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# Estimation of Mean Nd:YAG Laser Capsulotomy Energy Levels for Different Grades of Posterior Capsular Opacification: A Comparative Study.

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**Abstract**

*Background:* Patients who have PCO with significantly reduced visual acuity need posterior capsulotomy to improve vision. Nd:YAG laser for posterior capsulotomy is a widely used, safe, non-invasive, and effective procedure with minimal complications. The aim of this study is to estimate mean energy levels for Nd:YAG laser capsulotomy in various subtypes of PCO (membranous, fibrous,and fibro-membranous). *Setting And Design:* This is a prospective comparative study at a rural based, tertiary level hospital. *Methods And Materials:* This study has been performed at our institute between September 2013 and September 2015 after taking clearance from the ethics committee. 100 eyes of 100 patients with PCO were considered for Nd:YAG laser capsulotomy after minimum period of 6 months following uncomplicated extracapsular cataract extraction.Statistical analysis was done by the unpaired t-test using SPSS software. *Results:* In our study, the mean initial and mean summated laser energy levels were different for different subtypes of PCO. There was a significant difference in mean initial laser energy levels for different subtypes of PCO ($p<0.001$). Mean initial laser energy level was minimum for membranous PCO (1.4 mJ) followed by fibro-membranous PCO (2.2 mJ) and maximum for fibrous PCO (3.2 mJ), whereas the mean summated energy level for membranous was 25.22 mJ, for fibrous 51.48 mJ and for fibro-membranous was 70.08 mJ. The mean summated laser energy level was maximum for fibro-membranous PCO despite having a comparatively lower mean initial energy level (2.2 mJ). It was significantly higher for bag-sulcus fixated IOLs (75.67 mJ) and sulcus fixated IOLs (55.76 mJ) than bag fixated IOLs (52 mJ) (ANOVA=0.035). *Conclusion:* The mean initial laser energy level and the mean summated laser energy level is different for different subtypes of PCO. The latter is higher for fibro-membranous type of PCO than fibrous and membrane

**Keywords:** Laser Capsulotomy; Posterior Capsular Opacification (Pco); Mean Energy Levels; Surgical Capsulotomy.

## Introduction

After cataract or posterior capsular opacification (PCO) is the most common delayed complication after ECCE surgery with or without PC-IOL and is reported to occur in 16 to 50 percent of patients [1]. Visually significant PCO is defined as that post-operative best corrected visual acuity, which is decreased by two lines on the Snellen's chart [3,4].

Apple et al. described two clinically distinguishable morphlogical forms of PCO: Fibrous type PCO and Elschnig pearl type PCO [5,6].

Patients who have PCO with significantly reduced visual acuity need posterior capsulotomy, I.e., opening up of the posterior capsule so as to improve vision. Posterior capsulotomy can be done by two ways: Neodymium doped yttrium aluminum garnet (Nd:YAG) laser capsulotomy and Surgical capsulotomy.

Nd:YAG laser for posterior capsulotomy is widely used and it has been gradually replacing surgical capsulotomy because it is safe, non-invasive and effective procedure with minimal complications like vitreous loss and endophthalmitis as compared to surgical capsulotomy [1,7,8,21,22,23].

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In Nd:YAG laser capsulotomy, a small opening is created in the center of the opacified posterior capsule by a Nd:YAG laser pulse with energy of a few millijoules (mJ) for a duration of a few nanoseconds [9]. Various factors such as IOL fixation, subtype of PCO etc. can affect the energy levels used for capsulotomy. Studies recommend a lower starting energy level for capsulotomy to minimize complications [10,11].

Till date, only few studies have analysed the impact of PCO subtypes on laser energy levels which are required for capsulotomy.

*Aims And Objectives*

1. To estimate mean energy levels for Nd:YAG laser capsulotomy in various subtypes of PCO (membranous, fibrous and fibro-membranous).

**Materials and Methods**

The study has been performed in our institute between September 2013 and September 2015.100 eyes of 100 patients withPCO were considered for Nd:YAG laser capsulotomy after a minimum period of 6 months following uncomplicated extracapsular cataract extraction. Before Nd:YAG laser capsulotomy, all patients were analysed in following manner:

*History:*

Demographic information like name, age, sex, occupation, address was obtained from each patient.

*Visual acuity:*

Visual acuity of all the patients was recorded using Snellen's chart or illiterate E chart, of both the eyes.

*Slit lamp examination*

Slit lamp examination was done for examination of the anterior segment. The extent and intensity of the subtypes of PCO (membranous i.e. pearl, fibrous and fibro-membranous) was evaluated by slit-lamp grading. Many slit lamp grading systems exist but none of them have been proven to be gold standard.[12] We used the slit lamp grading criteria described by Kruger et al. [13] in 2000. Kruger et al. used grading system 0 to 3 for the evaluation of PCO. Grade 0= absent, Grade 1=very mild, Grade 2= moderate, Grade 3= dense white. The capsule behind the optic was evaluated within a central area of 3 mm diameter and also was evaluated in the periphery. Distinction was given to the grading of elschnig pearls and fibrosis [13].

Grading criteria was important in deciding the initial energy level for subtypes of PCO, necessary for Nd:YAG laser capsulotomy [14].

*Tonometry:* Intraocular Pressure was measured by using Goldmann applanation tonometer. Normal range of IOP was considered to have range of 10-21 mm of mercury (mmHg).

*Fundus examination:*

Fundus was examined using direct or indirect ophthalmoscope to rule out the cause of reduced vision other than PCO. Ultrasound B-scan was done in patients with dense PCO.

Patient selection was done by following criteria

*Inclusion criteria:*

1. Patients operated by ECCE with posterior chamber intraocular lens implantation.
2. Patients with significant PCO.
3. Age between 40 to 80 years.

*Exclusion criteria:*

1. Patients operated by ECCE without intraocular lens implantation.
2. Past history of any ocular surgery other than cataract.
3. Any clinical evidence suggestive of glaucoma.
4. Any other anterior or posterior segment pathology.
5. Eyes with any ocular adnexal disorder.
6. History of diabetes, pemphigus, collagen vascular diseases, stevens johnson's syndrome or immunocompromised status.

*Preparation of the patient:*

After complete evaluation, patient was taken for Nd: YAG laser Capsulotomy under topical anesthesia with dilated pupil .

*Capsulotomy technique:*

The opening was created in a cruciate pattern. The energy and pulses were increased gradually according to the thickness of capsule until an opening was created. The starting initial energy level, number of pulses used to create capsulotomy and the mean laser energy level were noted in each case.

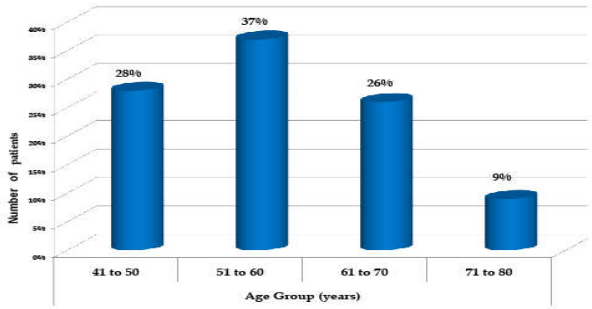
*Post laser follow-up:*

Following the capsulotomy, all patients were routinely given topical antibiotics-steroid combinations and topical anti-glaucoma drops (Beta blocker timolol eye drops twice a day) for 2 weeks. Patients were reviewed after an hour for tonometry and slit lamp biomicroscopy. Anterior chamber reactions were examined. IOP assessment was done after an hour, 1 week, 1 month and 6 months post procedure.Any rise in IOP was noted. If it was raised for a few hours and returned to normal within 7 days, the patient was said to have a 'transient IOP rise'. Persistent IOP rise was labelled if sustained high IOP values were observed on follow up visits. Patients were also assessed for visual acuity, and any incidence of iritis, retinal detachment and cystoid macular edema was looked out for.

*Age distribution:*

**Table 1/Fig.1:** Age group wise distribution of patients undergoing Nd:YAG laser capsulotomy.

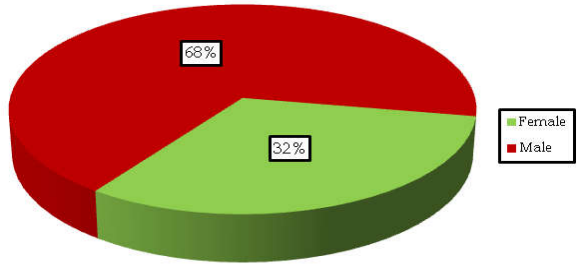
| Age Group | Frequency | Percent |
|---|---|---|
| 41 to 50 | 28 | 28.0 |
| 51 to 60 | 37 | 37.0 |
| 61 to 70 | 26 | 26.0 |
| 71 to 80 | 9 | 9.0 |
| Total | 100 | 100.0 |




*Sex Distribution:*

**Table 2/Fig.2**: Sex wise distribution of patients undergoing Nd:YAG laser capsulotomy.

| Sex | Frequency | Percent |
|---|---|---|
| Female | 32 | 32.0 |
| Male | 68 | 68.0 |
| Total | 100 | 100.0 |




## Results

Table 1 shows that out of 100 patients with PCO, a large number of patients (37%) were between 51 and 60 years of age. Mean age in the study was 58 years with 9.07 SD and ranging within 42 to 79 years.

Table 2 shows that 68% were male and 32% were females.

Table 3 shows that the mean interval between surgery and onset of PCO was 23.52 months with 11.95 months standard deviation. The interval was within 8 months to 60 months duration.

Table 4 shows that in membranous PCO, maximum number of patients (77.8%) needed 0.5-1.5mJ initial energy levels for capsulotomy.

In fibrous PCO, maximum number of patients (57.1%) required 2.6-3.5 mJ of intial energy.

In fibro-membranous PCO, 75% of patients required 1.6- 2.5 mJ of initial energy.

The initial energy level was significantly different for different subtypes of PCO ($p<0.001$).

Table 5 shows that in membranous PCO, maximum number (81.5%) of patients needed summated energy levels between 21 to 30 mJ. In fibrous PCO, maximum number (33.3%) of patients required summated energy levels between 51 to 60 mJ and in fibro-membranous PCO, maximum number (34.6%) of patients needed summated energy levels between 71 to 80mJ.

The summated energy levels were significantly different for different subtypes of PCO ($p<0.001$).

Table 6 shows that the mean initial laser energy level for membranous PCO was 1.433 mJ, for fibrous PCO 3.276mJ, and for fibro-membranous PCO 2.269 mJ.

Mean summated laser energy level for membranous PCO was 25.22 mJ, for fibrous PCO was 51.48 mJ and for fibro-membranous PCO was 70 mJ.

**Table 3:** Mean interval between cataract surgery and onset of PCO.

| | N | Minimum | Maximum | Mean | Standard Deviation |
|---|---|---|---|---|---|
| Interval between surgery and onset of PCO (Months) | 100 | 8 | 60 | 23.52 | 11.95 |

The mean initial energy level and the mean summated energy level was significantly different (P<0.001) for different subtypes of PCO.

Table 7 shows that before Nd:YAG laser capsulotomy, VA of patients was either 6/12 or less than that. After the procedure, the VA improved to 6/6 in 36% and to 6/9 in 37% of the patients. None of the patients were having VA less than 6/18.

## Discussion

Nd:YAG laser capsulotomy is the treatment of choice for PCO[8,15] which appears to be a safe, non-invasive, and an effective procedure. In Nd:YAG laser capsulotomy, opening is created in the opacified posterior capsule by pulses of few millijoules of energy. Our aim of the present study was to analyzed the energy level of Nd:YAG laser capsulotomy in various subtypes of PCO. Grading of PCO was done on slit lamp to know the

**Table 4/Fig.3:** Initial laser energy level (mJ) for different subtypes of posterior capsule opacification (PCO).

| Initial Energy (mJ) | Type of PCO | | | Total |
|---|---|---|---|---|
| | Membranous | Fibrous | Fibro-membranous | |
| 0.5 to 1.5 | 21<br>77.8% | - | - | 21<br>21.0% |
| 1.6 to 2.5 | 6<br>22.2% | 5<br>23.8% | 39<br>75.0% | 50<br>50.0% |
| 2.6 to 3.5 | - | 12<br>57.1% | 13<br>25.0% | 25<br>25.0% |
| 3.6 to 4.5 | - | 3<br>14.3% | - | 3<br>3.0% |
| 4.6 to 5.5 | - | 1<br>4.8% | - | 1<br>1.0% |
| Total | 27<br>100.0% | 21<br>100.0% | 52<br>100.0% | 100<br>100.0% |

Chi-Square Tests

| | Value | df | P value |
|---|---|---|---|
| Pearson Chi-Square | 100.802 | 8 | <0.001 |

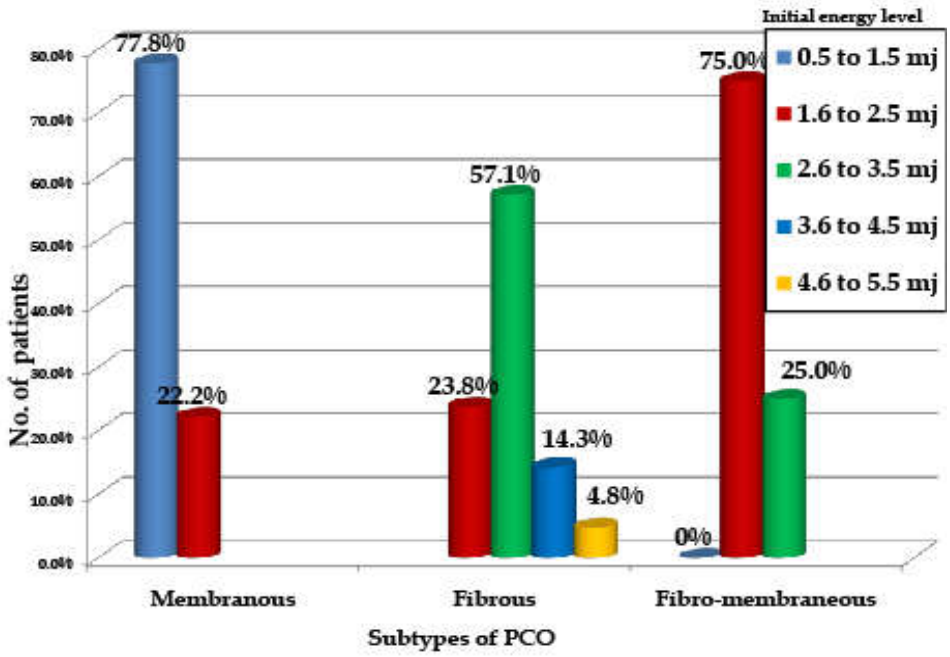


**Table 5/Fig. 4:** Summated laser energy level (mJ) for subtypes of PCO.

| Summated Energy (mJ) | Type of PCO | | | Total |
|---|---|---|---|---|
| | Membranous | Fibrous | Fibro-membranous | |
| 21 to 30 | 22 | - | - | 22 |
| | 81.5% | | | 22.0% |
| 31 to 40 | 4 | 5 | 1 | 10 |
| | 14.8% | 23.8% | 1.9% | 10.0% |
| 41 to 50 | 1 | 5 | 3 | 9 |
| | 3.7% | 23.8% | 5.8% | 9.0% |
| 51 to 60 | - | 7 | 6 | 13 |
| | | 33.3% | 11.5% | 13.0% |
| 61 to 70 | - | - | 15 | 15 |
| | | | 28.8% | 15.0% |
| 71 to 80 | - | 2 | 18 | 20 |
| | | 9.5% | 34.6% | 20.0% |
| 81 to 90 | - | 2 | 9 | 11 |
| | | 9.5% | 17.3% | 11.0% |
| Total | 27 | 21 | 52 | 100 |
| | 100.0% | 100.0% | 100.0% | 100.0% |

## Chi-Square Tests

| | Value | df | P value |
|---|---|---|---|
| Pearson Chi-Square | 115.186 | 12 | <0.001 |

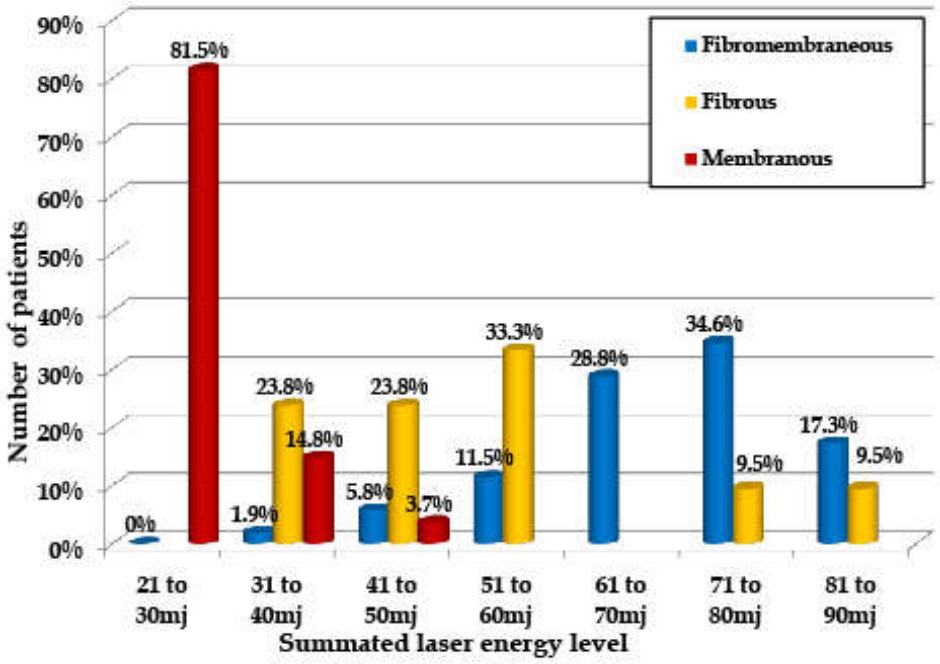
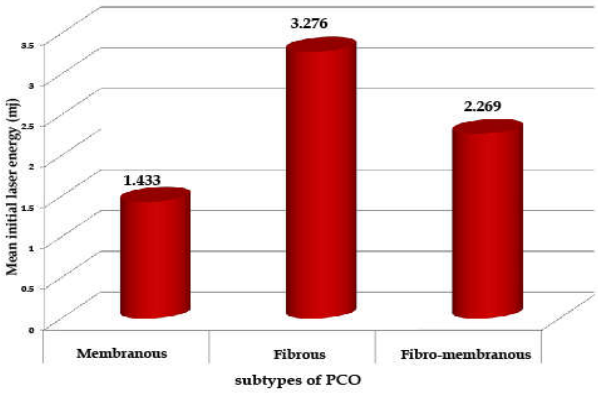


**Table 6/Fig. 5:** Mean initial laser energy level (mJ) and mean summated laser energy level (mJ) in different subtypes of PCO.

| Energy level ( mJ) | | N | Mean | S.D | Minimum | Maximum |
|---|---|---|---|---|---|---|
| Initial | Membranous | 27 | 1.433 | 0.543 | 0.6 | 2.4 |
| | Fibrous | 21 | 3.276 | 0.715 | 2.2 | 5.0 |
| | Fibro-membranous | 52 | 2.269 | 0.456 | 1.6 | 3.2 |
| | Total | 100 | 2.255 | 0.833 | 0.6 | 5.0 |
| summated | Membranous | 27 | 25.22 | 4.77 | 21 | 41 |
| | Fibrous | 21 | 51.48 | 15.06 | 32 | 86 |
| | Fibro-membranous | 52 | 70.08 | 11.26 | 38 | 90 |
| | Total | 100 | 54.06 | 21.91 | 21 | 90 |

Anova

| Anova | Sum of Squares | df | Mean Square | F | P value |
|---|---|---|---|---|---|
| Initial laser energy level | 40.139 | 2 | 20.069 | 68.285 | <0.001 |
| Summated laser energy level | 35934.043 | 2 | 17967.021 | 150.273 | <0.001 |



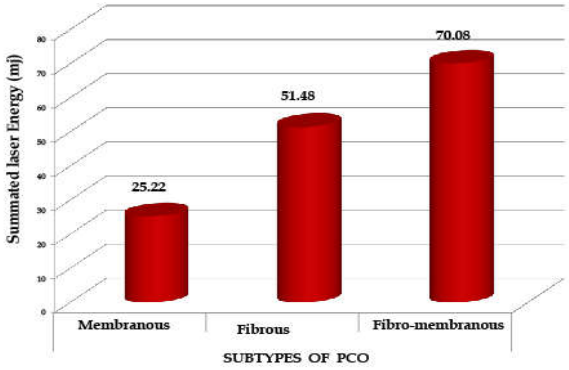
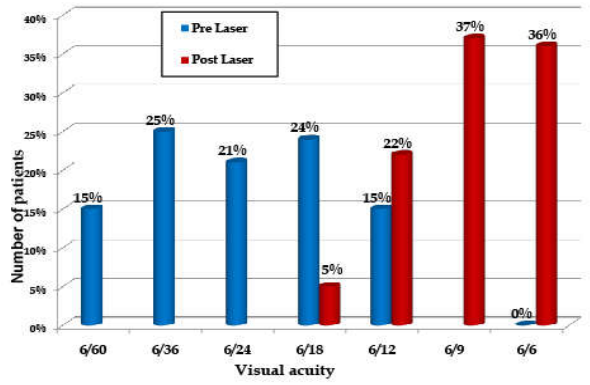




**Table 7/Fig. 6:** Visual acuity (VA) in pre and post Nd:YAG laser capsulotomy.

| Visual acuity | Pre Laser | | Post Laser | |
|---|---|---|---|---|
| | N | % | N | % |
| 6/60 | 15 | 15.0% | 0 | 0 |
| 6/36 | 25 | 25.0% | 0 | 0 |
| 6/24 | 21 | 21.0% | 0 | 0 |
| 6/18 | 24 | 24.0% | 5 | 5.0% |
| 6/12 | 15 | 15.0% | 22 | 22.0% |
| 6/9 | 0 | 0% | 37 | 37.0% |
| 6/6 | 0 | 0% | 36 | 36.0% |
| Total | 100 | 100.0 | 100 | 100.0 |




density of PCO and to set the initial energy for laser capsulotomy.

A total of 100 patients having PCO after cataract surgery were evaluated in the present study. Maximum number of patients (37%) were in the age group of 51 to 60 years with a mean age of 58 years. Burq et al. showed a mean age of 59.5±6.2 years.[16]

In our study, male patients were more in number (68%) than females(32%). In the study by Bari K N (2013) [17], 57% were males and 43% were females. Tayyab et al. reported almost similar sex ratio [18].

In our study, visual acuities of 6/6 or 6/9 were achieved in 73% patients(6/6 in 36% and 6/9 in 37%). Patients with a visual acuity 6/60 were 15% and post procedure the number dropped to zero. For those with a visual acuity 6/36, the number post procedure was zero as well from. In 2014, Khan WA et al. conducted a study on 200 patients and reported that visual acuity 6/6 or 6/9 was achieved in 76.5% patients [19]. Dawood et al. reported the visual acuity was improved in 93.92% and no improvement was seen in 6.08% of patients [20].

In our study, grading of subtypes of PCO was done, so as to know the density of PCO. Mean initial laser energy level for Grade 1 was 1.431± 0.397 mJ, for Grade 2 PCO 2.331±0.305 mJ and for Grade 3 PCO was 3.3±0.561 mJ. The mean initial laser energy level was significantly different in the three grades of PCO ($p<0.001$).

A retrospective study by Bhargava et al. (2012) showed that the required initial and summated laser energy levels depend on thickness of PCO. The mean initial energy level for membranous, fibrous and fibro-membranous PCO was 1.8 mJ, 3.1 mJ, 2.7 mJ respectively and mean summated energy was 22.80 mJ, 80.06 mJ and 80.48 mJ respectively. It was observed that maximum mean summated laser energy(80.48 mJ) was required for fibro-membranous type of PCO despite of lower mean initial energy level (2.7 mJ) [14].

Bhargava et al. (2015)evaluated the Nd:YAG laser capsulotomy energy levels for PCO in 474 patients. The total laser energy levels were significantly higher for fibrous and fibro-membranous types of PCO [10].

Auffarth et al. (2000) examined 172 patients for estimation of energy level required for Nd:YAG laser capsulotomy. The average total energy level required for capsulotomy was 12.7±9.4 mJ. Also, 26 patients required repeat capsulotomy which indicates that high mean energy level was required for thicker PCO [21].

In our study, the mean initial and mean summated laser energy level was different for different subtypes of PCO. There was a significant difference in mean initial laser energy level for different subtypes of PCO ($p<0.001$). Mean initial laser energy level was minimum for membranous PCO (1.4 mJ) followed by fibro-membranous PCO (2.2 mJ) and maximum for fibrous PCO (3.2 mJ).

In our study, the mean initial and mean summated laser energy levels were different for different subtypes of PCO.

There was a significant difference in the mean summated laser energy level for subtypes of PCO ($p<0.001$). Mean summated laser energy level for membranous was 25.22 mJ, for fibrous 51.48 mJ and for fibro-membranous was 70.08 mJ. Mean summated laser energy level was maximum for fibro-membranous PCO despite of lower mean initial energy level (2.2 mJ). Mean summated laser energy level was significantly higher for bag-sulcus fixated IOL's (75.67 mJ) and sulcus fixated IOLs (55.76 mJ) than bag fixated IOLs (52 mJ) (ANOVA=0.035).

## Conclusion

PCO is a common complication after cataract surgery. Nd:YAG laser capsulotomy is the treatment of choice for PCO. PCO can be managed safely by Nd:YAG laser capsulotomy with improvement in visual acuity. Mean initial laser energy level and mean summated laser energy level is different for different subtypes of PCO. Mean summated energy level is higher for fibro-membranous type of PCO than fibrous and membranous (pearl) type of PCO. Grading of PCO is important to know the density of PCO and to estimate an initial laser energy level in various subtypes of PCO.

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