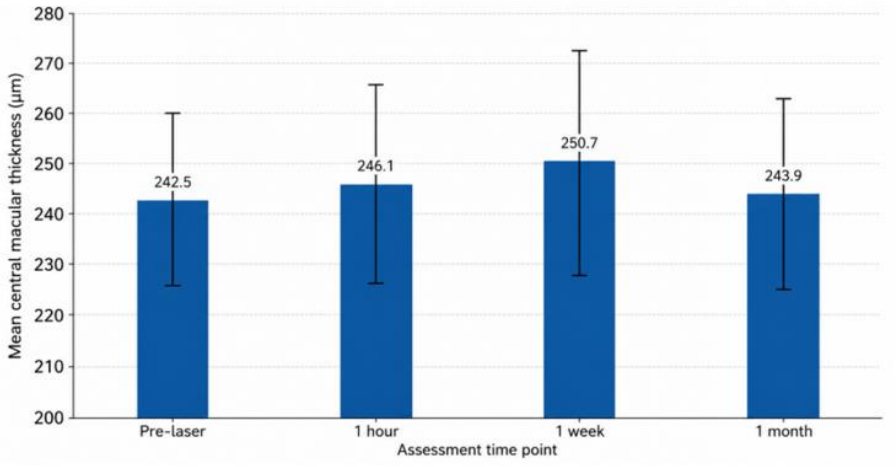

Figure 3. Mean central macular thickness at each assessment time point; error bars represent standard deviations.

Adverse Events

Mild anterior chamber flare was noted in seven of 58 participants (12.1%) at one hour, but was completely resolved by one week for all affected eyes. No displacement of the intraocular lens, significant lens pitting, vitreous prolapse, cystoid macular edema, retinal tears, or retinal detachment, or endophthalmitis was

noted in any of the participants during the one month follow up.

DISCUSSION

This study measured intraocular pressure, best-corrected visual acuity, and central macular thickness at set time points after Nd:YAG laser posterior capsulotomy on 58 adult eyes with significant posterior capsular opacification (PCO). The procedure made a notable improvement to vision. Intraocular pressure (IOP) and central macular thickness (CMT) showed mild, transient improvement. One month after the procedure, IOP and CMT returned to baseline values and showed no significant change.

The main clinical benefit of the procedure was improvement in vision. At one month after the procedure, 89.6% of eyes had best-corrected visual acuity of 6/12 or better, and mean logMAR acuity improved from 0.64 to 0.14. These results demonstrated rapid and sustained visual improvement after restoration of a clear visual axis and were comparable to previous reports.[14] Comparable improvements in visual acuity have also been reported over six months of follow-up.[15] Studies from lower-middle-income settings have similarly documented favorable visual outcomes after capsulotomy.[16] Visual outcomes may vary according to associated clinical factors.[17] The high rate of positive outcomes in the present study may also be attributed to the exclusion of eyes with macular disease, retinopathy, significant corneal opacities, and glaucoma.

The mean intraocular pressure (IOP) increased by 2.7 mmHg at one hour and then returned to baseline levels. This transient increase is consistent with previously reported IOP changes after Nd:YAG laser posterior capsulotomy.[18] Acute elevations in IOP after capsulotomy have also been documented.[19] Effects of Nd:YAG treatment on the anterior segment and intraocular pressure have likewise been reported.[20] Recent evidence continues to document early IOP changes following capsulotomy.[21] The exclusion of patients with glaucoma and ocular hypertension, together with the use of a postoperative pressure-lowering topical medications, likely explains the absence of clinically significant IOP increases. Early IOP measurement remains appropriate in eyes with existing optic nerve disease or structural outflow impairment.

Central macular thickness increased by 3.6 µm one hour after procedure and by 8.2 µm one week after procedure. Thickness approached the baseline value one month after procedure. This pattern is more consistent with a transient inflammatory response than with cystoid macular edema and agrees with previous reports of short-lived macular changes after capsulotomy.[22] Prospective clinical studies have also reported changes in macular thickness and related ocular parameters after capsulotomy.[23] Studies of macular edema identify retinal pathology and prior inflammatory disease as important risk factors.[24] Cystoid macular edema related to capsulotomy has been reported to respond to topical ketorolac.[25] Spectral-domain optical coherence tomography was useful for detecting small, subclinical changes that might not be appreciated during routine fundus examination.[26]

Mild, transient anterior chamber inflammation was noted in 12.1% of subjects. There were no reported cases of retinal tears or detachment, intraocular lens displacement, or endophthalmitis. Although these observations support a positive short-term safety profile, unusual or delayed complications cannot be ruled out in a sample of 58 subjects followed for one month.[27] Retinal detachment has been reported as a rare delayed complication after Nd:YAG posterior capsulotomy.[28] Newer studies describe changes in the choroidal layer and choroidal vasculature after capsulotomy, which warrant further investigation.[29]

The main strengths of the study were the prospective design, the use of Goldmann applanation tonometry and spectral-domain optical coherence tomography, and the evaluation of three clinically relevant endpoints at the same follow-up intervals. Main weaknesses were the small number of study subjects, one study center, one month follow-up and no classification of posterior capsular opacification by morphology, capsulotomy size or total laser energy. Multicenter studies with longer follow-up periods are required to assess later complications and determine patient groups that may need closer follow-up.

CONCLUSION

Nd:YAG laser posterior capsulotomy significantly improved best-corrected visual acuity in adults with visually significant posterior capsular opacification.[30] One hour after surgery, average intraocular pressure increased slightly. One week after surgery, central macular thickness also increased slightly, and both parameters returned to baseline after one month. There were no

significant pressure spikes, cystoid macular edema, or adverse events. Early assessment of intraocular pressure and selective optical coherence tomography remain useful for detecting complications in patients with coexisting ocular risk factors.

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