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Analysis of visual outcome of Neodymium: Yttrium-Aluminum -Garnet (Nd: YAG) laser capsulotomy in patients with Posterior Capsule Opacification

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Objective: Posterior capsular opacification (PCO) is a postoperative complication causing decreased visual acuity. This study aims to study the efficacy of Nd: YAG laser capsulotomy in posterior capsular opacification following cataract surgery by analyzing the visual outcome. **Material and Methods:** A prospective study included a sample size of 50 eyes of 37 patients with Posterior capsular opacification following uneventful cataract surgery with significantly decreased visual acuity. Detailed anterior and posterior segment examination was done, best-corrected visual acuity (BCVA) was recorded along with measurement of IOP. Posterior capsulotomy was performed using Nd: YAG laser (Neodymium: Yttrium-aluminum–garnet) and patients were followed up. Visual acuity was assessed and complications if any were recorded. **Results:** It was noted that 74% of the patients at the end of 1st week and 78% of the patients at the end of 1st and 3rd month had significant visual improvement following Nd: YAG laser capsulotomy. There was a statistically significant difference in Post Nd: YAG laser BCVA on follow up with P-value <0.001. Complications encountered were the rise in IOP in 6% of the population at the end of 1 hour and 1st day of the procedure, iris bleeding was noted in 4% of the population, intraocular lens damage in 2 %, and cystoid macular edema in 2 % of the study population.

Keywords: Nd: YAG laser capsulotomy, Posterior capsular opacification

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Introduction

Posterior capsular opacification (PCO) is a complication following cataract surgery which causes optic clarity disturbances and decreased visual acuity [1]. PCO is caused due to proliferation and migration of residual lens epithelial cells within the posterior capsular bag [2,3] and the incidence of patients requiring neodymium: Yttrium-aluminum–garnet(Nd: YAG) laser capsulotomy postoperatively range from 2% to 50% [4]. To improve vision in patients with PCO, Nd: YAG laser capsulotomy is done which is a relatively non-invasive procedure and serves as an excellent treatment modality [5,6]. Aron-Rosa and Fankhauser et al [3] proposed Nd: YAG laser capsulotomy as an effective treatment for PCO in the 1980s, it is generally a safe and successful procedure but documented complications include a transient rise in intraocular pressure, corneal edema, iris bleeding, uveitis, lens subluxation or dislocation, lens pitting, retinal detachment, cystoid macular edema and endophthalmitis [3]. Through the 1980s and early 1990s, the incidence of PCO ranged between 25-50%.PCO is a major problem in pediatric cataract surgery where the incidence approaches 100% [7]. This study aims to study the efficacy of Nd: YAG laser capsulotomy in posterior capsular opacification following cataract surgery by analyzing the visual outcome.

Materials and Methods

This study was conducted after obtaining Institutional Ethical Committee clearance in the Outpatient department at Saveetha Medical College and Hospital for 6 months A Prospective study included a sample size of 50 eyes of 37 patients and study was conducted after obtaining an informed and written consent from all the patients.

Based on the previous hospital records, the approximate number of potential Eligible subjects attending the study setting during the data collection period were considered as 500. Hence a finite population correction was applied for 500. The sample size was calculated assuming the proportion of Visual outcome as 65%. Other parameters considered for sample size calculation were 12.8% absolute precision and 95% confidence level. The following formula was used for sample size calculation. The following formula was used for sample size

$$n' = \frac{NZ^2P(1-P)}{d^2(N-1) + Z^2P(1-P)}$$

Where *n* = Sample size

N= Population Size= 500

Z= Z statistic for a level of confidence level= 1.960

P = Expected prevalence/proportion of outcome= 0.65

D = Precision= 0.128

The required sample size as per the above-mentioned calculation was 48. To account for a non-participation rate/ loss to follow up rate of about 5%, another 2, subjects will be added to the sample size. Hence the final required sample size would be 50.

Statistical methods: Visual outcome was considered as the primary outcome of interest. Descriptive analysis was carried out by mean and standard deviation for quantitative variables, frequency, and proportion for categorical variables. Data is represented using appropriate diagrams like bar and pie diagrams. The association between categorical explanatory variables and the quantitative outcome was assessed by comparing the mean values. The mean differences along with their 95% Confidence interval were presented. Independent sample t-test/ ANOVA was used to assess statistical significance.

The association between explanatory variables and categorical outcomes was assessed by cross-tabulation and comparison of percentages. Odds ratio along with 95% CI presented. Chi-square test/ Fisher's was used to test statistical significance. Univariate binary logistic regression analysis was performed to test the association between the explanatory variables and outcome variables. Variables with statistical significance in univariate analysis were used to compute multivariate regression analysis. P-value < 0.05 was considered statistically significant. Data were analyzed by using SPSS software for windows.

Inclusion criteria: Pseudophakic patients with posterior capsule opacification following an uneventful small incision cataract surgery (SICS) with evident decreased visual acuity were included in the study.

Exclusion criteria: Includes patients with corneal scars or edema, uveitis, posterior segment pathologies, high myopes, and uncooperative patients

Detailed ophthalmic examination was done which included a slit-lamp examination of the anterior segment, fundus examination by direct and indirect ophthalmoscope, best-corrected visual acuity (BCVA) using Bailey Lovie log MAR charts, and measurement of intraocular pressure by Goldmann applanation tonometry. Assessment of PCO on slit lamp-acquired retro-illumination images after complete mydriasis was done. Type of PCO was noted as fibrous, pearly, and mixed type. Clinical grading of PCO was done (Grade 0-Posterior capsule completely clear and no Lens epithelial cells (LEC) migration; Grade 1-LEC migration at the periphery with a clear visual axis; Grade 2-LEC migration onto the visual axis with no drop in best-corrected visual acuity (BCVA); Grade 3-LEC migration onto the visual axis with BCVA better than 6/12; Grade 4-LEC migration onto the visual axis and BCVA of 6/12 worse). Grade 4 PCO was considered as visually significant PCO and was considered as an indication for Nd-YAG capsulotomy. Under topical anesthesia, the posterior capsulotomy was performed with Nd: YAG laser, usually starting with 1 – 2 MJ / pulse and gradually increased until the desired responses were obtained. Steroid eye drops were prescribed to all the patients for one week. Post laser follow up was done at 1hour,1 day,1 week,1 month,3 months of the procedure, and during each visit best-corrected visual acuity using Bailey Lovie logMAR charts, IOP measurement, anterior and posterior segment examination was done and if any complications occurred was also recorded.

Results

Among the study population of 50 eyes of 37 patients, the mean age of the patients was 56.4±5.63 years (Figure 1) and males (59.4%) were more in number than females (40.5%) (Figure 2). The time interval between cataract surgery and the development of posterior capsular opacification is depicted in Table 1. Most of the patients in the study group, presented with PCO which was 1-5 years following cataract surgery (46%). Types of PCO observed in the patients is shown in Table 2, 44% of patients presented with the fibrous type of PCO.

Fig-1: Age distribution.

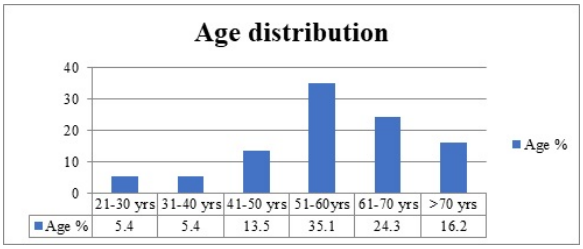

Fig-2: Gender distribution.

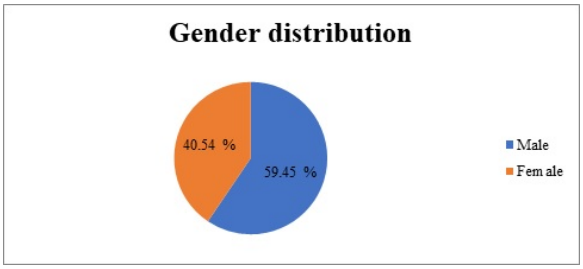

Table-1: Time interval between cataract surgery and the development of PCO.

Duration from surgery	Number of eyes	Percentage
3months -6 months	9	18
>6 months – 1 year	13	26
1.1 year – 5years	23	46
5.1 year – 10 years	4	8
>10 years	1	2

Table-2: Types of PCO.

Type of PCO	Number of eyes	Percentage
Fibrous type	22	44
Pearl type	16	32
Mixed type	12	24

Table-3: Distribution of study group based on Pre Nd: YAG laser capsulotomy BCVA (n=50 eyes).

Pre laser BCVA	Number of eyes	Percentage
<3/60	10	20
3/60-6/60	25	50
6/36-6/18	15	30

Best-corrected visual acuity was documented pre and post-laser as shown in Tables 3 and 4. Among the study population, at the end of 3 months of the procedure, BCVA of 78 % of the patients improved to 6/12-6/6 and 20% of them improved to 6/36-6/18 and 1 (2%) patient had poor visual acuity following capsulotomy. There was a statistically significant difference in Post Nd: YAG laser Best-corrected Visual acuity on follow up with P-value <0.001. (Table 4). The amount of IOP rise following Nd: YAG laser capsulotomy was noted at each follow-up visit which was measured using the

Goldmann Applanation Tonometer. Around 6% of the patients showed a transient increase in IOP (>21mmHg) after 1 hour and 1 day of the procedure and there was no elevation of IOP on further follow-up visits of the patients. There was no statistically significant difference in Pre and Post Nd: YAG laser measurement in IOP (mmHg) with P-value 0.217. (Table 5). Complications following laser were recorded which included iris bleeding with minimal hyphema in 4% of the study population, intraocular lens damage in 2 % and cystoid macular edema was observed in 2% of the study population which was treated appropriately (Table 6).

Table-4: Distribution of study group based on Post Nd: YAG laser capsulotomy BCVA (n=50 eyes).

Follow Up	Visual Acuity				Chi-square	P-value
	Visual Acuity < 3/60	Visual Acuity 3/60 -6/60	Visual Acuity 6/36-6/18	Visual Acuity 6/12- 6/6		
1 Hour	2 (4%)	12 (24%)	18 (36%)	18 (36%)	48.98	<0.001
1 Day	0 (0%)	6 (12%)	20 (40%)	24 (48%)		
1 Week	0 (0%)	1 (2%)	12 (24%)	37 (74%)		
1 Month	0 (0%)	1 (2%)	10 (20%)	39 (78%)		
3 Months	0 (0%)	1 (2%)	10 (20%)	39 (78%)		

Table-5: Distribution of study group based on the measurement of IOP before and after the laser(n=50 eyes)

IOP (mmhg)	Pre-Laser (N=50)	Follow Up(N=50)					Chi-square	P-value
		1 Hour	1Day	1 Week	1 Month	3 Months		
11-15	22 (44%)	24 (48%)	22 (44%)	24 (48%)	25 (50%)	26 (52%)	13.128	0.217
16-20	28 (56%)	23 (46%)	25 (50%)	26 (52%)	25 (50%)	24 (48%)		
>21	0 (0%)	3 (6%)	3 (6%)	0 (0%)	0 (0%)	0 (0%)		

Table-6: Complications following Nd: YAG laser capsulotomy.

Complications	Number of eyes	Percentage
Intraocular pressure elevation	3	6
Iris bleeding	2	4
Intraocular lens damage	1	2
Cystoid macular edema	1	2

Discussion

Posterior capsular opacification results from the growth and abnormal proliferation of LECs on the capsule at the time of cataract surgery. These cells migrate to the posterior capsule where they approach the central visual axis and cause visual axis obscuration, resulting in the dimness of vision. The PCO has two types, fibrous and pearly type. Sometimes a combination of both is also found.

The Lens Epithelial Cells (LEC) that line the anterior capsule is believed to be responsible for fibrous PCO. Clinically it is seen as a wrinkling on the posterior capsule at the site of fusion of the anterior and posterior capsules. The LECs lining the pre-equatorial zone is responsible for the pearl or proliferative PCO [8-12].

This study reveals that Nd: YAG laser capsulotomy is effective for the treatment of posterior capsular opacification following cataract surgery. The mean age of the patients presented in our was 56.4±5.63 years. Males (59.4%) were more in number than females (40.5%).

The maximum time interval between cataract surgery and development of posterior capsular opacification is 1 to 5 years 23 eyes (46%). The most common type of PCO found in the present study was fibrous type 22 eyes (44%) [13-18].

Various innovations in the grading system have been reported in the literature. According to the Madurai PCO grading scale. No PCO- No evidence of Posterior Capsule Opacification (PCO) seen before and after pupillary dilation to a minimum of 6 mm. With a direct ophthalmoscope, a clear view of the optic disc, blood vessels, and the nerve fiber layer is obtained. Grade I is No central PCO seen. PCO is seen only with the pupil dilated to a minimum of 6 mm.

With a direct ophthalmoscope, a clear view of the optic disc, blood vessels, and the nerve fiber layer is obtained. Grade II is PCO present in the central visual axis, detectable in an undilated pupil. With a direct ophthalmoscope, there is a mild obscuration of fundus detail, in that the optic nerve head is seen but the retinal nerve fiber layer and the blood vessels are not seen.

Grade III is a PCO present in the central visual axis with an undilated pupil. With a direct ophthalmoscope, there is a marked obscuration of fundus detail, in that even the margins of the optic nerve head are not clearly defined because of the PCO [19,20].

Barman et al [21] reported a software for assessing PCO, in the POCO man software, images are analyzed by a set protocol of defining the area of the posterior capsule, removing the Purkinje light reflexes by intensity segmentation, contrast enhancement, filtering to enhance low-density PCO, and variance analysis using a co-occurrence matrix to assess the texture. It provides a semi-objective assessment of PCO and is valid and repeatable. Another system that captures high-resolution images is the EAS-1000 system (Scheimpflug video photography).

However, the IOL material has been seen to significantly influence the scatter light density measurements and thus the intensity of PCO quantified by this system cannot be directly compared with different optic materials. This makes the system less applicable to evaluating PCO [22,23]. Moreno et al [24] reported the use of optical coherence tomography (OCT-1) to quantify PCO and to discriminate between different types of PCO. PCO evaluation with OCT is based on peak intensity (PI) and posterior capsule thickening (PCT), with PCT indicating the distance between two reflectivity spikes with an approximate axial resolution of 10 µm.

Invasive Surgical removal of capsular opacity is considered in selected cases as surgery-related complications like vitreous loss and endophthalmitis are at higher rates in surgical removal. Surgical removal is done in cases of visual axis opacification in young children, thick PCO, and cases where Nd: YAG laser capsulotomy is ineffective in clearing the visual axis [20]. A non-Invasive procedure such as Nd: YAG laser capsulotomy was introduced as an effective procedure, but it has many complications.

Gardner et al [8], analyzed 100 patients, who underwent Nd: YAG laser posterior capsulotomy. The study reported that 48% of the population had best-corrected visual acuity between 6/18 to 6/6 at 24 hours and at end of one week, 73% of the entire population had a significant increase in visual acuity. In this study population, at the end of 3 months of the procedure, BCVA of 78 % of the patients improved to 6/12-6/6 and 20% of them improved to 6/36-6/18 and 1 (2%) patient had poor visual acuity following Nd: YAG laser capsulotomy. Hossain et al [17] in his study reported only a few patients to complain of reduction of near vision because miosis most commonly was found in focal central PCO, where distant vision is adequate to have a large pupil size.

After seven days of capsulotomy, 76% of patients gained 6/12 or better vision. Eighty percent of patients gained visual acuity of 6/12 with optical correction after thirty days. On the other hand, 64% of patients had pre-capsulotomy near vision.

< N10 and 16% of patients had N8. A few complications of the rise in intra-ocular pressure ruptured anterior hyaloid face, and IOL pitting after 7 days of capsulotomy was noted in his study.

Yazici et al [18] evaluated a two-year outcome of phacoemulsification combined with primary posterior curvilinear capsulorhexis (PPCC) in 93 eyes of 91 adult patients. PCO occurred in only two (2.2%) patients. No serious complications such as retinal detachment and endophthalmitis were observed during the follow-up. They concluded that cataract surgery combined with PPCC is a safe procedure in adults. H Vijaya Pai et al [19] in 2019 in their study reported that phacoemulsification with continuous curvilinear capsulorrhexis, hydrodissection, and meticulous cortical clean-up before IOL insertion is known to be most efficacious in preventing PCO formation. All the IOLs used in their study were variants of a hydrophobic acrylic material which is known to have lesser PCO rates compared to silicone or polymethylmethacrylate (PMMA) materials, also it had a posterior square edge design which has been stated to be an important factor in preventing PCO. The other important factor stated was the presence of a continuous 360-degree posterior enhanced square edge with good apposition of the optic to the posterior capsule. The presence of such a continuous barrier is known to prevent the lens epithelial cell migration from the optic-haptic junction, toward the visual axis

Elevated IOP is recognized as the most common complication, although usually transient, following Nd: YAG laser capsulotomy. Thompson et al [10] reported that IOP typically begins to rise immediately after the laser capsulotomy, peaks at 3-4 h, but may remain elevated at 24 h, and usually returns to baseline at 1-week. In the present study, about 6% of the population showed a rise in IOP >21mmHg at 1st hour and the end of 1st day of the procedure. Complications following Nd: YAG laser posterior capsulotomy can occur which has been reported in the literature which includes elevated intraocular pressure, iris bleeding, intraocular lens damage, uveitis, cystoid macular edema (CME), retinal detachment, endophthalmitis, and macular hole [11,12,13].

Mukesh et al [20] in his study reported CME developed in 0.5 to 2.5 % of cases, IOL damage was reported from 9.4 to 33% of cases and retinal detachment occurred in 1.6-1.9% of laser capsulotomy cases over 3 years [25,26].

In the present study iris bleeding with minimal hyphema was noted in 4% of the population, intraocular lens damage in 2 %, and CME in 2 % of the population. Hyphema resolved spontaneously with topical steroids and CME was treated with intravitreal steroids.<

Patients with intraocular lens damage are under observation and regularly followed up. There was no evidence of retinal detachment, endophthalmitis, or macular hole in the present study. The documented visual improvement of the subjects in this study confirms the efficacy of Nd: YAG laser in postoperative PCO and serves as the best option.

Fig-3:Posterior capsular opacification.

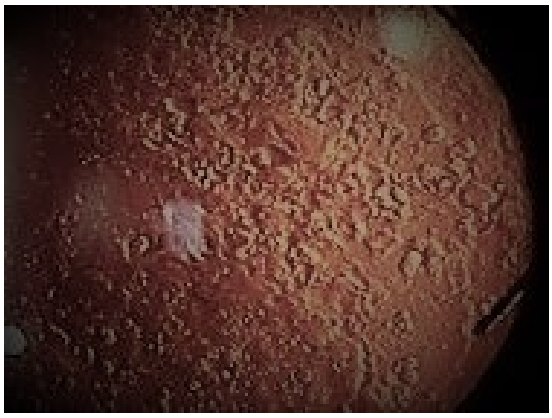

Fig-4: Post Nd: YAG capsulotomy opening.

Limitations

The limitations of the present study were small sample size, a single surgical procedure with a limited period.

The current study also did not take into account the type of Intra-ocular lens causing PCO. Hence, a longer duration of the study period with a large sample size taking into consideration other factors contributing to PCO, that thereby conclude the added information obtained.

Conclusion

Thus Nd: YAG laser posterior capsulotomy is a minimally invasive, safe, and effective procedure that provides an excellent visual outcome in the patients. The Nd: YAG laser is a noninvasive surgical tool that provides excellent posterior capsulotomies.

What does the study add to the existing knowledge?

From the above study, it is clear that Nd: YAG laser posterior capsulotomy is a safe and effective procedure for creating a capsular opening. The visual outcome in our patients showed significant visual improvement and the complication rate reported was also low. The reported complications were actively managed hence concluding the advantage of the procedure.

Author's contribution

Dr. Deepa R and **Dr. V. Panimalar A. Veeramani** conceived, planned, and carried out the study. Dr. V. Panimalar A. Veeramani assisted with data analysis, Dr. Deepa R. analyzed the data and wrote the manuscript with input from the other author.

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