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ORIGINAL RESEARCH

Endothelial Cell Study In Patients Undergoing Nd- Yag Capsulotomy Post Cataract Surgery

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ABSTRACT

Introduction: Posterior Capsular Opacification (PCO) is a common condition that can occur months or even years after cataract surgery. The standard treatment is a laser procedure called Nd:YAG laser capsulotomy. Although effective, it may cause side effects such as increased eye pressure, swelling in the retina (cystoid macular oedema), damage to the corneal cells, retinal detachment, and marks on the intraocular lens (IOL).

Aim: This study aimed to examine how the corneal endothelial cells are affected before and after Nd:YAG laser capsulotomy in patients with PCO, using a test called specular microscopy.

Materials and Methods: This was a prospective observational study conducted at Pacific Medical College, Udaipur, India. It included 50 eyes from 50 patients with PCO, carried out between January and April 2025. All patients received Nd:YAG laser treatment in the affected eye and were checked again after one week and one month. Specular microscopy was used to measure Endothelial Cell Density (ECD), Coefficient of Variation (CV), and the percentage of hexagonal cells (hexagonality). Data was analyzed using SPSS version 26.0, with Chi-square and ANOVA tests to check for significance.

Results: After one week, 90% of patients (45 out of 50) had a Best Corrected Visual Acuity (BCVA) better than 6/18, and after one month, 94% (47 patients) had BCVA of 6/18 or better. The average ECD before the laser was 2356.76 cells/mm². This dropped to 2231.8 cells/mm² after one week and 2199.2 cells/mm² after one month. The reduction in ECD at one month (157.56 cells/mm²) was statistically significant ($p < 0.0001$).

Conclusion: Nd:YAG laser capsulotomy is a safe, effective, and non-invasive procedure for managing Posterior Capsular Opacification. However, it can lead to structural and functional changes in the corneal endothelial cells.

INTRODUCTION

Cataract surgery is one of the most frequently performed procedures in ophthalmology and typically provides excellent visual outcomes. This is largely due to advancements in surgical techniques, instrumentation, and intraocular lens (IOL) technology. However, despite improvements in lens design and materials, a late postoperative complication known as Posterior Capsular Opacification (PCO) can still occur [1].

The risk of PCO is reduced when the IOL maintains full contact with the anterior capsule. Studies have reported that the incidence of visually significant PCO is approximately 11.8% at one year, 20.7% at three years, and 28.4% at five years following cataract surgery [2]. PCO can result in reduced visual acuity, impaired contrast sensitivity, glare, and monocular diplopia [3].

Several risk factors are associated with the development of PCO. Patients with diabetes are more prone to develop PCO compared to non-diabetics. Other contributing factors include uveitis, high myopia, retinitis pigmentosa, traumatic cataract, and myotonic dystrophy. The occurrence of PCO is also influenced by the type of IOL material used. Hydrophobic acrylic lenses are associated with a lower incidence of PCO compared to lenses made from polymethyl methacrylate (PMMA) or hydrophilic acrylic materials [4].

When PCO leads to a significant decline in vision, opening the posterior capsule becomes necessary. This can be achieved either surgically or with a Nd:YAG laser capsulotomy, the latter being the preferred technique due to its effectiveness and non-invasive nature, with a success rate exceeding 95% [5]. The Nd:YAG laser, made from a synthetic crystal of Neodymium-doped Yttrium Aluminium Garnet, emits light at a wavelength of 1064 nm and works by photodisruption—a process that ionizes tissue—unlike argon or krypton lasers [3].

Despite its high success rate, Nd:YAGcapsulotomy may cause certain complications, such as increased

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intraocular pressure, cystoid macular edema, corneal endothelial cell loss or damage, retinal tears or detachment, and IOL pitting [2].

The corneal endothelium is a single layer of hexagonal cells adhering to Descemet's membrane and in contact with the aqueous humor. It helps maintain corneal transparency through a fluid regulation mechanism that keeps the corneal stroma in a state of relative dehydration [4].

In this study, corneal endothelial structure and function were evaluated using non-contact specular microscopy. Modern specular microscopes use advanced imaging and software to analyze endothelial cell shape, size, and density. The device projects light onto the cornea, captures the reflection at the endothelial-aqueous interface, and generates a specular photomicrograph for analysis [4].

As limited studies exist on the effect of Nd:YAG laser capsulotomy on the corneal endothelium, this research aimed to assess endothelial morphology and function before and after the procedure.

Objectives:

The primary aim of this study was to compare changes in Cell Density (CD) and Coefficient of Variation (CV) before and after Nd:YAG capsulotomy.

MATERIALS AND METHODS

This prospective observational study was conducted in the Ophthalmology Outpatient Department atPacific Medical College, Udaipur , India, from October 2024 to February 2025. The study adhered to the ethical principles outlined in the Declaration of Helsinki and was approved by the Institutional Ethics Committee. Written informed consent was obtained from all participants.

Inclusion Criteria:

Patients aged 35 to 85 years
Diagnosed with PCO
Scheduled for Nd:YAG laser capsulotomy

Exclusion Criteria:

Patients with corneal pathologies such as endothelial dystrophy, scars, or trauma
Retinal diseases
Pseudoexfoliation syndrome
Active uveitis
Traumatic cataract
Diabetes mellitus

Study Procedure: The study included 50 eyes from 50 patients diagnosed with PCO. All patients underwent a detailed ophthalmic evaluation, which included:

Visual acuity testing using Snellen's chart (unaided, aided, and with pinhole)
Slit-lamp examination of the anterior segment
Fundus examination using a 90D lens and indirect ophthalmoscopy
Intraocular pressure (IOP) measurement using applanation tonometry
Non-contact specular microscopy using the Topcon SP-3000P

The central corneal area was evaluated using the automatic mode. Endothelial Cell Density (ECD) was measured using the cell center method. The Coefficient of Variation (CV) in cell size and the percentage of hexagonal cells (hexagonality) were also recorded.

Nd: YAG Laser Procedure: Before the procedure, pupils were dilated using tropicamide 0.8% and phenylephrine 5%. Corneal anesthesia was achieved with 0.5% proparacaine eye drops. The Nd:YAG laser capsulotomy was performed using a slit-lamp-mounted laser system with the patient seated.

Laser energy levels ranged from 1.8 to 4.2 mJ, depending on the PCO thickness. The laser beam was focused 125 µm behind the posterior capsule. A 4 mm cruciate-shaped opening was created, starting from the 12 o'clock position down to 6 o'clock, then extending toward the 3 and 9 o'clock positions. The number of laser pulses used for each procedure was recorded.

Post-Procedure Care:

Patients were prescribed:
Topical flurbiprofen eye drops three times a day for two weeks
Topical timolol 0.5% eye drops twice a day for one week

Follow-up evaluations were done at one week and one month after the procedure. At each visit, Best Corrected Visual Acuity (BCVA), ECD, CV, and hexagonality were reassessed.

Statistical Analysis

All collected data were analyzed using **Statistical Package for the Social Sciences (SPSS)** software, version 26.0. Descriptive statistics were used to summarize the data, including means and standard deviations for continuous variables.

To evaluate differences in Endothelial Cell Density (ECD), Coefficient of Variation (CV), and hexagonality at different time points (pre-laser, one week, and one month post-procedure), a **one-way repeated measures Analysis of Variance (ANOVA)** was applied. For categorical variables, such as visual acuity outcomes and type of PCO, the **Chi-square test** was used to determine statistical significance.

A **p-value less than 0.05** was considered statistically significant for all comparisons.

RESULTS

This prospective study included 50 eyes from 50 patients who underwent Nd:YAG laser capsulotomy. Participants ranged in age from 35 to 85 years, with the majority (72%) aged over 60 years.

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Of the total, 27 patients (54%) were male and 23 (46%) were female. The right eye was treated in 56% of cases, while the left eye was treated in 44%. Posterior capsular opacification (PCO) was classified as Elschnig's Pearls type in 34 eyes (68%) and as fibrous type in 16 eyes (32%).

Visual Acuity Outcomes: As depicted in [Table1], prior to the laser procedure, 48% of patients exhibited visual acuity ranging from 6/60 to 6/24, 38% had visual acuity between 6/18 and 6/6, and 14% had worse than 6/60. Following Nd:YAGcapsulotomy, 45 patients (90%) achieved best corrected visual acuity (BCVA) of 6/18 or better at one week, increasing to 47 patients (94%) at one month. This improvement was statistically significant ($p < 0.0001$).

Table1: Best Corrected Visual Acuity (BCVA) Before and After Nd:YAG Laser Capsulotomy

Visual Acuity Range	Prelaser (%)	1 Week Postlaser (%)	1 Month Postlaser (%)
< 6/60	14%	—	—
6/60 – 6/24	48%	—	—
6/18 – 6/6	38%	90%	94%

Laser Energy Requirements: The total cumulative laser energy applied ranged from 25 to 110 mJ. The mean energy required for the Elschnig's Pearls type was 54 mJ, whereas fibrous type PCO required a significantly higher mean energy of 86 mJ. The proportion of patients requiring <50 mJ was significantly greater among those with Elschnig's Pearls type PCO, while those requiring >75 mJ were predominantly in the fibrous PCO group. This difference was statistically significant (Chi-square = 26.02, $p = 0.0003$) [Table 2].

Table 2: Energy Levels Required in Different Types of PCO

Cumulative Laser Energy (mJ)	Elschnig's Pearls (n=34)	%	Fibrosis (n=16)	%
<25	1	2.94%	0	0%
26–50	10	29.42%	1	6.25%
51–75	22	64.70%	4	25%
76–100	1	2.94%	10	62.5%
101–125	0	0%	1	6.25%
Total	**34**	**100%**	**16**	**100%**

Endothelial Cell Density(ECD): The mean pre-laser ECD was 2356.76 cells/mm², which declined to 2231.8 cells/mm² at one week and 2199.2 cells/mm² at one month post-procedure. The reduction in ECD from baseline to one month (157.56 cells/mm²) was statistically significant ($p < 0.0001$) [Table3].

Table 3: Comparison of Endothelial Cell Density (ECD) at Pre-laser, One Week, and One Month Follow-up

Time Point	Mean ECD (cells/mm²)	Standard Deviation (SD)	F-value	p-value
Pre-laser	2356.76	213.09		
One week	2231.80	208.60		
One month	2199.20	209.56	1911.8	< 0.0001

Coefficient of Variation(CV): The CV increased progressively from a pre-laser mean of 33.74% to 35.58% at one week and 37.22% at one month. This increase was statistically significant ($p < 0.0001$) [Table4].

Table 4: Comparison of Coefficient of Variation (CV) at Pre-laser, One Week, and One Month Follow-up

Time Point	Mean CV (%)	Standard Deviation (SD)	F-value	p-value
Pre-laser	33.74	2.03		
One week	35.58	1.99		
One month	37.22	2.13	402.41	< 0.0001

Hexagonality: Hexagonality decreased from 65.34% at baseline to 62.02% at one week and 60.42% at one month. The decline from baseline to one month was statistically significant ($p < 0.0001$) [Table5].

Table 5: Comparison of Hexagonality (%) at Pre-laser, One Week, and One Month Follow-up

Time Point	Mean Hexagonality (%)	Standard Deviation (SD)	F-value	p-value
Pre-laser	65.34	2.65		
One week	62.02	2.57		
One month	60.42	2.41	852.80	< 0.0001

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DISCUSSION (Enhanced Language)

Posterior Capsular Opacification (PCO) remains the most frequent long-term complication following uneventful cataract surgery. Nd:YAG laser capsulotomy has become the standard non-invasive treatment due to its efficacy and safety in restoring visual function in pseudophakic eyes [6].

In this study, the gender distribution was nearly equal, with no significant predilection observed, consistent with earlier studies by Aslam TM, Dharmaraju B, and Spalton DJ [7–9]. The majority of cases were in patients over 40 years, aligning with the typical age group affected by senile cataract and its sequelae.

Elschnig's Pearls type PCO was more prevalent (68%) than the fibrous type (32%). The energy required for capsulotomy was significantly higher in fibrous PCO, attributed to the denser, more fibrotic nature of the opacity. These findings are in line with those reported by Agarwal G et al. and others [2,3].

The visual outcomes post-procedure were favorable, with 90% of patients achieving BCVA of 6/18 or better within one week, and 94% by one month. These outcomes support the high success rate of Nd:YAGcapsulotomy as observed in previous studies [3,8].

However, a measurable impact on the corneal endothelium was observed. A statistically significant reduction in ECD occurred from baseline to one month post-procedure. This decline may be due to the effect of laser energy on endothelial cell integrity, potentially through disruption of the sodium-potassium ATPase pump mechanism, which is essential for maintaining endothelial cell function and corneal transparency [10].

The increase in Coefficient of Variation (CV) from 33.74% to 37.22% over one month reflects an increase in cellular size variability (polymegathism), suggesting endothelial stress or damage. Although some previous studies reported non-significant CV changes, the results of this study show a clear trend toward endothelial structural alteration [3].

Similarly, hexagonality—indicative of cellular pleomorphism—decreased significantly over the follow-up period, from 65.34% to 60.42%. This suggests loss of regular hexagonal cell shape, further confirming endothelial remodeling. These findings are comparable to those of Rajappa N et al., who also noted significant declines in hexagonality post-capsulotomy [3].

The degree of endothelial cell loss appears to be correlated with the amount of energy used during the laser procedure. Therefore, minimizing energy exposure, ensuring precise laser focus, and using techniques such as contact lens stabilization may help reduce endothelial damage.

This study highlights the importance of pre- and post-procedural specular microscopy evaluation to monitor endothelial health and inform safe laser practices.

CONCLUSION

Nd:YAG laser capsulotomy continues to be a widely accepted, effective, and non-invasive procedure for treating posterior capsular opacification (PCO), offering rapid visual rehabilitation for patients following cataract surgery. This study confirmed that a significant proportion of patients (94%) experienced an improvement in Best Corrected Visual Acuity (BCVA) to ≥6/18 within one month of the procedure, underscoring its clinical efficacy.

However, the findings also highlight measurable and statistically significant alterations in corneal endothelial parameters—specifically a decrease in endothelial cell density (ECD), increased coefficient of variation (CV), and reduced hexagonality—suggesting that the procedure can compromise corneal endothelial integrity.

These changes, while within acceptable clinical limits, point to the importance of optimizing procedural parameters. The extent of endothelial cell loss was likely influenced by cumulative laser energy, type of PCO (with fibrotic types requiring more energy), and other intraoperative factors. Therefore, it is imperative to:

Use the lowest effective laser energy to achieve adequate capsulotomy.

Ensure precise posterior capsule focusing to avoid anterior segment damage.

Employ a contact lens or protective interface during the procedure to stabilize the eye and minimize collateral energy dispersion.

Evaluate corneal endothelium pre- and post-operatively using specular microscopy, particularly in patients with borderline endothelial counts or preexisting corneal conditions.

Further research with larger sample sizes and extended follow-up periods is recommended to assess the long-term impact of Nd:YAG laser on corneal endothelium and to refine safety thresholds for energy delivery. Customizing the laser approach based on PCO morphology may also enhance outcomes while reducing risks.

Recommendations

1. **Minimize Laser Energy Use:** Nd:YAG laser capsulotomy should be performed using the **lowest effective energy** necessary to achieve adequate capsular opening, especially in patients with pre-existing low endothelial cell counts.
2. **Tailor Approach Based on PCO Type:** Given that **fibrotic-type PCO** requires significantly higher energy than Elschnig's Pearls type, preoperative classification of PCO morphology can help tailor laser settings and reduce unnecessary endothelial exposure.
3. **Pre-and Post-Procedural Specular Microscopy:** It is advisable to perform **specular microsopy** before and after the procedure to monitor corneal endothelial health, particularly

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in elderly patients or those with borderline endothelial function.

4. **Use of Contact Lens During Procedure:** Employing a **contact lens (e.g., Abraham lens)** during laser capsulotomy helps stabilize the eye, improves laser focusing, and can significantly **reduce inadvertent corneal damage**.
5. **Accurate Laser Focusing:** Laser energy should be focused precisely on the posterior capsule to avoid anterior segment complications and minimize energy scatter toward the corneal endothelium.
6. **Monitor for Delayed Complications:** Patients should be followed up for at least **one month post-procedure**, with attention to intraocular pressure changes and endothelial cell status.
7. **Educate Patients on Risks and Follow-Up:** Patients should be **counseled** about both the benefits and possible complications of Nd:YAG laser capsulotomy, and the importance of **adhering to follow-up schedules** for optimal outcomes.
8. **Encourage Further Research:** Larger, multicentric studies with **longer follow-up durations** are needed to better understand the long-term implications of Nd:YAGcapsulotomy on corneal health and visual quality.

REFERENCES

1. Salmon JF. Kanski's Clinical Ophthalmology: A Systematic Approach. 9th edition. London: Elsevier; 2020. 331.
2. Agarwal G, Kumar S, Malik VK. Effect of Nd:YAG laser posterior capsulotomy on corneal endothelial cell count in relation to the power of laser used. International Journal of Science and Research. 2019;8(1):1178-83.
3. Rajappa N, Lune A, Magdum R, Mehta R, Patil P, Radhakrishnan OK. Evaluation of corneal endothelium before and after neodymium: Yttrium-aluminium-garnet laser capsulotomy in posterior capsular opacification. Sudanese J Ophthalmol. 2013;5(2):73-78.
4. Qasim KF, Hasanain AR. Effect of neodymium: Yttrium-aluminium garnet laser capsulotomy on endothelial cells count in posterior capsular opacification. J Ophthalmol. 2018;3(6):01-06.
5. Khambhiphant B, Liumsirijarern C, Saehout P. The effect of Nd:YAG laser treatment of posterior capsule opacification on anterior chamber depth and refraction in pseudophakic eyes. Clin Ophthalmol. 2015;9:557-61.
6. Shaikh A, Shaikh F, Adwani JR, Shaikh ZA. Prevalence of different Nd:YAG laser induced complication in patients with significant posterior capsule opacification and their correlation with time duration after standard cataract surgery. International Journal of Medicine and Medical Sciences. 2010;2(1):12-17.
7. Aslam TM, Devlin H, Dhillon B. Use of Nd:YAG laser capsulotomy. SurvOphthalmol. 2003;48(6):594-612.
8. Dharmaraju B, Vijayasree S, Sridhar K. A clinical study of visual outcome in Nd:YAG laser capsulotomy in posterior capsule opacity. Int J Contemp Med Res. 2016;3(9):2665-68.
9. Spalton DJ. Posterior capsular opacification after cataract surgery. Eye. 1999;13:489-92. [10] Levin LA, Nilsson SFE, Ver Hoeve J, Wu SM, Kaufman PL, Alm A. Adler's physiology of the eye. 11th edition. USA: Elsevier; 2011. 168-257.
10. Kanchanaranya N, Sonthirathi S. Effect of neodymium: YAG (ND:YAG) laser capsulotomy on the corneal endothelium in treating posterior capsule opacity. Thai Journal of Ophthalmology. 2015;7(2):06-12